Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE)

Nitrogen Summer Institute 2025

June 26 - 27, 2025

AGU Conference Center
2000 Florida Avenue, NW
Washington, DC 20009

NSERC CRSNG

NSF

UKRI Engineering and Physical Sciences Research Council

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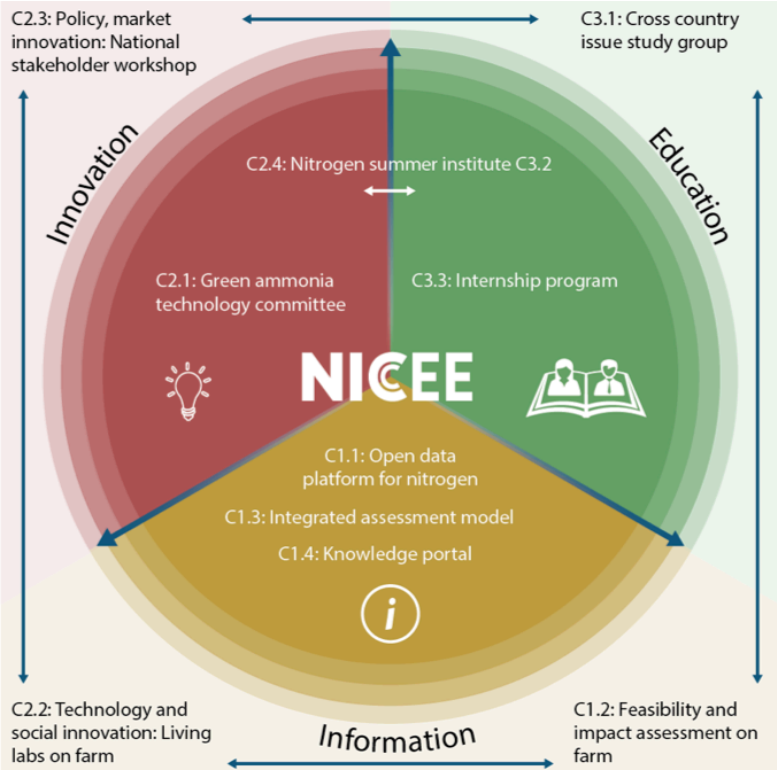


About NICCEE

The Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE) is a transdisciplinary and transnational network dedicated to advancing sustainable and climatesmart nitrogen (N) management through socioeconomic and technological innovation.

OUR MISSION: To enable and accelerate socioeconomic and technological innovation for **sustainable** and **climate-smart nitrogen management** with **use-inspired** and **data-driven approaches.**

INITIAL FOCUS: respond to the opportunities and challenges of **renewable-based nitrogen technologies** (*e.g.,* green ammonia) to provide clean energy and support food production while mitigating climate change.

Spearheaded by University of Maryland Center for Environmental Science (UMCES) with key partners in the US (New York University, University of Massachusetts Amherst), Canada (University of Guelph), and the U.K. (Rothamsted Research), Morocco (UM6P) and beyond, NICCEE is working to support sustainable nitrogen management across the globe. The NICCEE global community involves more than 25 partners across eight different countries, making connections across academia, NGOs, international organizations, government agencies, and private companies.

OUR VISION: NICCEE will serve as an **information hub** with state-of-the-art cyberinfrastructure to monitor the lifecycle and effects of nitrogen in agriculture-food-energy systems, an **innovation platform** to facilitate the co-development of technological and socioeconomic solutions with a broad spectrum of stakeholders, and an **education center** to nurture the next generation of scientists and innovators championing sustainable and climate-smart nitrogen management.

NICCEE will establish itself as a global leader and knowledge source on the impact of renewable-based nitrogen on nitrogen flows in agriculture and energy economies.

NICCEE is jointly funded by the US National Science Foundation (NSF) under award no. 2330502, the Natural Sciences and Engineering Research Council of Canada (NSERC-CRSNG) under award no. ALLRP 585018 - 23, UK Research and Innovation–Engineering and Physical Sciences Research Council (UKRI-EPSRC) under award no. EP/Y025776/1.

NICCEE Community Guidelines

NICCEE is committed to providing **a safe and brave space for individuals, groups and communities to collaborate, innovate, and respond to the challenges and opportunities of green ammonia.**

Please respect the diversity of our community and be generous of others' views. We do not tolerate personal attacks, harassment of any kind, intimidation, violence, or disruptive behavior. NICCEE is dedicated to fostering a welcoming and inclusive environment that promotes collaboration, constructive dialogue, and intellectual integrity.

See *Appendix A* for the complete NICCEE Principles of Conduct.

A Note from NICCEE's Director

Thank you for joining us for the 2025 Nitrogen Summer Institute!

As a mother of two, a scientist from China working in the United States, and a collaborator with colleagues around the world, NICCEE's mission feels more personal than ever this year.

Today, one in eleven people around the world still face hunger, despite the application of over 100 million tons of nitrogen fertilizer to boost food production. The global agriculture–food system remains profoundly inefficient and imbalanced in its nitrogen use: only 16% of applied nitrogen ends up in food. The rest is largely lost—wasting farmers' investments, polluting our air and water, and contributing to climate change and ozone depletion that threaten future generations.

