

Policy pathways to advance Nitrous Oxide Monitoring technology for Agriculture

Policymakers can drive improvement in managing atmospheric pollution caused by excess nitrogen, strengthen climate resilience, and support farm profitability by creating conditions that encourage development and deployment of technologies to track nitrous oxide (N₂O) emissions

Introduction: Today, N₂O emissions are an overlooked agricultural super pollutant. They create outsized environmental harms and are notoriously difficult to measure and manage, limiting the potential to optimize nitrogen management on farms. This inefficient nitrogen management is both costly for farmers and damaging to the environment, and addressing it requires us to fully understand how and where nitrogen applied as fertilizer is lost to the atmosphere as N₂O.

Current N₂O management barriers include the shortage of cost-effective and accurate sensors, lack of infrastructure to support data use, and absence of coordination mechanisms. To overcome these barriers and offer farmers, governments and businesses tools to track and manage N₂O emissions, we need a new generation of technology companies. These businesses would provide services similar to those for agricultural carbon dioxide and methane MMRV.

The time is now for N₂O MMRV because of growing industry and regulator discontent with uncertain emissions estimates, increasing pressure to optimize on-farm nitrogen management, and recent technological advances presenting new opportunities to address this problem at scale. Targeted R&D advances can make N₂O MMRV accurate and cost-effective enough for widespread use in agricultural industry. These R&D advances can be made by companies pursuing market incentives, researchers or non-profits to provide a foundation on which companies can build. To incentivize the creation of this foundational IP and resulting business cohort, we need policy that enables and rewards accurate measurement of N₂O emissions at federal, state, local and international levels.

What is the Roadmap?: The Ag N₂O MMRV Roadmap is a scientific consensus document developed by N₂O researchers and policy advocates from nonprofit, business, philanthropic, and research institutions across the United States. It sets out the research gaps that, when addressed, can make agricultural N₂O MMRV viable as a market focus, business foundation, and policy lever.

Why Does Measuring N₂O emissions Matter?: Nitrogen is a valuable input to agricultural systems whose loss is bad for both farmers' bottom lines and the environment. Current fluctuating fertilizer prices and growing awareness of human health impacts make reducing N losses a priority. Better management of nitrogen losses can help farmers optimize fertilizer use and reduce input costs. With the right tools, reducing N₂O emissions is aligned with more profitable and sustainable farm management, reduced N losses and avoided consequences for human health and the climate.

Roadmap Takeaways: This roadmap identifies cases where improved N₂O measurement is good for both business and the environment: voluntary carbon offset markets, corporate supply chain emissions management (scope 3), and more efficient fertilizer applications. The roadmap also outlines the steps we need to take to get there: building cheaper, more robust and portable sensors; developing new ways of measuring N₂O, creating measurement networks that cover

major agricultural areas, and combining AI-driven machine learning with existing models. These priorities need directed funding and coordination to seed innovative companies and public benefit organizations, and regulatory and market conditions that will enable them to thrive.

What Comes Next: A Policy Strategy

Federal agencies, state governments, companies, private foundations, and non-profits have an important opportunity to drive N₂O MMRV research breakthroughs and grow an industry that serves the food sector, leveraging further advances in sensors, data infrastructure, and AI.

Need for Federal Coordination on Nitrous Oxide: In 2024, multiple federal agencies convened to integrate a variety of approaches on MMRV. Subsequently, a clear role emerged for the federal government to coordinate research strategy among the federal agencies and technological development around MMRV- a need that extends to N₂O. This coordinating effort can be revived through strategic partnerships. For example, cross agency coordination could be led by the Office of Science Technology Policy and facilitated by the National Academies and the National Laboratories. A wide range of public and private research institutes, technology and food value chain companies can be critical contributors to this effort¹. For example, multinational food companies are concerned with tracking N₂O emissions and nitrogen use as they work to meet their indirect greenhouse gas emissions targets (known as Scope 3) and can join public-private partnerships to advance N₂O MMRV. Philanthropies and non-profits active in agriculture, food systems, climate resilience, and science advancement can catalyze private funding, lead community building, and maintain trusted partnerships between research, industry and government actors. All these actors are positioned to fund applied science R&D and research translation programs to advance market readiness.

Need for State Action on Nitrous Oxide: States are key partners for translating the N₂O roadmap into reality, with unique policy levers that are crucial for accelerating technology development and market readiness. They can enable N₂O emissions tracking through state-level incentive programs, R&D investments, and state agricultural programs to help farmers and businesses alike.

State technology development strategies are also a critical pipeline for N₂O MMRV incubation and innovation. States can represent American innovation on the global stage and demonstrate technological leadership by promoting nitrous oxide MMRV. States can also work together to coordinate N₂O mitigation strategies domestically, and as part of global nitrogen strategies. For states with climate action plans setting long term climate goals, investment in improved N₂O

¹ “Nitrous Oxide (N₂O) Emissions from California Lands | California Air Resources Board,” accessed September 15, 2025, <https://ww2.arb.ca.gov/our-work/programs/soil-emissions-california-lands/nitrous-oxide-n2o-emissions-california-lands>.; General Mills, “General Mills Partners with Regrow Agriculture to Monitor Agriculture at Scale,” General Mills, June 14, 2022, <https://www.generalmills.com/news/press-releases/general-mills-partners-with-regrow-agriculture-to-monitor-agriculture-at-scale>.

emissions MMRV is an opportunity to increase the credibility of those plans and demonstrate leadership in the global climate community.²

Departments of natural resources, agriculture, state-funded land-grants, and other research institutions can drive N₂O MMRV research and implementation.³ State managed technology hubs and business incubators can utilize roadmap recommendations to steer state economic development strategies and fill technology gaps.⁴ This includes creating technology incubation pipelines to support businesses creating the sensors and models needed.

Conclusion: The N₂O roadmap is a starting point: a consensus agenda outlining the science, coordination, and technology needed to better manage agricultural nitrous oxide emissions. Meeting the technological and scientific challenge for measuring N₂O emissions will require stronger partnerships among researchers, governments, businesses, and farmers, and doing so can unlock new tools, new markets, and more sustainable agricultural systems.

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https://ww2.arb.ca.gov/sites/default/files/2024-03/California%20CPRG%20Priority%20Climate%20Action%20Plan%202024%20March%201_0.pdf; <https://www.c2es.org/document/climate-action-plans/>

³ <https://iot4ag.us/about-us/>

⁴ [A playbook for innovation hubs and ecosystems | McKinsey](#); <https://www.congress.gov/crs-product/IF12794>