RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CGIAR

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

Ryan Institute

NUI Galway OÉ Gaillimh

CLIFF – GRADS

Climate, Food and Farming Network

GRA Development Scholarships

Round 5 Call for Student Applications: Capability Building through Research Stays for Low Emission Agriculture

The CLIFF-GRADS Programme invites applications from PhD students from developing countries[1] for short term (4-6 month) scientific training and research on the measurement, modelling and mitigation of greenhouse gas emissions, or carbon storage in agricultural systems relevant to developing countries (this may be in the context of enhancing food security). Research will be conducted in association with CGIAR and GRA scientists.

The deadline for Round 5 CLIFF-GRADS student applications is the 1st September 2022.

Grants of $12,000 USD will be awarded to PhD students from developing countries for research stays that will be completed before the end of 2024

Eligibility

Individuals applying for the Programme must be citizens of developing countries[1], be undertaking their PhD in a University in a developing country and must not have previously been awarded a CLIFF-GRADS grant.

Background

The Climate, Food and Farming, Global Research Alliance Development Scholarships (CLIFF-GRADS) Programme is a joint initiative of the Global Research Alliance on Agricultural Greenhouse Gases (GRA) and the CGIAR. CLIFF-GRADS builds capability in early-career scientists from developing

[1] As defined by the International Monetary Fund https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/groups.htm#oem

countries to conduct applied research in agriculture greenhouse gas emission quantification and mitigation.

In the first four rounds of CLIFF-GRADS, a total of 124 PhD students received grants, furthering their research skills and strengthening international agriculture emission research networks.

Application instructions

Applicants must complete the CLIFF-GRADS Round 5 online application form and submit the following necessary documentation merged into a single PDF file. Applications must be in English and applications that are in any other language will not be accepted.

- 1-2 page motivation letter *(described below)*
- 1-page academic curriculum vitae (CV / Resume) that includes your contact details
- Letter of support from your PhD supervisor at your current host university

Motivation Letter

Your motivation letter should be no more than two pages, and must include the following:

1. Your name, nationality and your PhD country
2. Objectives of your graduate research
3. The specific research opportunity or opportunities (up to 3) in order of preference to which you are applying *(see list below)*. Please list the research stay name and number.
4. Your qualifications to conduct research on greenhouse gas emissions and/or soil carbon storage in agricultural systems, relevant to the research opportunity for which you are applying.
5. A description of how scientific training received under the CLIFF-GRADS Programme will improve your graduate research and contribute to your career.

Selection process

Successful applicants will demonstrate the relevance of their PhD research for the project to which they are applying. Successful applicants will be matched with a project and notified by email by mid-October, 2022.

Applicants are selected based on three criteria:

1. overall level of research experience,
2. relevance of PhD thesis topic or other research experience to the CLIFF-GRADS objective, and
3. the clarity of description of how the CLIFF-GRADS experience will improve the student's scientific capability and contribute to their career.

Duration

CLIFF-GRADS research stays are expected to be a maximum of 6 months. Students and research supervisors are welcome to extend the stay by mutual agreement if additional funding is available to support a longer stay.

Related Opportunities

The GRA and the CGIAR may organise webinars, workshops, and other activities for capacity building. These opportunities will provide professional experience and serve as networking and communication platforms for CLIFF-GRADS students to share research and experiences with each other. CLIFF-GRADS students are not expected to use their funding for these opportunities.

Funding

Funding for this CLIFF-GRADS call is provided by the New Zealand Government and the CGIAR Trust Fund donors and contracts are administered by the Ryan Institute of the National University of Ireland, Galway.

Additional information

Programme coordinator: all enquiries relating to this call for applications should be directed to the cliffgrads@globalresearchalliance.org email address.

CLIFF-GRADS: https://globalresearchalliance.org/library/cliff_grads-fellowship/

GRA: https://globalresearchalliance.org/

CGIAR: https://www.cgiar.org/initiative/32-mitigate-plus-research-for-low-emission-food-systems/

List of Research Stays

SOILS

1. Long-term effect of biochar-based soil amendments on greenhouse gas emissions in low-input cropping systems

***Keywords**: acidic soil, nitrous oxide, liming, phosphorous*

Brief project outline:

Although several studies have been made to reduce greenhouse gas emissions (GHGs) from soils through biochar application, the quantitative evidence is mainly obtained from incubation experiments and/or short-term field trials. Furthermore, most studies applied biochar at far higher rate (> 10 t ha^{-1}) than is realistic for developing countries, where the availability of organic residues for biochar production is limited. Thus, long-term field experiments that mimic the low-input cropping systems are required to draw general conclusions. In addition, it is unclear to what extent the nutrient content (e.g., phosphorous) and liming effect of biochar influence N_2O emission from acidic soils. This proposal is therefore aimed to investigate nitrous oxide (N_2O) emission after long-term application of biochar and uncover the underlying mechanisms, using the long-term field trial commenced in 2012 at Jimma University, Ethiopia.

Accordingly, N_2O emission will be measured from maize and legume fields that have been amended with different biochars since 2012. In addition, mesocosm experiment will be conducted to elucidate the underlying mechanisms. Chambers will be used to collect the gas samples, and the emissions will be quantified using gas chromatography. At the end of this project, it is possible to determine whether: (i) long-term application of biochar reduces N_2O emissions in low-input cropping system, irrespective of application rate and feedstock types, and (ii) N_2O mitigation potential of biochar in acidic soils depends on its phosphorous content and liming effect. This project will help the students to acquire a wide variety of skills, including GHG measurement and scientific writing.

Desired technical skills and/or experience:

- Knowledge in soil science or environmental sciences
- Practical experience in using gas chromatography or INNOVA
- Practical skill using isotopic studies or interested to learn
- Good communication and teamwork
- To work in intercultural environments
- Fluent in writing and speaking English

Host institution and location: Jimma University, Jimma, Ethiopia

Preferred dates for research visit: To be discussed with supervisor

2. Effects of disturbance on CH_4 uptake capacity and physiology of atmospheric CH_4 oxidizing bacteria

Keywords: *physiology, atmospheric methane oxidation, disturbance, survival, pure cultures*

Brief project outline:

Atmospheric CH_4 oxidizing bacteria (atmMOB) consume up to 50 million tons of CH_4 annually. These bacteria are found globally in soils, but the lack of pure cultures, for a long time prevented physiological insights. In 2019, we published the first physiological study on atmMOB (PNAS), demonstrating that atmMOB use multiple atmospheric gases for growth. Based on this, we secured grants for the project Living on Air, part of the research group Cells in the Cold. We have recently demonstrated that atmMOB can fix atmospheric nitrogen and carbon while capturing energy from atmospheric trace gases CH_4, CO and H_2, suggesting them as key primers for primary production and potentially important nitrogen fertilizers in soils (Schmider et al. *In prep*). One of our new areas of research focus is disturbance effects on the physiology and CH_4 oxidation capacity of atmMOB. AtmMOB are slow-growing organisms and therefore vulnerable. However, we do not yet understand their strategies for survival and growth. Consequently, atmMOB sensitivity to stress, regeneration after physiological disturbance and how this affects gas consumption, is unknown.

In this project we will evaluate growth strategies of atmMOB, how they regenerate physiologically after mechanical stress and changing conditions (temperature, nutrients), and how this links to cellular uptake of atmospheric gases. These results will be aligned with gas uptake measurements in grasslands and forests exposed to different types of land-use in a collaboration with researchers from the Norwegian Institute of Bioeconomy Research (NIBIO).

Desired technical skills and/or experience:

We welcome a CLIFF GRADS PhD candidate competent in soil science, methane oxidizing bacteria, and soil parameter and methane oxidation rate estimation to apply for a stay with the Cells in the Cold research group and help develop our research in a new exciting direction.

Host institute and location: Cells in the Cold research team, Department of Arctic and Marine Biology, UiT, The Arctic University of Norway, Tromsø Norway.

Project leader / research supervisor:

Department of Arctic and Marine Biology, UiT, The Arctic University of Norway.

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - June 2023

3. Monitoring and Accounting for Environmental Co-Benefits of Soil Carbon and Greenhouse Fluxes and Trade-off Analysis of Land Management Systems.

Keywords: *co-benefits, trade-off, GHG, soil carbon*

Brief project outline:

There is pressure on agriculture to meet environmental goals that will ensure food production for the world's expanding population as agriculture both influences and is influenced by climate change. No evaluation has been conducted to determine which adopted climate-smart agriculture (CSA) farming practices would result in improved soil health and lower emissions. The project aims to address this gap by developing and promoting an appropriate framework for monitoring and accounting for environmental Co-Benefits of Soil Carbon and Greenhouse Fluxes and assessing trade-offs between adaptation and mitigation practices in agriculture, as well as by disseminating, informing, and influencing the climate change adaptation and mitigation policy-making process through scientific action research-based results.

To attract additional agricultural investment, it is necessary to quantify adaptation co-benefits in order to track adaptation progress and to monetize and value the mitigation co-benefits resulting from adaptation actions. Quantifying the co-benefits of agricultural adaptation practices is crucial for the sustainability of agriculture as well as for the design, implementation, and evaluation of agricultural adaptation strategies' impacts. Experiments in the field, field surveys, and modelling are all components of the project. The student will test the developed framework within an integrated crop-livestock farming system. They will conduct a field survey to collect soils, GHGs and socio-economic data as well as utilize legacy data to validate the framework in an integrated crop-livestock system. This will refine the standardized tool for monitoring CSA activities. and Lessons learned from integrated system applications would be used to enhance the monitoring tool's usability for climate-smart practices across diverse agricultural systems.

Desired technical skills and/or experience:

- Hands on experience in Soil GHG emissions sampling.
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- English is the working language

Host institution and location: Kenya Agricultural and Livestock Research Organization (KALRO)

Preferred duration of research visit: 6 months

Start and end month of research stay: March 2023 - August 2023

4. Generating quality-assessed soil GHG information to support climate-smart agriculture in Ethiopia

Keywords: *soil, agriculture, Ethiopia, data science, digital soil mapping*

Brief project outline:

Climate Smart Agriculture (CSA) can mitigate the impacts of climate change focusing on three foundational pillars: sustainable increase of agricultural productivity, building resilience and adaptive capacity to climate change, and reducing greenhouse gas emissions to mitigate climate change. To achieve CSA, agriculture production systems need to use natural resources and other inputs more efficiently through an innovative system of land-soil-crop (LSC) information services (IS). In Ethiopia, LSC information is often not used effectively in decision-making, because it is not available in an organised and accessible form and is not seen as 'owned' by national organisations. As a result, stakeholders at national and local levels, including smallholder farmers, are not well equipped to evaluate their policies, plans and farming practices, and improve and transform these in a climate smart manner. This research stay will contribute to an ongoing project (https://www.isric.org/projects/land-soil-and-crop-information-services-lsc-support-climate-smart-agriculture-desira) that aims to generate quality-assessed LSC information to support climate smart agriculture in Ethiopia. The student will support soil data collection and mapping soil properties for the study area, including agronomically relevant properties such as the root zone plant-available water holding capacity. Use will be made of state-of-the-art machine learning digital soil mapping technologies, which also includes uncertainty quantification. If time permits the student will also contribute to collecting crop yield information and the set-up and calibration of the QUEFTS and WOFOST crop yield models to support deriving climate smart fertilizer recommendations.