The rise of renewable-based and distributed nitrogen production brings promising opportunities, but also significant challenges. We must act swiftly and thoughtfully to ensure these innovations contribute meaningfully to a more sustainable world.

I feel the weight of the complex and turbulent times we are living through. Environmental, technological, and geopolitical pressures are mounting. Yet amid this uncertainty, one truth remains clear: advancing sustainable nitrogen management is a grand challenge we must face—together.

This is where NICCEE comes in. We are committed to showing that meaningful progress is possible, and that it can be achieved through collaboration across countries, sectors, and disciplines.

The Nitrogen Summer Institute was created to foster this spirit of partnership. Over the next few days, I hope you will engage deeply, think boldly, and build lasting connections as we work together toward more efficient and sustainable nitrogen solutions.

Thank you for being part of this journey.

Xin Zhang, PhD
Director, Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE)
Professor, University of Maryland Center for Environmental Science
Editor, Earth's Future (AGU)

Shared event resources

We created a shared folder for resources to support your participation throughout the 2025 Nitrogen Summer Institute, including the meeting program, breakout group notes, the NICCEE Principles of Conduct, and more.

Access it here or scan the QR code.
https://drive.google.com/drive/folders/1J80iYjwhEbvui4Rtharn7R796_UorJyP?usp=drive_link

At-A-Glance

Wednesday, June 25, 2025 (*Optional field trip; register to attend*)

7:45 AM	Meet at bus pickup location
9:00 AM - 11:30 AM	Tour agricultural field sites
12:00 PM - 1:30 PM	Lunch (*provided*)
5:00 PM - 6:00 PM	Washington DC sightseeing boat cruise

Thursday, June 26, 2025

8:30 AM - 9:00 AM	Kick-off ice breaker
9:00 AM - 10:00 AM	Opening remarks & welcome to NICCEE
10:00 AM - 10:10 AM	Community expectations
10:30 AM - 12:30 PM	Session 1: Renewable Nitrogen Technologies in Agriculture: From Innovation to On-Farm Application *Panel discussion followed by breakout session.*
12:30 PM - 1:30 PM	Lunch *(provided)*
1:30 PM - 3:30 PM	Session 2: Policy Progress and Market Challenges *Panel discussion followed by breakout session.*
4:00 PM - 5:30 PM	Poster Session
6:30 PM	Welcome dinner (*provided*)

Friday, June 27, 2025

9:00 AM - 9:30 AM	Opening remarks
9:30 AM - 11:00 AM	Catalyst Lab
11:15 AM - 12:15 PM	Plenary discussion
12:15 PM - 1:15 PM	Lunch *(provided*)
1:15 PM - 3:15 PM	Session 3: Measuring & Modeling Nitrogen *Panel discussion followed by breakout session.*
3:30 PM - 4:30 PM	Reflections & next steps

Meeting Schedule

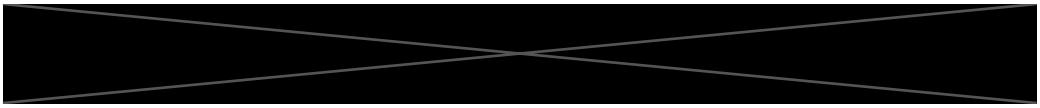
Wednesday, June 25, 2025 (*Optional field trip; register to attend*)

(breakfast on your own)

7:45 AM **Meet at bus pickup location.** Gather in lobby of The Churchill Hotel
Wear closed toe shoes and long pants. Bring water, snacks, sunscreen, bugspray, etc.

1914 Connecticut Ave NW, Washington, DC 20009

8:00 AM - 9:00 AM Drive to Beltsville Agricultural Research Center field site



9:00 AM - 10:00 AM **Tour field site**

Visit a small agricultural catchment with a corn-soybean rotation system (typical US cropping system) to learn how runoff and nutrient losses are monitored in the Chesapeake Bay watershed.
Note*: this will include a 10 - 15 minute walk to the field site.*

10:00 AM - 10:30 AM Drive to the University of Maryland (UMD) Central Maryland Research & Education Center (CMREC) Upper Marlboro Facility

10:30 AM - 11:30 AM **Tour CMREC Upper Marlboro Facility**

Tour a UMD farm for faculty-led research featuring various crops and a new experiment on the fate of nutrients applied in biosolids.

11:30 AM - 12:00 PM Drive to lunch

12:00 PM - 1:30 PM Lunch

The Union Bar and Grill
3950 Garden City Dr, Hyattsville, MD 20785

1:30 PM - 2:30 PM Return drive to Washington, DC. Drop off at The Churchill Hotel

2:30 PM - 4:00 PM Break

4:00 PM - 4:45 PM ***[On your own]*** Travel to sightseeing boat tour departure location

Those who would like to walk as a group are encouraged to gather in the lobby of The Churchill Hotel. The walk is approximately 1.5 miles and estimated to take 40 minutes.

If you choose a rideshare like Uber or Lyft, please *carpool* and *save your receipt* to be eligible for reimbursement.

4:45 PM **Meet at sightseeing boat tour departure location**

Tickets instruct you must arrive 15 minutes prior to tour departure at 5pm.

Capitol River Cruises
Washington Harbour Georgetown
3050 K Street, N.W., Washington, DC 20007
(End of 31st St across from Fiola Mare on the dock)

5:00 PM - 6:00 PM **Washington DC sightseeing boat cruise**

Thursday, June 26, 2025

AGU Conference Center
2000 Florida Avenue, NW - Washington, DC 20009
Luna-Mountain View-Volcano Rooms - 113A,B,C

8:00 AM - 8:30 AM Guest arrival and check-in
(Coffee & light breakfast provided)

8:30 AM - 9:00 AM **Kick-off ice breaker**
Scan the QR code to play!
https://www.menti.com/alp29oxz98jg

9:00 AM - 10:00 AM **Opening remarks & welcome to NICCEE**

9:00 AM - 9:10 AM *Welcome*
Xin Zhang, NICCEE Director; Professor, University of Maryland Center for Environmental Science

Fernando Miralles-Wilhelm, President, University of Maryland Center for Environmental Science

B. Jan Middendorf, Program Director, Office of International Science and Engineering, National Science Foundation

9:10 AM - 9:40 AM *Keynote*
Nagaraja Rao Harshadeep, Global Lead (Disruptive Technology), Lead Environmental Specialist; Environment, Natural Resources & Blue Economy Global Practice, World Bank

9:40 AM - 9:55 AM *NICCEE overview*
Xin Zhang, NICCEE Director; Professor, University of Maryland Center for Environmental Science

Claudia Wagner-Riddle, NICCEE Canada-Lead; Professor, University of Guelph

Adrian Collins, NICCEE UK-Lead; Science Director, Rothamsted Research

9:55 AM - 10:00 AM *General announcements*
Sarah Garvey, NICCEE Program Manager; Assistant Research Scientist, University of Maryland Center for Environmental Science

10:00 AM - 10:10 AM **Community expectations**

Lora Harris, Professor, University of Maryland Center for Environmental Science

10:10 AM - 10:20 AM Group photo

10:20 AM - 10:30 AM Coffee break

10:30 AM - 12:30 PM **Session 1: Renewable Nitrogen Technologies in Agriculture: From Innovation to On-Farm Application**

This session explores the challenges and opportunities associated with renewable nitrogen technologies in real-world agricultural systems. Speakers will explore the technical feasibility of on-farm deployment, innovations in renewable-based nitrogen production technologies, and how current products align with actual farm needs and existing infrastructure. **The goal of this session is to uncover practical pathways from renewable-based nitrogen production to effective, scalable on-farm use.**

10:30 AM - 11:15 AM *Presentation series* (45 minutes)
Please hold questions for the Questions & Discussion period.

Nianqiang (Nick) Wu, Armstrong-Siadat Endowed Chair Professor, University of Massachusetts Amherst

[*pre-recorded*]
Mario Tenuta, Senior Industrial Research Chair in 4R Nutrient Management and Professor, University of Manitoba

Yujing Gao, Assistant Research Scientist, University of Maryland Center for Environmental Science

Mike Castellano, Professor, Iowa State University

Eric Rosenbaum, Senior Agronomist, Rosetree Consulting LLC

Chun Dai, Graduate Research Assistant, University of Maryland Center for Environmental Science

11:15 - 11:35 AM *Questions & Discussion* (20 minutes)

Moderator: **Eric Davidson,** Professor, University of Maryland Center for Environmental Science

11:35 AM - 12:10 PM *Breakout discussions* (35 minutes)

Breakout leaders:
1. Kristin Fisher (red)
2. Adrian Collins (orange)
3. Lorenzo Rosa (yellow)
4. Claudia Wagner-Riddle (green)
5. Edin Thornton (blue)
6. Kate Congreves - *virtual*

Notetakers:
1. Jill Sturtevant
2. Jun Suk Byun
3. Chi Vi
4. Taehoon Kim
5. Andy Sai
6. Mathieu Proulx - *virtual*

Breakout prompts (select 2):
1. Map a single renewable-based nitrogen fertilizer product from production to a crop- or system-specific on-farm use. Include key logistical steps, infrastructure

needs, and decision points. Identify opportunities for improvement or innovation to support current and future adoption
2. What are the practical challenges to adopting renewable-based nitrogen at scale? Where do promising solutions already exist? What are the biggest unknowns?
3. What is the role of field testing in informing more effective renewable-based nitrogen management? What makes a field trial scientifically rigorous and practically valuable for producers and other supply chain actors?
4. What kinds of governance, training, policy or other support are needed to facilitate successful adoption?

12:10 PM - 12:30 PM *Large group feedback* (20 minutes)
Each group is invited to share for ~5 minutes.

Moderator: **Eric Davidson,** Professor, University of Maryland Center for Environmental Science

12:30 PM - 1:30 PM Lunch *(provided)*
Optional building tour available at 1:00pm.

1:30 PM - 3:30 PM **Session 2: Policy Progress and Market Challenges**

This session examines the evolving policy landscape surrounding renewable-based nitrogen products. Discussions will cover the recent NICCEE Nitrogen Governance Workshop, key regulatory, socioeconomic and environmental concerns, and the roles of industry and philanthropy. **The goal of this session is to foster collaboration and strengthen public and private partnerships, identifying potential frameworks to support climate-smart nitrogen management and sustainable transitions.**

1:30 PM - 2:10 PM *Panel discussion* (40 minutes)
This portion will begin with a featured presentation on the North American Nitrogen Governance Workshop, followed by a prompted discussion with the panelists and moderator. Please hold questions for the open Questions & Discussion period.