Desired technical skills and/or experience:

- Excellent interpersonal skills
- Ability to work in diverse cultural and social environment
- Very good skills to use open-source computer software applications (QGIS, R …)
- Experience in soil and agronomy research is strongly advised.

Host institution and location: ISRIC – World Soil Information**,** Wageningen, The Netherlands.

Preferred duration of research visit: 6 months

Preferred dates for research visit: 1 April 2024 - 30 September 2024.

5. Using CQESTR Model to Predict Soil Organic Carbon Changes and CO2 Emissions.

Keywords: *process-based carbon model, carbon sequestration, and CO_2 emissions.*

Brief project outline:

The CQESTR is IPCC Tier II Model. It was developed by our research group and will be used in this project to predict SOC stocks from data collected by a candidate. It is proposed that a Ph.D. candidate will obtain experience in process-based soil C modelling, using the CQESTR (CQESTR : USDA ARS) model. Specifically, the Ph.D. candidate will (1) learn how to prepare CQESTR input files; (2) utilize existing experimental data to run CQESTR model simulations (data from our long-term experiments and published literature, or long-term soil C data collected by the Ph.D. candidate at his/her institution); (3) predict best management practices for C storage and reduced CO_2 emissions under particular soil and climatic conditions; (4) run climate change simulation scenarios under IPCC projected RCP scenarios; and (5) synthesize and integrate the information to select the best management practices for future climatic conditions.

Expected Results**:** The Ph.D. candidate expected to learn how to analyze soil C, run the models and estimate carbon storage/loss under different land management scenarios while in the United States. Prior to departure, the fellow will give an exit seminar. Upon returning to the home country, the fellow should be able to design experiments to improve SOC and the potential to sequester C, transfer knowledge gained to colleagues, and continue research collaboration with U.S. scientists and GRA-Croplands Research Group (https://globalresearchalliance.org/research/croplands/).

Desired technical skills and/or experience:

- PhD candidate competent in soil science
- Good understanding of factors influencing soil organic C sequestration and CO2 emissions
- Experience in database development
- Experience in modelling and statistical analysis

Host institute and location: USDA- Agricultural Research Service - Soil and Water Conservation Research Unit, Pendleton OR 97801, USA.

Preferred duration of research visit: 6 months

Preferred dates for research visit: April 2024 - September 2024.

6. Influence of the soil sampling protocol in the total Soil Carbon Stock at regional level

Keywords: *agricultural systems, modelling, regional level*

Brief project outline:

In recent decades, carbon sequestration in soil has been promoted to mitigate CO_2 emissions. One of policymakers' objectives in 4per1000 project is to implement soil management techniques to increase organic C inputs and to reduce soil organic carbon losses, such as application of organic waste, reducing tillage intensity, leaving crop residue, including crop rotation and cover crops, and proper irrigation management.

Soil sampling and sample analysis protocols could be decisive to properly estimate soil carbon stock. In Spain, as in other countries, there is a National systematic sampling based, in this case, on an 8 x 8 km mesh that covers the entire agro-pastoral area, which represents a total of 4,401 plots in the country. However, the LUCAS database presents a total of 4,363 plots in Spain, with some differences in the sampling protocol. The main difference is found in the number of subsamples per sampling plot (5 subsamples in Lucas versus 21 in the National sampling), which also varies with respect to the sampling area (16 m^2 vs 250m^2), which is extremely important when it comes to being representative of the sampling area.

Because of that, we are planning to make a systematic sampling comparing both protocols, to define the potential bias. Our proposal focuses on sampling the entire surface of the Community of Madrid (CAM) with the two sampling protocols. CAM presents a great variability in lithologies and edaphic characteristics that can be a reference when considering extrapolating results to the rest of the Iberian Peninsula. In addition, focusing on Madrid by proximity allows us to optimize the duration of field sampling. The Lucas sampling presents a total of 59 plots in the CAM, compared to the 74 plots that we already have characterized in this Community. The proposal is based on sampling these 133 with the two protocols and obtaining a total of 266 samples for analysis.

Furthermore, with these data, we can evaluate the temporal changes in SOC using the different comparing sampling protocols.

This proposal includes field sampling, laboratory analyses and statistics modelling work.

Desired technical skills and/or experience:

- Basic experience with large databases
- Basic experience in field and laboratory
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Basic Spanish skills are desirable but not essential

Host institution and location: Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, INIA, Madrid, Spain.

Preferred duration of research visit: 6 months

Preferred dates for research visit: Between January 2023 – April 2024

7. The dynamics of N_2O production and consumption with soil depth in grazed agroecosystems

Keywords: *denitrification, livestock, greenhouse gases, grassland, nitrogen*

Brief project outline:

Nitrous oxide (N_2O) is a potent greenhouse gas emitted from soils within grazed agroecosystems, following fertiliser, slurry/manure, and urine deposition to pasture. One of the major pathways of N_2O formation in soil is denitrification, where NO_3^- is reduced through a series of different reductase enzymes into gaseous forms (NO, N_2O and N_2). Increasing the proportion of N emitted as N_2, rather than N_2O, is an understudied N_2O mitigation strategy. Quantifying N_2 emissions above the high atmospheric background is challenging, but advances in stable isotope techniques have emerged which allow greater insight into N_2O production and consumption processes rather than measuring N_2 directly. Livestock urine-N can travel to different depths within the soil profile via differences in urine volume between individual urine events and between small and large ruminants, and due to differences in soil moisture dynamics. This will influence dynamics of N_2O emission and consumption. This project will investigate:

i. How urine volume, N content and contrasting soil moisture influences NH_4^+ and NO_3^- concentrations at different soil depths

ii. Whether N_2O produced in deeper soil layers has a greater opportunity of being completely denitrified to N_2

Aim i) will be achieved via field-based simulations of urine deposition, quantifying concentrations of mineral N in the profile (using ^{15}N-spiked urine). For aim ii) a gaseous stable isotope pool dilution approach (using $^{15}N_2O$) and an N_2O isotopic analyser will be used to investigate the dynamics of N_2O production and consumption (i.e., conversion of N_2O to N_2) in laboratory incubations of soil cores.

Desired technical skills and/or experience:

- Good understanding of techniques in soil sampling and analysis
- Be able to work independently
- Ability for creative problem solving
- Good level of English required
- Being comfortable in working in both fields and laboratory environment
- Desirable experiences in stable isotopes, greenhouse gas sampling methodologies and/or mathematical modelling.

Host institution and location: Bangor University, North Wales, UK.

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 – August 2023

8. Evaluating the potentials of CSA Practices for Mitigating Soil Greenhouse Gas Emissions from Agricultural Land in Central Highland of Ethiopia

***Keywords**: CSA practices, greenhouse gas emissions, process-based model*

Brief project outline:

Evaluating of the potential of CSA practices in reducing greenhouse gas emission is a very necessary step to set strategically targeting CSA practices to agricultural areas where adoption is most impactful. The potential of CSA practices in reducing greenhouse gas emission varies depending on weather condition and field scale soil properties. In Ethiopian context, there has been little or no effort at all doing such kind of evaluation of CSA practices across scales. Shiferaw 2021 reported that little research is available about CSA practices in mitigating GHG emissions in Ethiopia. Thus, substantial scientific evidence is required to inform policies and implementation guidelines for better targeting of CSA practices in Ethiopia.

Denitrification Decomposition (DNDC) is a process-based model, and currently becoming popular for being used to evaluate CSA practices potential in reducing GHGs emission. Integrating of this model with spatially explicit datasets like soil properties, weather conditions and CSA practices in the agricultural fields simulate GHGs emissions. Gabriel McNunn et al. 2020 developed Denitrification Decomposition (DNDC) model framework to assess Climate smart agriculture opportunities for mitigating soil greenhouse gas emissions across the U.S. Corn-Belt. Accordingly, in this study this modelling framework will be customized and employed to simulate GHGs emissions and evaluate the potential of CSA practices in terms of reducing GHGs emission in central highland of Ethiopia. The objective of this stay is to spatially quantify the potential GHGs reduction of CSA practices in central highland of Ethiopia

A model-based accounting framework will be employed to estimate spatially explicit GHGs reductions associated with the adoption of CSA practices. The framework integrates multiple components including the DNDC model, soils and weather data. In this study the modelling framework will use multiple states to predict mean annual changes in soil GHG emissions based on SOC stock changes, N_2O emissions, and CH_4 fluxes corresponding with the adoption of several CSA practices.

This proposal involves modelling exercise.

Desired technical skills and/or experience:

- Ability to work independently and in team
- Good scientific writing skill for high impact journals
- Modelling experience using large spatial dataset
- R (or python) programming

Host institution and location: Alliance Bioversity-CIAT, Ethiopia Office, Addis Ababa

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - June 2023

9. SOC stabilization mechanisms and their regulation factors under different climate-smart agricultural practices and Mediterranean conditions.

Keywords: *agriculture, soil carbon pools, microbial activity, rainfed woody crops*

Brief project outline:

Agriculture and associated land-use changes contribute ~25% of total global anthropogenic greenhouse gas (GHG) emissions (Paustian et al., 2016), being CO_2 responsible for 50% of average annual GHG emissions for the 2000-2009 period (Smith et al., 2014). Isolated studies reveal how soil can be very relevant as carbon sinks, capable of changing annual carbon balances in terrestrial ecosystems (Le Quéré et al., 2018). In this sense, the adoption of sustainable agricultural practices can substantially reduce these emissions and sequester some of the CO_2 removed from the atmosphere by plants, which is further incorporated as carbon in soil organic matter.

Currently, there is no universally applicable list of best management practices to enhance soil organic carbon (SOC). CEBAS-CSIC is currently involved in a national project financed by the Ministerio de Ciencia e Innovación: "TESTING AND EVALUATING SUSTAINABLE AGRICULTURAL PRACTICES TO OPTIMIZE ECOSYSTEM SERVICES IN RAINFED SYSTEMS (AGRI_SER)) leading long-term experiments in nine woody crop fields (distributed in different locations of Murcia and Granada region), focused on understanding the SOC stabilization mechanisms and the regulation factors evolved under different climate-smart agricultural practices and edapho-climatic conditions. This applied project will provide information on the effects of combining different climate-smart agricultural practices (i.e., reduced tillage, growing cover crops, crop residue retention measures, compost) on the mitigation potential of rainfed Mediterranean agroecosystems.

The student will conduct measurements of soil carbon stocks, carbon pools, enzymatic activities, basal respiration and microbial biomass under different management strategies. This proposal includes both laboratory and field work as well as training on different methodologies to estimate and calculate carbon sequestration rates from the agricultural sector. The stay will enable the candidate to interact with most relevant research groups working on soil carbon storage in agricultural systems across Europe. The CLIFF GRAD project proposed here will contribute to the GRA Soil carbon sequestration Network.

Desired technical skills and/or experience:

- Hands on experience with field and laboratory work, particularly with soils
- Data management and statistical analyses
- Independent and team player
- Basic Spanish skills and driving licence are desirable but not essential

Host institution and location: Soil and Water Conservation Research Group, Centro de Edafología y Biología Aplicada del Segura (CSIC, Spanish Research Council), Murcia, Spain (www.cebas.csic.es; www.soilwaterconservation.es)

Preferred duration of research visit: 6 months

Start and end month of research stay: February 2023 – July 2023

10. Attributing the SOC change and dynamics to land use change, land management and climate change in Ethiopia

***Keywords**: carbon, land management practices, land use change, climate change, NDC*

Brief project outline:

Soil organic carbon (SOC) is the largest pool of carbon in terrestrial ecosystems. Any change in the SOC dynamics affect the CO_2 in the atmosphere. Many international initiatives exist to increase SOC, e.g., the 4 per 1000 initiative on Soil for Food Security and Climate launched by the French Ministry of Agriculture at the United Nations Framework Convention for Climate Change Conference of the Parties (UNFCCC COP 21) and the Land Degradation Neutrality programme run by the United Nations Convention to Combat Desertification (UNCCD).

Understanding factors determining the SOC dynamics at the national level is important to target and guide national intervention so as to achieve NDCs. So far, the focus of most of the process based SOC models are on the impacts of soil and land management on SOC predictions. However, land use change contributes to the significant carbon dynamics at national and regional level. When the SOC dynamics is considered at longer period like 50-100 years, as most of the carbon models do, climate change through altered precipitation and temperature will play important role in covering the SOC dynamics. The objective of this research stay is to (1) modelling and mapping SOC dynamics in space and time, and (2) attribute the dynamics and changes to factors related to land use, land management and climate change in the highland of Ethiopia.

This proposal involves modelling exercise.

Desired technical skills and/or experience:

- Ability to work independently and in team
- Good scientific writing skill for high impact journals
- Modelling experience using large spatial dataset
- R (or python) programming

Host institution and location*:* Alliance Bioversity-CIAT, Ethiopia Office, Addis Ababa

Preferred duration of research visit: 6 months

Preferred dates for research visit*:* January 2023 - June 2023

11. Evaluating the application of arbuscular mycorrhizal fungi to reduce N_2O emissions

***Keywords**: arbuscular mycorrhizal, N_2O emissions, denitrification, genes*

Brief project outline:

In recent years, different management alternatives have been proposed to reduce N losses from the soil-plant system. In this sense, a potential effect of arbuscular mycorrhizal fungi (AMF) on N_2O emissions has been observed. AMFs induce changes in soil structure, in available water, pH, and in the availability and quality of labile carbon. These factors affect denitrification (biological process that contributes most to N_2O emissions). Therefore, these fungi could be expected to influence soil nitrogen availability by reducing N_2O emissions.

The complex interaction between the environmental conditions of the soil and the multiple effects on the production and consumption of N_2O, as well as the great discrepancy in the results of the bibliography regarding the influence of AMFs on the N_2O emission, indicate that more detailed studies of the processes of N_2O production. In this framework, the new molecular technologies (PCR-DGGE, qPCR) allow examining the abundance of guilds and taxa, and the expression of certain genes involved in the processes of nitrification and denitrification; and its study would allow greatly clarify the expected response of N_2O production to the inclusion of AMFs.

Therefore, it is intended to increase our knowledge about the behaviour of the microbial groups potentially involved in the production of N_2O and understand the biological processes involved, which are intimately associated with soil environmental conditions. This work will contribute to the knowledge of the impact of crop management practices on N_2O emissions and microbial community involved in its production.

The general objective of this project is to contribute to knowledge about management practices that allow reducing GHG emissions without reducing yields.

The student will conduct an experiment that aims to evaluate:

- the effect of inoculation with AMF on N2O emissions and yield maize
- the effect of soil moisture conditions on the AMF interaction – N2O emissions
- Understand the interaction between AMF and the expression of genes associated with the processes of nitrification and denitrification

This proposal includes both laboratory and field work.

Desired technical skills and/or experience:

- Hands on experience with plants and microorganisms (bacteria, fungi)
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills.

Host institution and location: Instituto de Innovación para la Producción Agropecuaria y el Desarrollo Sostenible, INTA Balcarce, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: October 2023 - March 2024

CROPLANDS

12. Greenhouse Gas Emissions from Intercropped Legumes in Winter Wheat under Dryland Cropping Systems

Keywords: *soil, CO_2, CH_4, N_2O, and soil organic carbon.*

Brief project outline:

Tillage results in the decomposition of soil organic C (SOC) and accelerates CO_2 emissions, while conservation tillage, especially no-tillage, reduces SOC losses and CO_2 emissions. A student will obtain experience in collecting Greenhouse Gas (GHG) samples using removable vented static chambers and **GRACEnet** protocols from the USDA-Agricultural Research Service. In addition, the student will have the opportunity to sample soils in intercropped legumes in wheat-fallow, wheat-wheat-sorghum, and wheat-wheat rotations, shadow a physical science technician, and become familiar with techniques employed to process samples and report gas emissions. Soil gas samples will be analyzed by Gas Chromatography (Scion-456-GC, with ECD, TCD and FID), and data will be processed using several models (e.g., HM, HMR) to calculate GHG fluxes. Soil gas samples (CO_2, N_2O, and CH_4) are collected weekly during the growing season and periodically after harvest.

Specifically, the PhD candidate will (1) participate in field studies to collect GHG (CO_2, N_2O, and CH_4) samples; (2) process samples and quantify gas emissions; (3) estimate the effects of tillage, crop rotation, and total precipitation on GHG flux; (3) learn how to select the proper model for each individual gas; (4) utilize existing experimental data from his/her experiment to integrate the information into a written report selecting the best management practices for the soil and climatic conditions. Upon returning to his/her home country the student should be able to design experiments to improve SOC, reduce GHG emissions, transfer knowledge gained to colleagues, and continue research collaboration with members of GRA- Croplands Research Group (https://globalresearchalliance.org/research/croplands/).

Desired technical skills and/or experience:

- PhD candidate competent in soil science
- Good understanding of major factors influencing soil N_2O, CH_4 and CO_2 emissions
- Good understanding of the role of soil water content, crop residues, soil organic matter, legume, and N fertilizers in GHG emissions under dryland cropping system.

Host institute and location: USDA-Agricultural Research Service - Soil and Water Conservation Research Unit, Pendleton OR 97801, USA.

Preferred duration of research visit: 6 months

Preferred dates for research visit: October 2023 - April 2024.

13. Soil use effect on GHG fluxes.

***Keywords**: GHG fluxes, diffusion, agriculture; mitigation GHG fluxes; oxidation; afforestation; agriculture; mitigation*

Brief project outline:

In Argentina, and other developing countries where the main productive activity is the agriculture sector, emissions of greenhouse gasses (GHGs) are important. Tree agriculture (wood production) promotes different benefits including carbon uptake by the tree and by soil, CH_4 uptake improvement by soils and upgrading soil characteristics.

Our proposal is to evaluate GHG emission/uptake from three contrasting systems (an agricultural land, a forested area, and a natural grassland as a control site) in two regions, by evaluating the diffusion coefficient in soil (one-chamber technique in field and laboratory conditions). Also, the soil GHG gradient will be measured in the first cm of soil (field measurements) that will allow to obtain GHG fluxes using Fick´s Law. Field measurements will be taken every 45 days to evaluate seasonal variation and several plots inside each system will be randomly selected to evaluate spatial variation. Also, soil characteristics will be determined in the laboratory (bulk density, humidity, organic matter, texture, ammonium, and nitrate) to correlate with GHG fluxes and diffusion coefficients. Residence time: 6 months. Includes measurement time and data analysis.

Desired technical skills and/or experience:

- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Basic Spanish skills are desirable but not essential

Hosting institution: CIFICEN (UNCPBA-CICPBA-CONICET, Tandil, Buenos Aires, Argentina)

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2023 – July 2023; or July 2023 – December 2023

14. Development of nitrous oxide emission factors associated to the use of foliar nano formulations

***Keywords**: volcanic soils, emissions, nitrogen use efficiency, grasslands*

Brief project outline:

The use of nitrogenous fertilizers in agricultural soils is essential to improve production yields. However, the use of nitrogenous fertilizers is responsible for the generation of nitrous oxide (N_2O), a potent greenhouse gas that is generated in the soil by biochemical processes for the degradation and use of nitrogen by the plant. This has resulted in the development of novel technologies to reduce these emissions as well as improve nitrogen use efficiency (NUE) by plants. We hypothesized that bypassing soil N cycle using nanoformulations applied as foliar fertilizer significantly reduced N_2O emissions, increasing NUE in grasslands and resulting in low N_2O emission factors. The student will join an experienced team quantifying N_2O emissions factors after the application of mitigation strategies, including the use of novel foliar nanoformulations to grasslands, integrating soil and plant measurement techniques.

This initiative will be integrated to the current GRA Flagship Reducing N_2O Emissions and Improving Accounting.

Depending on COVID19 conditions, the student will need to comply with all specific requirements in place at the time of implementing the scholarship.

Desired technical skills and/or experience:

- Availability for field and laboratory work
- Ability to work as part of a team
- Organized and meticulous
- Independent thinking and ability to resolve problems
- Basic Spanish skills are desirable

Host institute and location: Instituto de Investigaciones Agropecuarias INIA Remehue, Osorno, Chile

Preferred duration of research visit: To be discussed with supervisor

Preferred dates for research visit: Preferably completed by 31 December 2023.

15. Greenhouse gas emissions associated with conservation agriculture from UK cropland using the DENitrification incubation system (DENIS)

Keywords: *conservation agriculture, nitrogen, carbon, crop rotations, intercropping, greenhouse gases, laboratory incubation, amendment,* ^{15}*N-enrichment analysis.*

Brief project outline:

Agriculture must sustainably provide global food security, but in the face of climate change there is concern about cropping effects on greenhouse gas (GHG) emissions from soil. Conservation agriculture (CA) might increase the sustainability of agricultural production systems. Diversification of cropping systems through rotations or intercropping, tillage practices (minimum tillage reduces the disruption of soil structure), retention of organic residues, or other means to sequester SOC, are critical components of CA. They increase the resilience of crop yields to climate variations and improve the structure of soils, but its impact on GHG budgets remains open. A stronger evidence base is needed to assess trade-offs between these factors and soils GHG budget under CA.

The research presented here is in line with the research that the GRA Cropland group is conducting on Agricultural greenhouse gases from CA. The research links to a wider network from the European Joint Programme, project 'CropGas' including sub-Saharan Africa and European countries, which will further add to the evidence base for the impact of CA practices on GHG budgets for agricultural soils. In addition, the project will have the additional expertise on soil GHG emissions through links with Bangor University (Profs. David Chadwick and Roland Bol). In the UK, CropGas will use soils from the large-scale rotation experiment (LSRE) at Rothamsted Research (RR). The successful student will examine, at laboratory scale, how changes in soil C and N pools affect GHG emissions from British soils under CA, using the unique DENitrification incubation system (DENIS) at RR.