David Kanter, Associate Professor, New York University

Anikka Fife, Graduate Research Assistant, University of Maryland Center for Environmental Science

John Foye, COO, Talus Renewables

Ian Clifford, Co-Founder, CEO & Chair, FuelPositive Corporation

Christopher Clark, Brookings LEGIS Congressional Fellow, Office of Senator Klobuchar

2:10 PM - 2:30 PM *Questions & Discussion* (20 minutes)

Moderator: **William San Martin**, Assistant Professor, Worcester Polytechnic Institute

2:30 PM - 3:10 PM *Breakout discussions* (40 minutes)

Breakout leaders:
1. Edin Thornton (red)
2. Bill Dennison (orange)
3. Tom Bruulsema (yellow)
4. Tongzhe Li (green)
5. David Kanter (blue)
6. Graham MacDonald - *virtual*

Notetakers:

1. Chun Dai
2. Andy Sai
3. Cat Davis
4. Jason Haley
5. Dong Liang
6. Mathieu Proulx - *virtual*

Breakout prompts (select 2):

1. What economic incentives (*e.g.*, subsidies, carbon pricing, risk-sharing) and policy instruments are most promising to enable adoption at scale? What economic and structural changes would be needed to support the transition?
2. Where are policy blind spots when it comes to environmental impacts and equity concerns with renewable-based nitrogen fertilizers? What kinds of governance strategies and inclusive policy tools (*e.g.,* farmer cooperatives, targeted subsidies, decentralized technology transfer channels) could promote smaller scale green ammonia adoption?
3. What role could NICCEE play in the future of policy on renewable-based nitrogen? What role should other actors play (*e.g.,* government, industry, researchers)?
4. What opportunities can NICCEE pursue to strengthen partnerships with the private sector? What can NICCEE offer to startups and corporate companies working on renewable-based nitrogen fertilizer?

3:10 PM - 3:30 PM — *Large group feedback* (20 minutes)
Each group is invited to share for ~5 minutes.

Moderator: **William San Martin**, Assistant Professor, Worcester Polytechnic Institute

3:30 PM - 4:00 PM — Coffee break

4:00 PM - 5:30 PM — **Poster Session & NICCEE Mixer**

NICCEE collaborators from the Education Team, Innovation Team, Information Team, and beyond are invited to share their current work in a poster session format. This is intended to be a relaxed session to allow people to network, explore the diversity of nitrogen research in agriculture, energy and food systems, and identify new questions and gaps in knowledge.

This session will feature work from the NICCEE cross-institute course, *Emerging Nitrogen Technology and Sustainability Challenges From Farm to Fork*, and showcase work from graduate students at UMCES, UMES, UMD, University of Guelph, McGill University, University of Manitoba and UM6P.

(Light refreshments provided.)

6:30 PM — **Welcome dinner**

El Tamarindo
1785 Florida Ave NW
Washington, DC 20009
(5 minute walk from conference venue)

Friday, June 27, 2025

AGU Conference Center
2000 Florida Avenue, NW - Washington, DC 20009
Luna-Mountain View-Volcano Rooms - 113A,B,C

8:00 AM - 9:00 AM Guest arrival and check-in
(Coffee & light breakfast provided)

9:00 AM - 9:30 AM **Opening remarks**

9:00 AM - 9:10 AM *Welcome & reminders*
Sarah Garvey, NICCEE Program Manager; Assistant Research Scientist, University of Maryland Center for Environmental Science

9:10 AM - 9:30 AM *Reflections from Day 1*
Luis Lassaletta, NICCEE Global Advisory Board Chair; Associate Professor, CEIGRAM-ETSIAAB-Universidad Politécnica de Madrid

9:30 AM - 11:00 AM **Catalyst Lab**

Led by graduate students of the NICCEE cross-institute course and instructors Lora Harris (Professor, UMCES) and Cat Davis (Principal Agent, UMCES), the Catalyst Lab is a student-facilitated session designed to spark creativity and collaboration across disciplines and sectors. This session aims to bridge gaps between research, practice and policy, and brainstorm novel solutions for nitrogen management on (and beyond) farms.

11:00 AM - 11:15 AM Coffee break

11:15 AM - 12:15 PM **Plenary discussion**

Role of NICCEE in green ammonia and renewable-based nitrogen innovation within broader agriculture-food-energy systems.

Moderators:
Xin Zhang, NICCEE Director; Professor, University of Maryland Center for Environmental Science
Eric Davidson, Professor, University of Maryland Center for Environmental Science

12:15 PM - 1:15 PM Lunch *(provided*)

1:15 PM - 3:15 PM **Session 3: Measuring & Modeling Nitrogen**

This session discusses current progress, ongoing challenges and gaps measuring and modeling nitrogen flows across scales—ranging from global assessments to field-level trial data. **The goal of this session is to improve the links between measurement, modeling, and actionable insights for stakeholders to enable more efficient nitrogen usage.**

1:15 PM - 1:55 PM *Presentation series* (40 minutes)
Please hold questions for the Questions & Discussion period.