Desired technical skills and/or experience:

- Master or comparable degree in a relevant scientific field such as soil science, soil biology, environmental or agricultural sciences or closely related subjects
- Experience with soil physical, biological and/or chemical methods
- Expertise and interest in plant-soil interactions
- Agronomic expertise
- Experience with laboratory experiments and field work
- Strong academic capacity and analytical skills
- Proficiency in written and oral English
- UK Driving licence or equivalent

Additional skills:

- have an inquisitive nature and desire to work with complex environmental questions
- have enthusiasm for research, be motivated to learn new things and show ability to work independently while being an active member of a research team
- be capable to work structured, accurate and independent
- have good interpersonal and communication skills

Host institution and location: Rothamsted Research, North Wyke, Devon EX20 2SB, UK

Preferred duration of research visit: 6 months

Preferred dates for research visit: To be confirmed with supervisor

16. Mountain grassland soil organic carbon sequestration

***Keywords**: grassland, mountain, fertilization, productivity, soil C sequestration*

Brief project outline:

Due to the large soil organic carbon (SOC) stock of the grasslands that contributes substantially to the terrestrial greenhouse gas sink, pastures and meadows are in the focus of scientific attention. However, grasslands also supply ecosystem services like feedstock production and erosion control, that are both tightly connected to SOC stocks and their turnover processes.

Despite their importance, the mechanisms that connect ecosystem nitrogen availability, plant productivity above and below ground, and the soil C budget are only poorly understood. Most research focusses on the SOC budget of cropland monocultures. These are difficult to interpret as plowing frequently disturbs biological processes. They are also unsuitable for generalization because the productivity response (primary source of SOC) of genetically homogenous crops is not representative for the diverse plant community found in grasslands.

In a grassland fertilization experiment in the Swiss Jura mountains, we investigate an ecosystem that has received the same treatment for over 40 years. Thus, this system is in a steady state, where the only discontinuous factor is the differences in the annual weather.

In an ongoing study, the candidate is invited to work on the question of whether increased N fertilization favours SOC sequestration via increased plant productivity (higher C input from organic material) or reduces SOC sequestration via increased decomposition through less N-limited microbiota. Research skills to be acquired include net ecosystem CO_2 exchange (NEE) measurements and establishing an NEE balance. Also soil C content analysis and soil density fractionation will be applied.

Desired technical skills and/or experience:

- Background in soil organic C cycling
- Able to work long hours at the field site during measurement campaigns
- Some experience with measurement instrumentation handling
- Tidy working in the soil lab
- Data management and evaluation skills, basic statistics

Host institution and location: Climate and Agriculture Group, Agroscope, Reckenholzstrasse 191, CH 8046 Zurich, Switzerland.

Agroscope is the Swiss Federal Research Institute for Agriculture.

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 – October 2023

17. Integrating cost-effective mitigation strategies to increase soil carbon storage in rainfed woody crops under semiarid conditions

Keywords: *rainfed almond orchards; cover crops management; soil carbon sequestration; semiarid conditions; food security*

Brief project outline:

Agriculture contributes about 25% of global greenhouse gases emissions into the atmosphere, which exacerbates climate change. Since soils account for the majority of agricultural emissions, the adoption of climate-smart agricultural practices like reducing tillage, compost application, growing cover crops, and crop residue retention, can be a powerful mitigation strategy by capturing carbon and decreasing greenhouse gas emissions. Moreover, increasing soil organic carbon can yield powerful synergies, such as enhanced fertility, water infiltration and productivity. However, to date, no single strategy has been identified as consistently cost-effective in mitigating climate change in semiarid Mediterranean agroecosystems.

IFAPA-Camino de Purchil is currently involved in different regional and national projects focused on assessing the climate change mitigation potential and other environmental benefits of regenerative agriculture (*i.e*., reduced tillage, growing cover crops, crop residue retention) under semiarid conditions. The student will conduct measurements of soil carbon storage, functional carbon pools, organic carbon mineralization rates, crop residue decomposition rates, and crop yields, in rainfed woody crops under different cover crop management strategies. The outcomes of the project will help to update emission estimation knowledge and to identify the most cost-effective cover crop management strategies under semiarid Mediterranean conditions.

This proposal includes both laboratory and field work as well as training on different methodologies to estimate soil CO2 emissions, carbon sequestration rates and carbon balance assessments from the agricultural sector. The stay will enable the candidate to interact with most relevant research groups working in greenhouse gas emissions mitigation strategies and soil carbon storage in agricultural systems in Spain.

Desired technical skills and/or experience:

- Hands on experience with field and laboratory work, particularly with soils
- Data management and analyses, and good team player
- Basic Spanish skills and driving license are desirable but not essential

Host institution and location: Institute of Agricultural Research and Training, Fishing, Food and Organic Farming of Andalusia (IFAPA Camino de Purchil)

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2023 – July 2023 (Flexible)

18. Sustainable removal of sugarcane harvest residues: impact on yield, soil carbon, and greenhouse gas emissions

Keywords: *nitrous oxide, carbon dioxide, methane, root biomass, carbon balance*

Brief project outline:

Sugarcane is one of the crops with the greatest capacity to produce biomass and renewable energy in the world. After harvesting the stems, up to 30 t ha^{-1} of dry matter from harvest residue remains in the soil, which has become the subject of research due to its potential to produce bioelectricity directly in the mills. However, the impacts of removing this material on soil organic carbon conservation (i.e., soil fertility), consequent greenhouse gas (GHG) emissions, and yield, determined jointly, are still unknown.

The student will conduct an experiment that aims to evaluate the effects of different rates of sugarcane residue removal on soil carbon, GHG emissions, and yield. This project will also generate novel knowledge related to how different amounts of sugarcane residues impact on the root biomass, the soil C: N relationship, and their impact on GHG emissions. The final goal of the project will be to determine the main criteria for recommending the sustainable removal of sugarcane residues. The outcome of the project will be a research publication.

The National Institute of Agricultural Technology (INTA) has an ongoing project to develop strategies to mitigate GHG emissions from crop systems. INTA welcomes a CLIFF GRADS PhD student competent in agricultural sciences and environment management to apply for this research stay in the eco-physiology group of the EEA Salta, Argentina. The project proposed here will contribute to the Integrative and Croplands Research Groups of the GRA.

Desired technical skills and/or experience:

- Good skills in field and laboratory experiments
- Familiarity with GHG measurements (static chamber method) and statistical approaches
- Effective teamwork and interpersonal skills
- Independent and reflective thinking
- Skills in writing science
- Basic Spanish skills are desirable but not essential.

Host institution and location: Salta Experimental Station, National Institute of Agricultural Technology (EEA Salta INTA). Cerrillos, Salta, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: January - June 2023.

19. Crop-pasture rotations systems as a mitigation alternative for GHG emissions in agricultural systems.

Key words: *long-term experiment, nitrous oxide, wheat, soybean, sorghum*

Brief project outline: For many years, crop-pasture rotation has been a very widely adopted agronomic practice in the agricultural systems in Uruguay. However, there are some areas of the country where agriculture systems are based on continuous cropping and have occupied many hectares for profit reasons. Long-term experiments that include rotational and continuous cropping treatments have allowed researchers to quantify effects on soil carbon stocks and nutrient dynamics. Further, a few years ago, N_2O emissions had been measured but not yet analysed in the context of the ELP. Therefore, the aim of this research activity is to compile and analyse information already generated and keep sampling GHG to improve the existing database.

Desired technical skills and/or experience:

- Good written skills
- Familiarity with GHG measurements and statistical approaches
- Effective teamwork
- Basic Spanish skills are desirable but not essential.

Host institution and location: Instituto Nacional de Investigación Agropecuaria, INIA La Estanzuela, Colonia, Uruguay.

Preferred duration of research visit: 6 months.

Preferred dates for research visit: February 2023 - August 2023

LIVESTOCK – ENTERIC METHANE

20. Effects of supplementation with wheat bran on methane production and nitrogen use efficiency of dairy cows fed grass diets.

Keywords: *wheat bran, grazing, pasture, methane emission, nitrogen excretion, dairy cow*

Brief project outline:

Chilean dairy cattle production in the South of the country is based on grazing. Pastoral systems are low cost, however, in Spring and Autumn pasture nitrogen content often exceeds animal requirements and excess nitrogen is excreted, causing metabolic energy waste, ground water pollution as ammonium, and emissions of nitrous oxide. Also, metabolizable energy supply from pasture limits milk production, and pasture fibre content can increase enteric methane emissions. Research is ongoing to identify feeding practices that increase energy and nitrogen use efficiency and contribute to mitigate greenhouse gas intensity in pastoral systems. Wheat bran is the most widely used by-product of local origin in pelleted concentrates for dairy cows in southern Chile and, when used as a supplement of pasture diets, it can contribute to alleviate energy shortages. Yet, there is a lack of knowledge related to the effects of wheat supplementation on methane gas emissions and nitrogen excretion of grazing dairy cows.

The CLIFF-GRADS student will conduct an experiment that aims to evaluate pasture supplementation with wheat bran vs. a pasture only diet on nitrogen use efficiency, methane emissions and milk production of dairy cows. Experimental methods will include the use of metabolism stalls with individual intake measured and total collection of faeces and urine to determine nitrogen and energy partitioning; the SF_6 technique for measuring methane emissions, stomach tubing; for rumen fermentation characteristics, among other measurements. Thus, this proposal includes both laboratory and field work.

This experiment is part of the Coordinated Research Project D3.10.31 funded by the Joint FAO/IAEA Programme entitled “Nuclear and related techniques to measure the impact of type of feeding and production system on greenhouse (GHG) emissions and livestock productivity”.

Desired technical skills and/or experience:

- Hands on experience with dairy cows
- Independent thinking and ability to resolve problems
- Being organized, meticulous and hardworking
- Effective teamwork and interpersonal skills
- Spanish-speaking ability is desirable but not essential

Host institution and location: Instituto de Investigaciones Agropecuarias, INIA Remehue, Osorno, Chile.

Preferred duration of research visit: 6 months

Preferred dates for research visit: July 2024 - December 2024.

21. Evaluation of promising agro-industrial by-products to increase dairy production and reduce Enteric Methane Emission of cattle in the Peruvian Amazon Region

Keywords: *circularity, enteric methane, mitigation, by-products*

Brief project outline:

Agro-industrial by-products are secondary products obtained during the harvest or processing of a principal commodity. The inclusion of by-products in ruminants feeding programs can bring potential improvement of *nutrient circularity, carbon footprint, and economic results* of both feed/food production systems by integrating diverse production systems at different space and time dimensions. The use of by-products in ruminant diets is becoming more prevalent, due to a simultaneous increase in their availability and as a strategy to reduce dependence on cereals and oilseeds-based feeds reducing costs of production compared to traditional feedstuffs. Despite the large use of by-products for animal feed around the world, some of them still need to be better studied in the Peruvian Amazon region because it was observed that their nutritional value including potential impact on enteric methane emission can vary substantially across seasons or due to factors such as poor control of processing techniques, fluctuating supply, limited access to suppliers, and poor marketing channels.

We welcome a PhD student to take part in a research project to work in collaboration to our team developing and implementing circular economy strategies through the use of agro-industrial by-products for sustainable animal feeding. Tasks will include the determination of chemical composition of by-products and in vitro measurements to determine digestibility and impact on methane emission as well as the identification of strategies to introduce them in prevalent production systems. This research will improve local understanding about the potential of by-products for increasing dairy production and reduce enteric methane emission in the Peruvian Amazon Region. This project is part of a larger programme (ERA-NET Co-fund) funded by AgResearch Limited, which includes international partners that contribute towards evaluating strategies for enhancing circularity between crop and livestock farming systems. The PhD student will be part of the Research group Livestock and climate change at the National Agrarian University La Molina. Opportunity will also be scheduled for the student to visit field research related to cattle nutrition and the integration of crop-ruminant livestock systems in the tropical region of Peru.

Desired technical skills and/or experience:

- Intermediate understanding of methodologies to determine feed chemical composition and in-vitro methodologies for determining digestibility and methane emission
- Basic Spanish skills are desirable but not essential

Host institution and location: Universidad Nacional Agraria La Molina, Lima (60 %) and San Martín in the Amazon region (40 %)

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - June 2023

22. Testing feed additives to reduce enteric methane emissions

Keywords: *livestock, feed additives, rumen, in vivo, in vitro*

Brief project outline:

There is an increasing need to significantly reduce global methane emissions, with enteric methane from livestock being one of the key targets. The use of feed additives has shown great potential as a strategy to reduce methane emissions from ruminant animals. However, despite extensive research over the past few decades, the suite of emerging feed additives to suppress enteric methane is limited and many constraints to their widespread usage have been identified. The research stay will be developed under the umbrella of the GRA Flagship project 'Technical guidelines to develop feed additives to reduce enteric methane', which is coordinated by the hosting group together with Wageningen University as part of the Feed and Nutrition Network of the LRG within the GRA. The overall aim of this Flagship project is to facilitate the development and use of feed additives to reduce enteric CH_4 emissions in the livestock sectors. The CLIFF-GRADS fellow will be involved in the development of the technical guidelines and protocols on good practices to test and develop feed additives of different nature (chemically synthesized, macro and micro algae, essential oils, saponins, tannins, antimicrobial peptides, probiotics…). The work to develop the technical guidelines will describe good practices to conduct trials in vitro and in vivo to target 3 main elements:

i. Efficacy and delivery options across different livestock production systems, especially in relation to the dietary management,
ii. unveiling the mode of action of the active molecules and
iii. adequate assessment of the persistency of the effects

This proposal includes both laboratory and computering work. The research fellow will participate in bibliography review and data processing and in experimental work using in vitro and in vivo approaches at CSIC. The lab and fieldwork will be part of the Horizon-Europe 'Re-Livestock: 'Facilitating innovations for Resilient Livestock farming systems' (2022-2027) project, coordinated by the hosting supervisor.

The selected candidate will benefit from i) participating in a globally active network of research groups and company actively investigating and evaluating feed additives, ii) reaching out to regional and global organisations pursuing use / implementation of feed additives, iii) interacting with other GRA research networks (i.e., Rumen Microbial Genomics and Manure Management, iv) Improved research skills in different disciplines such as rumen function and biochemistry

Desired technical skills and/or experience:

- Knowledge on ruminants nutrition
- Hands on experience with animals
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Basic Spanish skills are desirable but not essential

Host institute and location: Estacion Experimetal del Zaidin (CSIC, Spanish Research Council), Granada, Spain (www.eez.csic.es)

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - June 2023

23. Exploring the role of methylotrophic methanogenesis in the rumen

Keywords: *livestock, microbes, methane*

Brief project outline

Enteric methane is the largest contributor to the environmental hoofprint from ruminants. In the rumen, methane is produced by methanogenic archaea that primarily use the hydrogenotrophic pathway that reduces CO_2 to CH_4 using H_2 as an electron donor. Methanogens that use the methylotrophic pathway to produce CH_4 represent ~20% of known methanogens but it has been suggested that they play a more important role in methane production than initially predicted. The diversity of these methylotrophic methanogens and their interactions with other microbes in the rumen is less known that for hydrogenotrophic methanogens. The student will work on in vitro rumen fermentation models using various conditions and substrates to favour or not the production of methane through the methylotrophic pathway. Microbial consortia will be characterized, and isolation of individual microbes will be an objective. The work has links to the GRA flagship project 'Mining rumen data to reduce methane' and as some methyl substrates are provided by the diet there are potential links with the flagship project 'Feed additives to reduce methane.' The work aligns with the H2020 HoloRuminant project and RMG network of the GRA.

Desired technical skills and/or experience:

- Hands-on experience in classical microbiology
- Creative thinking and challenge seeker
- Organized and meticulous
- Autonomous person appreciating teamwork
- Basic French skills are desirable but not essential

Host institution and location: INRAE, UMR Herbivores, Clermont-Ferrand, France

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2023 - August 2023.

24. Monitoring of enteric methane emission of extensive livestock systems of mountains environments of Argentina.

Keywords: *enteric methane emission, SF_6 tracer technique, mountain environments.*

Brief project outline:

To date, there is very little field experiments about the emissions generated in Argentina livestock systems and most of the experiments that have been developed have focused on the Pampas region, where approximately 70% of the activity is concentrated. However, extrapolating these data to the rest of the country, which is characterized by a great eco-geographical diversity, both latitudinal and altitudinal, it is highly imprecise due to the variation of the environmental conditions and the management of the productive systems. Therefore, studying GHG emissions in other regions of our country (latitude) and evaluating the effects of other variables (such as altitude), constitute a very promising research area.

In this project, we propose the use sulphur hexafluoride (SF_6) tracer technique to quantify methane emissions in livestock systems. The data obtained in this project will be useful to complete the national inventory of greenhouse gases (GHG) in livestock systems and to have local information on the potential to reduce GHG emissions by diet management.

We can provide a training of the candidate in two research lines:

1) Measurements of the enteric methane emission using the SF_6 tracer technique.

- Assembly and calibration of SF6 permeation tubes
- Assembly and calibration of sampler collection systems
- Assembly and calibration of flow restrictors
- Calibration and measurement of CH4 and SF6 in air samples by gas chromatography.

2) In vivo assays.

- Evaluation of productive performance
- Evaluation of enteric methane production using different diets
- Evaluation of ruminal samples: perform molecular techniques for the study of the dynamics of the ruminal microbiota and techniques to determine the fermentative parameters.

The PhD Students will participate in several essays that will take place in the north regions of Argentina.

Desired technical skills and/or experience:

- Familiarity with animal handling procedures
- Familiarity with general laboratory techniques
- Independent and reflective thinking
- Basic Spanish skills are desirable but not essential.

Host institute and location: National Technological University, Buenos Aires Regional Faculty (UTN), Bs As, Argentina.

National Institute of Agricultural Technology (INTA), Hurlingham, Bs As, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: June 2023 - December 2023.

25. Regional databases to evaluate goodness of fit of GHG prediction models

***Keywords**: livestock, modelling*

Brief project outline:

The use of by-products has been proposed as an alternative to increase C circularity of agricultural systems, avoid dependence of synthetic supplements, and in some cases reduce enteric methane emission intensities of the integrated crop-livestock system. Many prediction models have been developed to estimate potential impacts of changes in ruminant feeding strategies on GHG emissions from livestock. However, due to the large variability on characteristics of agricultural systems, there is a need to challenge these models to predict emissions from different agro-climatic regions. In order to scale the GHG mitigation potential up to a broader scale, the predicting ability and accuracy of models need to be assessed.

The aim of this study will be to use internal data of experimental trials using by-products fed to cattle from different agroclimatic regions to validate the performance of GHG prediction models from livestock production, especially pastoral ones. Those systems are included in the case study of the ERA-NET circularity project "INTEGRITY" (2022-2024).

The student will work with data (France, Argentina) of methane emissions from cattle, analyse the potential CH_4 mitigation effect alternative management options.

The student will gain skills of modelling, data analysis and publication.

Desired technical skills and/or experience:

- Knowledge of animal science, ruminant nutrition, livestock production systems
- Effective teamwork and interpersonal skills
- Good communication in English
- Basic French desirable but not exclusive

Host institution and location: INRAe, UMRH, Theix, France.

Preferred duration of research visit: To be discussed with supervisor

Preferred dates for research visit: In 2023

26. Evaluating strategies for ruminant methane abatement of Argentina livestock systems.

Keywords: *livestock, CH_4, mitigation, SF_6*

Brief project outline:

Animal production represents a significant source of greenhouse gases (GHG) through methane (CH_4) emission, mainly due to ruminant enteric fermentation. There are a large number of available technologies that could be applied to reduce CH_4 emissions in livestock systems. Mitigation strategies may differ due to their feasibility, cost and possibility of application by end users. Some of them can be applied in intensive production systems, but not in pastorally based systems. In this project, we propose the use Sulfur hexafluoride (SF_6) technology for quantification of CH_4 emissions. The data obtained in this project will be useful to build up an accurate national inventory of livestock systems to have local information on the potential for reducing GHG emissions by diet management.

We will provide training to the CLIFF-GRADS student in:

1) Measurement of enteric methane emission (using the SF6 tracer technique).

- Assembly and calibration of permeation tubes.
- Assembly and calibration of sample collection tubes and flow restrictors.
- Evaluation of the productive performance.
- Animal management procedures to enteric CH_4 emission measurement.
- Measurement of respiratory air sampling (5 consecutive days).
- Gas chromatography for CH_4 and SF_6 analysis.

2) In vitro: Evaluation of innovative strategies for methane reduction in ruminants, using in vitro gas production and dual –flow continuous culture system

The PhD Students will participate in several trials that will take place in different regions of Argentina.

Desired technical skills and/or experience:

- Ability to work independently and in team
- Hands on experience with animals
- Familiarity with general laboratory techniques
- Independent and reflective thinking.

Host institute and location: National Institute of Agricultural Technology (INTA), Hurlingham, Bs As, Argentina.

EEA Balcarce INTA. National Technological University, Buenos Aires Regional Faculty (UTN), Bs As, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: May 2023 - October 2024

27. Dairy manure application to pecan production in circular integrated crop and livestock systems as a strategy to mitigate greenhouse gases emissions and enhance carbon sequestration

Keywords: *pecan, dairy manure, CICALS, GHG mitigation, carbon sequestration*

Brief project outline:

Greenhouse gases (GHGs) in the atmosphere attained high levels (418 ppm, 1896 ppb and 335 ppb for carbon dioxide, CO_2; methane, CH_4; and nitrous oxide, N_2O respectively), posing a threat to atmospheric physico-chemistry. Agriculture emits the three mentioned GHGs, but N_2O sourced by soil, fertilizers and manure, and CH_4 sourced by soil and enteric fermentation are of the utmost concern as a result of farming and dairy, respectively. This has highlighted the importance of circular integrated crop and livestock systems (CICALS) as a way to mitigate GHG emissions and sequester carbon. In Argentina, 37 % of emitted GHG are sourced by agriculture and livestock, with manure management having 15.4 % share out of that total, linked mainly to dairy farms. A way to leverage that dairy manure is using it as fertilizer, turning the system into a CICALS. Dry fruit trees where management is intensive such as pecans (*Carya illinoensis*) may contribute to close the N loop and also sequester C. Previous studies have demonstrated that pecans respond to manure addition through a nut yield increase. Besides, C sequestered by pecans may attain 7.9 to 10 Mg C ha^{-1} yr^{-1}.

To date, we have found no studies on pecan related to dairy manure application effect on GHG emissions and carbon sequestration. Therefore, this project focuses on determining GHG emissions and carbon sequestration after dairy manure application to pecans, as indicators of system circularity in a CICALS. The student will conduct a field experiment aiming to evaluate GHG emissions and carbon sequestration as affected by dairy manure application to pecan. Our results will provide new knowledge about the CICALS as GHG mitigation strategy.