Jillian Sturtevant, General Assistant, University of Maryland Center for Environmental Science

Yusheng Zhang, Researcher, Rothamsted Research

Asma Jebari, Researcher, Rothamsted Research

[*virtual*]
Kate Congreves, Associate Professor, University of Saskatchewan

Yafei Guo, Postdoctoral Researcher, Rothamsted Research

1:55 PM - 2:15 PM *Questions & Discussion* (20 minutes)

Moderator: **Xin Zhang**, NICCEE Director; Professor, University of Maryland Center for Environmental Science

2:15 PM - 2:55 PM *Breakout discussion* (40 minutes)

Breakout leaders:

1. Xin Zhang (red)
2. Eric Davidson (orange)
3. Luis Lassaletta (yellow)
4. Adrian Collins (green)
5. Claudia Wagner-Riddle (blue)
6. Page Kyle - *virtual*

Notetakers:

1. Alaiya Cave
2. Taehoon Kim
3. Anikka Fife
4. Saul Wood
5. Chun Dai
6. Mathieu Proulx - *virtual*

Breakout prompts (select 2):

1. What tools or information developed at NICCEE could be useful for stakeholders in the private sector? What about policymakers at regional, national, or international levels?
2. How can we enable and sustain data collection, modeling, and other activities in a tight funding environment?
3. What are the most important measurement gaps for understanding renewable N impacts? What are the next steps to address these gaps?
4. How do we integrate stakeholder perspectives (e.g., farmers, regulators) into modeling processes? What are the key components to consider when co-developing research questions, data collection methods, and modeling approaches?
5. How can NICCEE's data and models be made more accessible to the general public and relevant stakeholders? How do uncertainties in measurement influence the confidence we have in model outputs and affect stakeholder decisions?

2:55 PM - 3:15 PM *Large group feedback* (20 minutes)
Each group is invited to share for ~5 minutes.

Moderator: **Xin Zhang**, NICCEE Director; Professor, University of Maryland Center for Environmental Science

3:15 PM - 3:30 PM Coffee break

3:30 PM - 4:30 PM **Reflections & next steps**

Xin Zhang, NICCEE Director; Professor, University of Maryland Center for Environmental Science

Poster Session

Green Ammonia in India: An Opportunity to Advance Sustainability?

Eric A. Davidson, N. Raghuram

India is a leader in developing green ammonia (GA) technologies, including the first demonstration plant in the world, built in 2021, producing 1800 MT yr -1 . At present, several billion-dollar-scale plants, mostly for fuel production and export, are due to come on line in 2026 and the following years. GA projects are eligible for incentives under the national government's green hydrogen mission and state governmental advanced technology policies. The Solar Energy Corporation of India has issued a tender for procuring 0.75 MMT yr -1 GA fertilizers, which is a small fraction of the total 17 MMT yr -1 domestic N fertilizer production, which is mostly urea with government subsidies. Over 80% of India's N fertilizer production requires importation of natural gas (>14 million m 3 yr -1), which is a financial burden and a food security vulnerability. Barriers to replacing subsidized urea with GA include little experience in using anhydrous or aqueous ammonia fertilizers. Ammonia is, however, already widely used in India as fuel for cooling community crop storage facilities. One Indian company is using GA in fermentation reactors to grow fungi for production of an easily digested, protein-rich flour that can be added to human food, such as chapatis and biscuits, and to livestock feed, which they plan to scale up in a factory in 2026. Although still in early development, GA in India could reduce the demand for subsidized urea, reduce reliance on imports of natural gas, reduce CO 2 emissions, improve human nutrition, and contribute to a more sustainable food production system.

Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE) UK field trials

Yafei Guo, Laura Cardenas, Alison Carswell, Brighton Chatindo, Saoirse Sheehy-Ariff, Saul Wood, Phil Nightingale, Sarah Gilhespy
UK Principal Investigator: Prof. Adie Collins

To support the develop an innovation platform to facilitate the co-development of technological and socioeconomic innovations associated with green ammonia, as fertilizer and energy, through living labs and stakeholder workshops on local, national, and global scales; deliver up-to-date information on green ammonia technology advancements and guide the co-development at farm to national scales; ultimately, addressing the need for stakeholder-driven technological innovation through a "living lab framework" approach with stakeholder feedback into the co-design. A two-year grassland field experiment is underway to test nitrogen (N) fertilizer treatments, including: zero N, calcium ammonium nitrate (YaraBela AXAN), calcium ammonium nitrate with a nitrification inhibitor (DMPP, 3,4-dimethylpyrazole phosphate), urea, and urea with dual inhibitors (Alzon neo-N: 2-NPT [1,2,4-triazole, a urease inhibitor] and MPA [3-methylpyrazole, a nitrification inhibitor]). Greenhouse gas emissions are measured using static chambers, and ammonia (NH_3) emissions are monitored with NH_3 tunnels. Soil N and C parameters (e.g., ammonium, nitrate, total C and N) will be assessed over time. Herbage mass production (kg dry matter/ha) and nutrient content will also be measured. The collected data will enable the calculation of emission factors and evaluation of nitrogen use efficiency (NUE) for each treatment.