This proposal includes both laboratory and field work.

Desired technical skills and/or experience:

- Hands on experience with research field work
- Critic thinking and ability to resolve problems
- Organized and meticulous
- Basic Spanish skills are desirable but not essential

Host institution and location: Instituto Nacional de Tecnología Agropecuaria, INTA Balcarce, Balcarce, Buenos Aires, Argentina.

Preferred duration of research visit: 6 months.

Preferred dates for research visit: September 2023 - February 2024.

28. Enteric methane emissions, nitrogen excretion and animal performance when including local by-products in beef steers grazing alfalfa

Keywords: *livestock, rumen, fermentation, CH_4, NH_3*

Brief project outline:

An improved integration of mixed crop-livestock production systems, by increasing nutrients circularity and reducing GHG emissions will result in more sustainable beef production. Effects on C footprint when including traditional by-products (e.g. corn distillers grains, soybean meal, etc.) have been widely studied. The use of less known local by-products in ruminant feeding programs deserves more attention regarding productive and environmental implications. Some available by-products contain secondary compounds (e.g. peanut skin, tannins), with potential to modify rumen microbial fermentation reducing methane production, ammonia accumulation and urinary N excretion. This is relevant for grazing systems based on high quality legumes as alfalfa, with a high ruminal degradation of its protein, determining a low N use efficiency and a high urinary excretion of ingested N.

This project aims to evaluate an appropriate local by-product, yet to be selected, that can reduce methane emissions and urinary N excretion when included as a supplement to grazing steers. The student will conduct an experiment that will evaluate the effects of the addition of a by-product on diet intake and digestibility, methane emissions (SF_6 tracer technique), body weight gain, feed conversion ratio, rumen fermentation parameters, nitrogen balance and excretion, in growing steers grazing alfalfa. Persistency of effects will be determined. This project will provide new knowledge on both, the immediate and long terms effects on methane production and N excretion when including a less known and local available by-product as a supplement to grazing steers.

This proposal includes both field and laboratory work.

https://www.eragas.eu/en/eragas/Research-projects/INTEGRITY.htm.

Desired technical skills and/or experience:

- Hands on experience with animals, particularly steers
- Experience with laboratory work
- Effective teamwork and interpersonal skills
- Organized and meticulous
- Independent thinking and ability to resolve problems
- Basic Spanish skills are desirable but not essential

Host institution and location: Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Manfredi, Manfredi, Córdoba, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: October 2023 - March 2024.

LIVESTOCK – LIVESTOCK SYSTEMS

29. Assessing biogas performance, socio-economic and environmental impacts of farm-scale biogas plants digesting manure in Ethiopia and Kenya

Keywords: *household biogas programme, methane, climate mitigation, manure*

Brief project outline:

Household biogas programme (HBP) has been under implementation in many countries including Ethiopia and Kenya to improve the living standards of farmers and their families by utilizing livestock manure for renewable energy and biofertilizer production. Considerable funds and social capital have been invested in HBP in these countries, but biogas technology adoption remains low. This raises fundamental questions on the opportunities and challenges of the current biogas programme in these countries.

The objective of the project is to assess the biogas performance, socio-economic and environmental impacts of the biogas programme and provide feedback for wider uptake. The student will conduct biogas user surveys, focus group discussions, key informant interviews, desk studies and field measurements on selected farms to assess manure management and biogas performance (manure storage and use, biodigester functionality, biogas yield, nutrient yield and quality), socio-economics impacts of the technology (energy substitution, health benefits, time and labour savings, women empowerment, fertilizer substitution etc) and environmental impacts (GHG emissions reductions, reduced firewood and carbon market potential). The results will be used to synthesis decision support toolkits needed to inform policy and attract investments in biogas programme. The project is linked to the MITIGATE+ and LCSR initiatives and includes both laboratory and field work.

Desired technical skills and/or experience:

- Experience in designing and executing a rural household survey
- Experience in GHG measurement and sample analysis
- Experience in data collection, management, processing and analysis
- Ability to work independently with minimal supervision in multi-disciplinary and multi-cultural environment
- Excellent communication skills
- Experience in writing scientific articles will be an added advantage.

Host institution and location: International Livestock Research Institute (ILRI), Nairobi

Preferred duration of research visit: 6 months

Preferred dates for research visit: Flexible start date. Preferably start early 2023

30. Optimizing anaerobic digestion process for climate mitigation, enhanced energy and nutrient recovery from cattle manure

Keywords: *biogas, anaerobic digestion, climate mitigation, methane, manure*

Brief project outline:

Anaerobic digestion (AD) is a biological process where different microbial species under anaerobic conditions decompose organic materials into biogas and nutrient-rich digestate as biofertilizer. The use of biogas as a clean energy source for cooking and lighting reduces firewood consumption and avoids deforestation. It decreases indoor air pollution and saves women's and children's time for firewood collection. Moreover, AD of manure reduces GHG emissions by avoiding methane emissions from natural decomposition of manure during storage and replacing fossil fuels with biogas for energy production. Therefore, AD has great potential for sustainably recovering resources like nutrients and energy from manure, addressing several of the challenges associated with manure handling and storage on farms.

To increase the uptake of biogas technology by farmers, there is a need to optimize the biogas process for enhanced energy and nutrient recovery. The AD process is complex—it includes various physical and biochemical reactions, and therefore, requires optimization of operational parameters to maintain a stable and efficient process. The objective of the study is, therefore, to optimize the process through co-digestion and regulating operating conditions (temperature and hydrolytic retention time) under laboratory settings. The student will set up lab-scale anaerobic digestion system and test the effects of co-digestion and operating conditions (hydraulic retention time and temperature) on biogas yield and the nutrient quality of digestates. The student will also determine the GHG mitigation, energy substitution and nutrient substitution potential of the technology under the optimized conditions. The project is linked to the MITIGATE+ and LCSR initiatives.

Desired technical skills and/or experience:

- Experience working in laboratory settings and use of GHG measurement techniques
- Experience in data collection, management, processing, and analysis
- Ability to work independently with minimal supervision in multi-disciplinary and multi-cultural environment
- Excellent communication skills
- Experience in writing scientific articles will be an added advantage.

Host institution and location: International Livestock Research Institute (ILRI), Nairobi

Preferred duration of research visit: 6 months

Preferred dates for research visit: Flexible start date. Preferably start early 2023

31. Directed evolution of rumen microbial cultures towards the identification and stimulation of electron sinks alternative to methanogenesis

***Keywords**: rumen, methane, fermentation, in vitro cultures, microorganisms, biochemistry, metabolism*

Brief project outline:

The student will conduct experiments that form part of an initially 3-year project that began in 2019, and which due to the COVID-19 pandemic was extended through March 31, 2024. Inhibiting methanogenesis in rumen in vitro cultures results in a consistent decrease in the recovery of metabolic hydrogen, which is in part redirected towards unidentified sinks. It is important to identify those sinks under different conditions to understand their potential nutritive value for the ruminant host animal. The objective of this project is to identify and stimulate electron sinks alternative to methane in rumen fermentation through microbial manipulation. We propose directing the evolution of rumen microbial communities in vitro by conducting sequential transfers of batch cultures, both in the presence and absence of inhibitors of methanogenesis. In each series of transfers, we will select cultures based on their fermentation products. In this way we will learn which electron disposal pathways alternative to methanogenesis have the greatest potential to be stimulated. The knowledge generated in this proof-of-concept experiment will be useful to design strategies to stimulate electron sinks alternative to methanogenesis in rumen fermentation that can at the same time enhance ruminant productivity.

Desired technical skills and/or experience:

- An inclination to work in the laboratory
- Interpersonal relationships and ability to work as part of a team
- Organized and meticulous
- Independent thinking and ability to resolve problems
- Basic Spanish skills are desirable but not essential

Host institute and location: Instituto de Investigaciones Agropecuarias INIA Carillanca, Temuco, Chile

Preferred duration of research visit: 6 months

Preferred dates for research visit: Preferably completed by March 31, 2024, although visits between April and December 2024 may be possible if additional research funds are secured by the research supervisor.

32. Enhancing assessment of cattle GHG emissions in African agro-pastoral systems: making use of high-frequency survey data collection

Keywords: *livestock, modelling, Africa, survey development, activity data collection*

Brief project outline:

The objective of the research stay is to enhance survey-based assessments of cattle GHG emissions in African agro-pastoral systems. The candidate will use existing data, collect novel data, and develop improved methods for data collection and GHG calculation. The work is broken down into three elements:

- Develop calculations to estimate annual GHGs from cattle herds from existing survey data (including animal activity, feed and water, manure management, slaughter age, milk production etc.);
- Take part in survey data collection to get a better understanding of the systems; and develop calculations to estimate GHG emissions on a two-week time-step, using the high frequency survey data (tracking index cows from herds, heart-girth, milk production, feed and water, activity, manure management etc.);
- Evaluation of the results, validation by comparison to animal measurements, assessment of error, and improvement of methodology.

The candidate will learn how to use the open-source household survey tool RHoMIS, participate in the design and implementation of surveys, and help to develop an interface for automated GHG emissions calculations from survey data. This contributes to improved methodologies for establishing IPCC Tier 2 emissions factors for African agro-pastoral systems (linked to Mitigate+). The candidate will work in an interdisciplinary team of social, geospatial, and animal nutrition scientists. This work will support research in the Earth observation and environmental sensing for climate-smart sustainable agropastoral ecosystem transformation in East Africa (ESSA) project. Field work will be carried out in the Taita Hills area of South Eastern Kenya.

Desired technical skills and/or experience:

- Experience in GHG modelling of livestock systems using large datasets
- Knowledge on smallholder livestock production systems in developing countries
- Interest in developing replicable methods for GHG assessment
- Excellent teamwork skills
- Excellent written and spoken English.

Host institution and location: International Livestock Research Institute, ILRI, Nairobi, Kenya.

Preferred duration of research visit: 6 months

Preferred dates for research visit: Early 2023

33. Modelling beef cattle production systems in Argentinean pampas: an approach for estimating marginal abatement cost curves

Keywords: *management strategies, GHG, cost-effectiveness, mitigation potential, policy recommendations*

Brief project outline:

Beef cattle production systems contribute to global warming through the emission of nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO2). Modelling tools for beef cattle systems analysis - including detailed cost–benefit assessments are required to integrate resource management for enhancing farmers' income and mitigating greenhouse gas (GHG) emissions. The marginal abatement cost curve (MACC) approach is a framework commonly used to integrate information for potential mitigation efforts and can help in identifying the most cost-effective managerial and technological GHG mitigation options to aid policy decision making. Robust MACC development is currently lacking for beef cattle systems in Argentina to define efficient mitigation measures for the sector.

This project arises from the collaborative work of two INTA research teams: one specialized in the economic and financial evaluation of agricultural production systems and the other that focuses on the modelling of beef cattle production systems and the calculation of their GHG. The overall objective of the project is to integrate economic analysis of different mitigation strategies for beef cattle production systems and their GHG in order to estimate MACC to aid policy decision making. The candidate will work in analysing, validating and integrating the information generated through modelling to estimate MACC. This proposal will include both desk and field work. The supervision of the candidate will be carried out by researchers from different INTA offices in the Pampas Region.

Desired technical skills and/or experience:

- Experience and skills in bioeconomic models
- Experience in calculating marginal abatement cost curves will be prioritized.
- Ability to work in a remote format
- Dedicated and organized with deadlines
- Used to write scientific papers and reports
- Good English skills (verbal, writing, reading)
- Ability to work in multidisciplinary teams
- Desire to learn and develop technical and personal skills.

Host institution and location: INTA, Argentina

Preferred duration of research visit: 6 months

Preferred dates for research visit: July 2023 – December 2023

34. Impacts of the inclusion of bioactive compounds into the diet of cattle on the emission of GHGs from depositions

Keywords: *N_2O, NH_3, bioactive compounds, emissions model*

Brief project outline:

Animal production systems convert feed protein into animal protein with an efficiency of 5 to 45% and the N in the remaining fraction (55-95%) leads to N losses via faeces and urine. In ruminants fed fresh, high-quality forages, most feed proteins solubilize rapidly and release loads of N in the rumen, resulting in large losses as NH_3, which ends up in the urine as urea. This can be diminished by slowing protein degradation, allowing some of it to reach the intestine, preventing microbial degradation. An increase in urinary N excretions generates greater losses due to volatilization and leaching, increasing GHG emissions such as N_2O.

The inclusion of secondary bioactive compounds, such as tannins or saponins in the diet, either through supplements or forages with a high content of these, such as *Lotus corniculatus* or *Onobrychis viciifolia* (Sainfoin), can reduce the degradation of proteins in the rumen and direct the N excreted into the faeces and thus decrease its concentration in urine.

The main aim of this project is to evaluate the effect of secondary bioactive compounds (i.e. tannins and saponins) on the emissions of N_2O and NH_3 from cattle depositions.

In order to achieve this, fresh faeces and urine will be collected from heifers fed green oats together with an additive based on tannins and saponins; and another group fed sainfoin (*Onobrychis viciifolia*) or alfalfa (*Medicago sativa*) hay together with the additive containing secondary compounds. Both groups will be contrasted with animals where the additive is not used (control group). The collected excreta will be placed in static chambers for the measurement of N_2O and semi-open chambers for NH_3. The excreta will remain in the chambers for four weeks in order to carry out the corresponding measurements. The gases will be extracted by a syringe and transferred to glass vials to be analysed with a gas chromatograph. Thus, data on the emissions of N_2O and the total volatilization of NH_3 in those periods under the different treatments will be obtained in order to run emission models.

Desired technical skills and/or experience:

- Experience working with livestock
- Independence thinking and ability to resolve problems
- Organized, responsible, effective teamwork and interpersonal skills.

Host institution and location: Instituto Nacional de Tecnología Agropecuaria, INTA. EEA Cesáreo Naredo. Partido de Guaminí, provincia de Buenos Aires, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: June 2023 - November 2023

35. Economics of GHG mitigation at farm level of cattle production systems in Portugal

***Keywords**: livestock, mitigation strategies, farm-level, abatement costs*

Brief project outline:

This project contributes to the GRA flagship project "Economics of GHG mitigation at farm level in global cattle production systems". The aim of the project is to identify the most cost-effective options for farm-level GHG mitigation strategies in different global production systems and provide evidence-based policy recommendations.

A detailed economic understanding of agricultural GHG mitigation strategies remains a challenge in global climate research. The costs of implementation and realization of GHG mitigation strategies at the farm level are not yet well-known. Furthermore, the data needed to conduct vital economic assessments is often not available or not comparable. Countries urgently need cost data to make informed decisions on which climate mitigation measures to support and fund in order to best implement their nationally determined contributions (NDCs).

This project aims to fill the cost data gap for cattle production. It will investigate the feasibility and cost-effectiveness of GHG mitigation strategies at the farm level. It aims to identify the most cost-effective management and technology options in different beef and dairy cattle production systems and regions, their co-benefits and possible adoption barriers to provide evidence-based policy recommendations on GHG mitigation strategies.

Desired technical skills and/or experience:

- Expertise in GHG emission measurement at the farm level in cattle production systems
- Basic knowledge of economic analysis at the farm level in cattle production systems would be desirable but not essential
- Basic knowledge of Excel
- Writing science publications
- Good English writing and speaking skills

Host institution and location: Algarve University, Campus de Gambelas, 8005-139 Faro, Portugal

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 – June 2023

36. Economics of GHG mitigation at farm level of cattle production systems

***Keywords**: livestock, mitigation strategies, farm-level, abatement costs*

Brief project outline:

This project contributes to the GRA flagship project "Economics of GHG mitigation at farm level in global cattle production systems" . The aim of the project is to identify the most cost-effective options for farm-level GHG mitigation strategies in different global production systems and provide evidence-based policy recommendations.

A detailed economic understanding of agricultural GHG mitigation strategies remains a challenge in global climate research. The costs of implementation and realization of GHG mitigation strategies at the farm level are not yet well-known. Furthermore, the data needed to conduct vital economic assessments is often not available or not comparable. Countries urgently need cost data to make informed decisions on which climate mitigation measures to support and fund to best implement their nationally determined contributions (NDCs).

This project aims to fill the cost data gap for cattle production. It will investigate the feasibility and cost-effectiveness of GHG mitigation strategies at the farm level. It aims to identify the most cost-effective management and technology options in different beef and dairy cattle production systems and regions, their co-benefits and possible adoption barriers to provide evidence-based policy recommendations on GHG mitigation strategies.

The CLIFF-GRADS student would work together with us and one of our research partners in the following countries: Argentina, Bangladesh, Ghana, Peru, or South Africa. Depending on the interest of the student and data availability, data collection and analysis from another country may be possible.

Desired technical skills and/or experience:

- Expertise in GHG emission measurement at the farm level in cattle production systems
- Basic knowledge of economic analysis at the farm level in cattle production systems would be desirable but not essential
- Basic knowledge of Excel
- Writing science publications
- Good English writing and speaking skills

Host institution and location: Thünen Institute, Brunswick, Germany

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 - August 2023

37. Measuring greenhouse gas fluxes in a pasture-based livestock system of Argentina

***Keywords**: cow-calf, methane, carbon dioxide, organic matter*

Brief project outline:

Pasture-based livestock systems offer a sizable opportunity to counterbalance the emission of greenhouse gases (GHG) associated with animal production through the simultaneous capture of carbon dioxide by grazed swards. In Argentina, cow-calf operation systems are strictly pasture-based; however, it is not clear whether the GHG balance of these systems is positive or negative, and thus which is the real footprint of the cattle livestock system more widespread in our country.

To shed light into this topic, a field experiment was recently launched, which involves the measurement of GHG fluxes in a cow-calf operation system typical of Argentina through the eddy covariance technique. This research is currently part of Argentina's Instituto Nacional de Tecnología Agropecuaria Projects "GHG emissions in agro-livestock and forestry. Mitigation actions" and "Management strategies increasing soil carbon sequestration for Climatic Change mitigation".

The student will aid in the conduction of this on-going research, helping with site maintenance and system function checking, and will also participate in the analysis of the GHG fluxes information already obtained. This proposal thus includes both lab and field work.

Desired technical skills and/or experience:

- Willingness to work with BIG data files
- Fluent English skills are essential
- Basic Spanish skills are desirable but not essential
- Skills in data visualization, presentation, and writing science reports
- Organized and meticulous
- Effective teamwork and interpersonal skills

Host institution and location: Instituto Nacional de Tecnología Agropecuaria (INTA), Estación Experimental Balcarce, Balcarce, Argentina

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 - September 2023

38. Exploring relationships between hydrogen consumers in the rumen

Keywords: *microbes, methane, culturing*

Brief project outline:

This project will be conducted within UMR Herbivores research unit at INRAE France .

Methane emissions from ruminants contribute to global warming and result in energy loss. Methane is produced in the rumen by methanogenic archaea that use hydrogen to reduce carbon dioxide to methane. However, other rumen microbes such as acetogens, Succinivibrionacaea or Eubacterium could also use hydrogen to produce volatile fatty acids and thus provide the animal host with extra energy.

Hydrogen plays a pivotal role in rumen fermentation dynamics and has been suggested to control the production of volatile fatty acids thermodynamically. With this research proposal, we aim to isolate hydrogen consumers from the rumen ecosystem. We will apply a classical anaerobic isolation approach using selective liquid media. Isolated strains will be further characterized using molecular biology tools, whole genome sequencing and transcriptomics. In parallel, the candidate could use rumen strains of hydrogen producers and hydrogen consumers, available in our lab, to create mini-consortia. This work will give insight into microbial symbiotic and competitive relationships driving the functioning of the rumen ecosystem.

Desired technical skills and/or experience:

- Hands-on experience in classical microbiology
- Creative thinking and challenge seeker
- Organized and meticulous
- Autonomous person appreciating teamwork
- Basic French skills are desirable but not essential

Host institution and location: INRAE, UMR Herbivores, Clermont-Ferrand, France

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2023 - August 2023.

39. Microorganisms in methane prediction models: Case study of lipid supplementation

Keywords: *methane, modelling, microbiote, lipid*

Brief project outline:

The dose effect of lipid supplementation with rapeseed oil on methane emissions, rumen fermentation parameters and microbial ecosystem was tested on 4 groups of lactating dairy cows, in a Latin square experiment set-up for 4 months. Located at the INRAE site in Theix, near Clermont-Ferrand, the 6-month trainee will be involved in the statistical analysis of the data with the following objectives 1) highlight changes in the taxonomic structure of the microbiota as a function of diet; 2) highlight changes in microbial activity (differential expression) as a function of diet and finally 3) to link the changes in 1) the structure and 2) activity of the microbial community to the detected changes in CH_4 production. The student will be in charge of statistical analysis of microbial data (R), animal performance (CH_4, rumen parameters) and develop prediction models including microbiota data. The student will participate in the dissemination of the results through meetings, report and/or publication.

Desired technical skills and/or experience:

- Master's in animal nutrition
- Mathematics /statistics
- R software

Host institution and location: INRAE, UMR Herbivores, Clermont-Ferrand, France

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 - June 2023.

40. Circularity and sustainability evaluation of integrated crop-ruminant livestock systems through farm modelling

Keywords: *life cycle assessment, nutrient cycling, carbon, greenhouse gas mitigation and adaptation, circularity.*

Brief project outline:

Mixed crop-livestock production systems are based on mutually beneficial interactions between crop and livestock production components and offer considerable scope for improvement in sustainability and circularity performance (e.g., nutrient recycling and efficient use of land and resources). Quantitative information about the sustainability and circularity of existing livestock production systems is essential and information (often fragmented and/or disaggregated) is critical to develop sustainability indicators and identify best practices and technologies that reduce environmental impact and improve profit.

INTEGRITY is a collaborative project that comprises research institutions from nine countries across three continents (INTEGRITY (eragas.eu)). The overall objective is to increase nutrient circularity and promote sustainability through improving the integration of crop-ruminant livestock production systems in diverse agro-climatic regions in the context of climate change. In addition to data collection, activities include the assessment of carbon circularity, and climate change mitigation and adaptation across different production systems using a variety of modelling tools. Model outcomes will aid in the decision-making process of farmers and stakeholders along the production chain of different mixed production systems.