Environmental, Economic, Social, and Technological Perspectives on Green Ammonia, as a Fertiliser: a systematic review

Asma Jebari, Adrian L. Collins

Nitrogen-based fertilisers play a crucial role in enhancing crop yields and supporting global food production, with ammonia being one of the most useful fertilisers. Ammonia is currently mostly produced by the traditional Haber–Bosch process. This process relies on fossil fuels and is highly carbon-intensive with detrimental consequences to the environment and society. In this systematic review, we aimed at understanding the implications of green ammonia (GA) technologies, as potential sustainable alternatives, not only in the context of socio- economic and environmental sustainability, but also in relation to the challenges and opportunities it presents for sustainable agriculture and economic viability. We identified 28 relevant studies covering the different GA technologies. Whilst the environmental and techno-economic implications of GA were covered well within the reviewed literature, corresponding social impacts regarding farmer attitudes towards GA received scant attention. From an environmental perspective, our findings indicate that GA significantly mitigates the climate change

impacts compared with conventional ammonia production. The key components in GA technologies such as electricity generation for water electrolysis, ammonium nitrate synthesis, and the air separation unit contribute the most to carbon footprints. From a technical perspective, compared with the conventional ammonia, decentralised GA production tends to be smaller in magnitude and requires less raw materials whilst being more energy intensive. In economic terms, GA remains less cost-effective than conventional ammonia. Therefore, enhancing the sustainability of GA production relies on further R&D and improvements in the technological components of production.

Bayesian estimation of gridded Nitrogen flow and balance using satellite ammonia measurements

Dong Liang, Chun Dai, Andrew Elmore, Xin Zhang

The current state of the art N flow and balance typically are at a coarse spatial resolution. Given the advancement of green ammonia production technologies, there is an interest in quantifying the N flow and balance at a local scale to inform management practices and technology innovations. This research develops a Bayesian statistical approach to fuse traditional survey-based estimates of N flows with the satellite ammonia measurements. Specifically, we aimed to (1) retrieve ammonia emission from L2 IASI data, only data within 25 km window and with coverage for over 80% of the month was used for the retrieval; (2) geo-process the existing fertilization rate and manure recovery data using ancillary land use data, this involves downscaling the fertilization and manure application data to a gridded scale using the high resolution cropland data layers and (3) apply a spatial statistical approach to impute the emission factors based on ground-based survey estimates of fertilization and manure sources. The model also ingested big data from remote sensing and environmental data such as temperature, pressure, elevation, and soil characteristics. This model will enable a fine-scale prediction of agricultural emissions sources, which in turn enables quantification of N flow and balance at a management-relevant spatial scale.

Low-carbon ammonia production is essential for resilient and sustainable agriculture

Stefano Mingolla, Lorenzo Rosa

Ammonia-based synthetic nitrogen fertilizers (N fertilizers) are essential for global food security, yet their production is highly energy- and carbon-intensive due to a heavy reliance on fossil fuels. This dependency not only contributes significantly to greenhouse gas emissions but also makes the supply chain vulnerable to disruptions, impacting the 1.8 billion people who depend on either imported fertilizers or natural gas. Here, we examine the global N-fertilizer supply chain and evaluate the trade-offs of emerging low-carbon ammonia production pathways, including carbon capture and storage (CCS), electrolytic, and biochemical processes. We compare both technological solutions and production paradigms, contrasting large-scale centralized facilities with small-scale decentralized plants. Our analysis reveals that each pathway presents unique, context-specific trade-offs, and there is no one-size-fits-all solution. Centralized production, while economically efficient at scale, faces significant limitations: high transportation costs and fragile supply networks restrict fertilizer access and exacerbate yield gaps, particularly in remote regions of the Global South. For example, in parts of Latin America and Sub- Saharan Africa, transportation can double fertilizer prices. Conversely, decentralized production can lower transportation costs, emissions, reliance on imports, and price volatility, potentially boosting agricultural productivity in these regions. However, decentralized systems often come with higher production costs and require robust policy support to become viable. Addressing climate change and ensuring food security will require a holistic, region-specific reconfiguration of the ammonia supply chain, balancing technological innovation, economic feasibility, and equitable access. Interdisciplinary approaches are essential to fully understand these trade-offs and to identify resilient pathways for feeding a growing population while minimizing climate impacts.

Long-term effect of synthetic and organic fertilizer inputs on grain nitrogen content

Keyu Ren, Minggang Xu, Wenju Zhang, Yinghua Duan, Xin Zhang

Grain nitrogen (N) content is a key determinant of grain quality and plays an essential role in calculating nitrogen use efficiency (NUE) in cropping systems. However, it is often assumed to be constant for a given crop, potentially overlooking important variability induced by fertilization practices. In this study, we evaluated long-term field trial

data across major agricultural regions in China to examine how different fertilizer strategies—including synthetic and organic inputs—affect grain N content over time. Our findings suggest that both crop yield and grain N concentration respond dynamically to fertilization regimes, and that ignoring these variations can lead to biases in NUE estimation. These results highlight the need to refine NUE assessment frameworks and support integrated nutrient management strategies that consider both yield and quality in the long term.

U.S. national grazing livestock (NGL) dataset for integrated land use research

Jillian Sturtevant, Ryan A. McManamay

Livestock, not only vital to global food production, is a major industry responsible for 40% of the global economy, employing 1.3 billion people. However, the presence of livestock does have notable environmental impacts. The conversion of land for the use of livestock contributes to the presence of greenhouse gases, and deterioration of soil via the nitrogen and phosphorus cycles. Therefore, it is imperative to identify the location and density of livestock, to fully understand their impact on local biomes. One dataset depicting the geographic location of livestock is the 2010 Gridded Livestock of the World (GLW3) dataset, a 10-km representation of cattle, buffaloes, horses, sheep, goats, pigs, chickens, and ducks. This dataset utilizes both weights from statistical models and static calculations. Although this is a reasonable model for a global perspective, in this study we chose to have a more detailed focus on the continuous United States (CONUS) for grazing livestock; a notoriously difficult commodity to quantify geospatially. Herein we describe the development of the National Grazing Livestock (NGL) dataset, a 30-m representation of grazing for goats, hogs, chickens, beef cattle, and dairy cows. NGL measures the animal density in grazing/pastureland identified by the National Land Cover Dataset (NLCD) from its association with above ground biomass. This is accomplished by predicting above ground biomass from ecological regions, soil type, precipitation, temperature, and animal density, adjusted animal densities, and calculated the difference to account for animal influence on vegetation. For validation, animal densities are compared between NGL and GLW3.

Evaluating Greenhouse Gas Emissions Mitigation and Adoption through Co-Developed Knowledge

Chi Vi, David Pelster, Erin Nelson and Claudia Wagner-Riddle

In May 2024, an on-farm trial was initiated at a commercial dairy farm, in Ontario, Canada, to evaluate impacts of beneficial management practices (BMP) packages co-developed by researchers and farmers for nitrous oxide (N 2 O) and carbon dioxide mitigation while promoting crop yield. The site is part of NICCEE's living labs component as well as a Living Lab – Ontario program delivered by the Ontario Soil Crop Improvement Association to bring together farmers, scientists, and other stakeholders to co-develop, test, and evaluate BMPs in real-world farm settings. Emissions are continuously measured using micrometeorological methods deployed on four 3-ha fields. The experimental area is being managed in two different phases of a 9-year crop rotation, with two fields under corn silage (2024) – soybean (2025) – alfalfa (2026 – 2027), and two fields in continuous alfalfa during the 4-year experimental period. Dual nitrification and urease inhibitors and a 15% reduction in urea-ammonium-nitrate rate were applied in one corn field, representing the co-developed BMP package, while the other corn field was managed using conventional practices. As alfalfa fields were newly seeded in 2024, no BMPs were applied. The use of co-developed BMPs in corn silage resulted in 28 % lower cumulative N_2O emissions in the cropping season of 2024 and 11 % greater crop yield compared to the conventional field. Cumulative emissions from alfalfa fields were approximately 76 % lower than that of corn silage.

A social study will be conducted in 2026 aiming to (i) understand experiences of researchers, farmers and cooperators about the co-development program; and (ii) identify constraints and opportunities to improve and expand co development programs. This study will use a participatory approach as the core methodology and carry out focus groups and in-depth interviews with key program cooperators. Findings from this research will highlight the role of participation in creating usable knowledge, empowering citizens, and addressing global issues.

Catchment Systems Model

Yusheng Zhang and Adie Collins

Green ammonia has great potential for the reduction of emissions associated with the production of inorganic nitrogen fertilisers which are essential for food security and sustainable development at global scale. However,

there are concerns about the wider environmental and ecological impacts with growing access to such agricultural inputs. To avoid any unintended environmental consequences, potential trade-offs need to be identified and strategies for their mitigation developed. Accounting for multiple pollutants associated with modern farming, a farm-to-landscape modelling framework for England, namely the Catchment Systems Model (CSM) has been developed to facilitate baseline evaluation, scenario comparison and cost and benefit analysis at management scales, e.g. farm, water management catchment and national scale. Multiple ecosystem services can be assessed to highlight co-benefits and trade-offs with alternative field and farm management strategies to business-as-usual. The modelling framework is being used to evaluate the effects of projected uptake of different low carbon fertilisers and improved nitrogen management on the overall environmental footprints of agricultural production across England and the implications for tackling interlinked global challenges, including climate change, resource exhaustion, habitat loss and population growth.

Soil Plant and Atmosphere Continuum SYStem (SPACSYS) model

Yusheng Zhang, Lianhai Wu, Adie Collins

Nitrogen management, especially chemical fertiliser application, at field scale is essential for agricultural production, but there remain concerns over resource use efficiency and emissions to the environment on intensively managed agricultural land. Based on existing understanding about various physical, chemical and biological processes and their interactions, detailed process-based modelling has been an indispensable tool for predicting the responses to changing field management practices including for yields, nutrient cycling and emissions to air and water under site-specific conditions. Process-based modelling has also been instrumental in upscaling experimental outputs from isolated and controlled experimental settings to help realise their maximum spatial benefits for guiding improved nitrogen management. The Soil Plant and Atmosphere Continuum SYStem (SPACSYS) model is one such dynamic simulation model which has a mixed dimensional and multi-layer structure, runs at field scale, and is driven by daily weather. It has multiple components to simulate plant growth, water movement and heat exchanges. The daily dynamics of carbon, nitrogen and phosphorus through the air, plant and soil continuum are represented. The model will be further developed and tested in new environmental settings first and then employed in conjunction with other field scale models to undertake ensemble modelling to provide robust evidence for potential changes in field management practices, such as use of fertiliser product types, application timing, etc. resulting from the emergence of green ammonia technology.

The 2025 Nitrogen Summer Institute poster session will also feature communication products from the NICCEE cross-institute course, *MEES698N: Emerging nitrogen technology and sustainability challenges from farm to fork*.

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Visit us online at niccee.org.

Have comments or questions about NICCEE and the Nitrogen Summer Institute? Scan the QR code.
https://forms.gle/PYc2qgVSRd6SNxSo7

Appendix A: NICCEE Principles of Conduct

The Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE) is committed to providing **a safe and brave space for individuals, groups and communities to collaborate, innovate, and respond to the challenges and opportunities of green ammonia**. NICCEE does not tolerate discrimination, harassment, or intimidation of any person or group on any basis, including race, ethnicity, religion, age, sex, sexual orientation, gender identity or expression, disability, national origin, citizenship status, socioeconomic background, position or title, political affiliation, caretaker status, or other characteristics. All members of the NICCEE community should expect to be held to the following code of conduct:

1. **Treat all members of the NICCEE community with respect, fairness, and courtesy at all times**. Actively cultivate a work environment that is respectful, supportive, friendly, and free from harassment and intimidation. The NICCEE community comprises people first and foremost. Physical and mental health, safety, and well-being are always top priorities.
    a. Respect differing opinions, perspectives, and identities.
    b. Respect the privacy and confidentiality of colleagues and their work.
    c. Respect intellectual property rights and give credit where it is due.
2. **Foster a culture of inclusivity and collaboration across disciplines, backgrounds and identities**. Recognize the value and unique contributions of everyone within the NICCEE community.
    a. Be mindful to avoid talking down to others based on their expertise. Discourage disciplinary pride that may hinder interdisciplinary collaboration.
3. **Critique output, not individuals**. Give constructive feedback with kindness and respect, and receive constructive feedback with an open mind.
4. **Practice open science and communication**. Share data sets, methodologies, computer code, and data visualizations openly and transparently. Thoroughly document research processes and results for reproducibility. Publish data sets and your findings whenever possible.
    a. **To foster trust and respect in the NICCEE community**, maintain the confidentiality of sensitive information, including personal disclosures and proprietary research data. Respect the intellectual property rights of others. Being open to sharing information that could benefit the research community is encouraged.
    b. **Communicate openly and honestly** within NICCEE, with outside colleagues and collaborators, and with the public.
5. **Strive to be interdisciplinary. Communicate complex ideas and jargon in language that is clear and understandable**.
6. **Respect one another's cultural identities and life experiences**. Recognize that cultural diversity enriches our understanding and approach to innovation in green ammonia.

NICCEE is committed to providing a working and learning environment free from sexual harassment through training, education, prevention programs, and policies and procedures that promote prompt reporting, prohibit retaliation, and promote timely, fair, and impartial investigation and resolution in a manner that eliminates the sexual harassment, prevents its recurrence, and addresses its effects. All members of the NICCEE community, as well as third parties and subcontractors, are subject to this policy. All NICCEE program participants will be expected to complete the UMCES training on "Sexual Harassment Prevention", or equivalent training in their home institution.

Incident Reporting

NICCEE will follow Title IX guidelines to recommend reporting of any harassment or discrimination, including instances of bullying, in a trauma-informed context that also provides additional support. The UMCES Title IX Coordinator is Lisa Ross, Assistant Vice President of Human Resources (titleix@umces.edu or lross@umces.edu).

Subcontractors will be required to demonstrate that they have established policies and procedures that comply with Title IX and that their program members are provided with contact information for the subcontractor's Title IX coordinator, or equivalent. UMCES requires that any agreement with a subcontractor acknowledges that the

parties will promptly share any reports of harassment or discrimination occurring in off-campus settings and that they agree to cooperate in any investigation involving their participants.

When disagreements arise, NICCEE recommends:

1. Whenever possible, engage in honest and civil dialogue between parties involved as a first step toward resolving disputes.
2. If needed, individuals may seek support from the UMCES Title IX Office

Resources

UMCES Code of Conduct
UMCES Policy on Sexual Harassment
UMCES Policy on Professional Conduct & Workplace Bullying
UMCES Policy on Non-Discrimination & Equal Opportunity

University of Guelph Human Rights Policy
University of Guelph Sexual Violence Policy

NSF Office of Equity and Civil Rights
NSF Office of Inspector General Hotline
NSF Awardee Civil Rights Compliance Program

** The NICCEE Code of Conduct is adapted from the UMCES code of conduct and UMCES policies on Sexual Misconduct, Professional Conduct & Workplace Bullying, and Non-Discrimination & Equal Opportunity.*