The candidate will work in the identification and evaluation of relevant circularity and sustainability indicators and practices that enhance nutrient and resource recycling, including a greater use of crop-livestock byproducts. The work will focus on the quantification of circularity improvements and climate change mitigation adaptation (LCA modelling) and adoption (agent-based modelling) strategies through an integrated systems approach. The candidate supervision will be carried out between AgResearch (New Zealand) and INTA (Argentina).

Desired technical skills and/or experience:

- Experience with life cycle assessment, carbon balance and multi-agent modelling (important, but not fully essential)
- Ability to work in a remote format
- Dedicated and organized with deadlines
- Used to writing scientific papers and reports
- Good English abilities (verbal, writing, reading)
- Ability to work in multidisciplinary teams and interact with people from diverse nationalities.
- Desire to learn and develop technical and personal skills.

Host institution and location: AgResearch, Grassland Research Centre, Palmerston North, New Zealand

Preferred duration of research visit: 6 months

Preferred dates for research visit: To be discussed with supervisor

41. Measuring housing-based emissions under natural ventilation using the tracer ratio method when cows are part-time grazing

Keywords: *livestock, CH_4, NH_3, dairy, tracer ratio method*

Brief project outline:

Dairy farming contributes significantly to global greenhouse gas (GHG) and ammonia (NH_3) emissions. In Switzerland, more than 90% of the dairy cows have access to pasture. Grazing offers advantages for animal welfare but also may reduce NH_3 emissions since the urine can quickly seep into the pasture and is exposed to the ambient air for only a short time. However, soiled areas in the housings continue to emit while the cows are on pasture. The database on NH_3 emissions from housing combined with grazing is very limited and to date, there are no emission data for methane (CH_4) or other GHGs from housings under grazing.

Aim of this study is the quantification of NH_3 and GHG (e.g. CH_4) emissions from naturally ventilated dairy housing combined with grazing, thereby varying typical grazing durations. Comparative emission measurements will be carried out in the naturally ventilated experimental dairy housing in Tänikon, Switzerland, with two separated compartments. Housing-based emissions of NH_3, CH_4 and carbon dioxide will be quantified using the proven tracer ratio method. Beside emission values, accompanying parameters like feed intake, climate and animal-related data, area's soiling etc. will be documented, which describe each measuring situation and depict their effect on emissions.

The PhD student will be involved in the emission measurements (installation, maintenance) and investigation of accompanying parameters. This proposal includes practical experience in conducting emission measurements as well as data and sample collection and processing (laboratory, office).

Desired technical skills and/or experience:

- Practical experience in the handling of dairy cows
- Ability to work and communicate in a team
- Good English language skills

Host institution and location:

Agroscope, Taenikon 1, CH - 8356 Ettenhausen, Switzerland

Preferred duration of research visit: 4 months.

Preferred dates for research visit: June 2023 - September 2023

42. In vitro assessment of ideal level of inclusion of by-products in beef cattle diets for decreasing methane emissions and enhance ruminal N metabolism

Keywords: *livestock, rumen, fermentation,* CH_4, NH_3

Brief project outline:

Beef production can be more sustainable through an improved integration of crop-livestock production systems by increasing nutrients circularity and reducing GHG emissions. Traditional by-products (e.g. corn distillers grains, soybean meal, etc.) have been widely studied. The use of less known local by-products in ruminant feeding programs may potentially improve C footprint. Some available by-products contain secondary compounds (e.g. peanut skin, tannins) which may modify rumen microbial fermentation reducing methane production and ammonia accumulation. This is particular important for grazing systems based on high quality legumes as alfalfa, with a high ruminal rate and extent of protein degradation.

This project aims to evaluate appropriated / suitable local by-products that can be included in livestock feeding programs using an *in vitro* batch culture technique. The student will conduct an experiment to evaluate the digestibility, fermentation kinetics and methane production of substrates that simulate diets containing conventional ingredients (basal diets) with a range of inclusion of selected local by-products, using rumen fluid from cattle fed diets of the production systems of interest. To determine the ideal level of inclusion, the selected by-products will be increasingly included replacing standard ingredients of the diets to identify the best cost-effective substitution rate (not compromising rumen fermentation). Finally, feeding calendars will be suggested considering the temporal availability of by-products.

This project will provide new knowledge on the optimum level of inclusion of less known and local available by-products that reduce methane emission and improve nutrient circularity.

This proposal includes mainly laboratory work.

https://www.eragas.eu/en/eragas/Research-projects/INTEGRITY.htm.

Desired technical skills and/or experience:

- An inclination to work in the laboratory
- Experience with in vitro fermentation techniques
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Independent thinking and ability to resolve problems
- Basic Spanish skills are desirable but not essential

Host institution and location: Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Manfredi, Manfredi, Córdoba, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - July 2023.

43. Evaluation of *Tagetes minuta* essential oil as a novel feed additive for decreasing methane emissions and enhance ruminal N metabolism

Keywords: *rumen, microbes, fermentation, CH4, NH3*

Brief project outline:

Methane is naturally produced in the rumen during the fermentation process of ingested feed by livestock, but the emission of this greenhouse gas is an important contributor to global warming. Many nutritional strategies are currently under investigation to reduce methane emissions while maintaining rumen function, and thus animal production. Rumen fermentation modulators can be used as a mitigation strategy. The use of plant secondary compounds to modify rumen microbial fermentation has proven to be effective, mostly in *in vitro* studies or in short term *in vivo* studies. Previous *in vitro* studies form our lab demonstrated the potential of *Tagetes minuta* essential oil to reduce methane production and alter N metabolism in the rumen, and this results need to be evaluated under *in vivo* conditions.

Thus, this project aims to confirm the potential of this essential oil in reducing methane emissions and improving N metabolism in the rumen, without affecting negatively rumen function; and to evaluate its persistency as a methane inhibitor in the middle term. The student will conduct an experiment that will evaluate the effects of the addition of *T. minuta* essential oil on dry matter intake, methane production, rumen metabolism, digestibility, and N excretion in growing lambs fed alfalfa pellets using open-circuit respiration chambers. Lasting of effects will be determined. This project will provide new knowledge on the effectiveness and persistency of using a novel essential oil not yet evaluated as a methane inhibitor.

This proposal includes both field and laboratory work.

Desired technical skills and/or experience:

- Hands on experience with animals, particularly sheep
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Basic Spanish skills are desirable but not essential

Host institution and location: Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Balcarce, Balcarce, Buenos Aries, Argentina.

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2024 - July 2024.

44. Mitigation of GHG livestock emissions under grazing conditions over improved native grasslands with high tannin legumes

***Keywords**: methane, nitrous oxide, native grasslands, tannin, legumes*

Brief project outline:

Beef production systems in Uruguay are mainly based on cattle grazing our native grasslands. Native grassland is very variable both regionally, due to very different soil types and diverge rainfall regimes, and temporarily. These natural variations, plus the historical grazing management practices, have facilitated native grassland degradation and quality loss, which in turn negatively affects animal consumption and promotes both methane and nitrous oxide emissions. A good management practice widely used by beef farmers in Uruguay is the improvement of native grasslands with legumes, which some of them are very high in its tannin content, due to the improvement in pasture quality and in animal performance. However, there are no national studies focused on the evaluation of these practices as a GHG mitigation alternative.

Therefore, the aim of this Project is to quantify the effect of high-tannin legumes introduced into a native grassland on methane and nitrous oxide emissions.

Desired technical skills and/or experience:

- Work independence
- Experience in animal management
- Good knowledge level of statistics and R-software
- Preferred experience working with GHG measurements but not a requisite.

Host institution and location: Instituto Nacional de Investigación Agropecuaria, INIA La Estanzuela, Colonia, Uruguay.

Preferred duration of research visit: 6 months.

Preferred dates for research visit: April 2023 - October 2023

RICE

45. Costa Rican rainfed rice system adapted to a transplant phase and its effect on soil carbon and on N_2O sources.

Keywords: *rice, soil carbon stability, N_2O sources*

Brief project outline:

Costa Rican rainfed rice production has decreased due to the climatic variability that has been occurring in the transition period from the dry to rainy season. For this reason, it is relevant to investigate the implementation of sowing by transplant once the rainy season is established in areas that have not been suitable for direct sowing.

The student would conduct an experiment that compares the seed planting system that involves intensive tillage with production under transplant sowing, which applies shallower tillage than commercial tillage in rainfed rice. The intern would participate in a field trial and monitor key variables such as rice productivity and nitrogen use efficiency using the ^{15}N technique. They would also carry out soil incubations to monitor the effect on C stability, following the ratio between the CO_2 flow and the C reserves in a Ultisol with several crop cycles using transplanting, and the N_2O sources, analyzing $^{15}N_2O$ and isotopomers $^{15}\alpha N_2O$ and $^{15}\beta N_2O$. The proposed internship includes both laboratory and fieldwork and facilitates learning about modern equipment and isotopic analysis.

The majority of studies thus far have been conducted on Asian flooded rice production systems, but less research is available for Latin-Americans' rainfed system adapted to a transplant phase. This proposal as part of the International Coordinated Research Project *Developing Climate Smart Agricultural practices for carbon sequestration and mitigation of greenhouse gases* (CRP D1.50.20 lead by Dr. Mohammad Zaman) will provide new knowledge about the effect of a transplanting sown system on tropical Ultisol soil carbon and N_2O sources.

Desired technical skills and/or experience:

- Lab and field work
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork
- Basic Spanish skills are desirable but not essential

Hosting institution: Coordinator of Laboratory of Greenhouse Gases and Carbon Sequestration, Environmental Pollution Research Center, University of Costa Rica

Preferred duration of research visit: 6 months

Preferred dates for research visit*:* May 2023 - October 2023

46. Sustainable rice cultivation to reduce methane emission on soil affected by seawater intrusion

Keywords: *inventory, methane, rice*

Brief project outline:

Methane is the main greenhouse gas from rice fields that contributes to climate change. One of the effects of climate change is seawater rise which leads to soil salinity in coastal areas. The agricultural land in the northern part of Java Island has been affected by seawater intrusion. In the saline-affected soil, the soil salinity was 5 – 9 and 1.3 – 1.5 dS m-1 during the dry and rainy seasons, respectively. Rice production was 3 – 4 t ha-1 in the saline-affected soil compared to 6 – 7 t ha-1 in the normal soil. An integrated system involving salt-tolerant rice cultivars and nutrient management should be conducted to maintain the rice cultivation on the soil affected by saline. An increase in the number of organic matters on the soil affected-saline could reduce soil salinity, increase soil properties, and recover the photosynthetic activities and plant growth, which induce yield production.

This research project will be conducted on the farmer field in the saline affected area. The ameliorant will be made from agricultural waste available around the research area. Therefore, this integrated system could be carried out by farmers after this project is finished. The objective of this research is to observe the amount of methane emission from the system in the saline affected rice field and to obtain the best combination of rice cultivar and ameliorant to reduce methane emission. The result of this project will provide a strategy to mitigate methane emissions from rice fields in coastal areas.

Desired technical skills and/or experience:

- Laboratory and field skills
- Teamwork
- Paper writing and publication skills

Hosting institution: Indonesia Agriculture Environment Research Institute (IAERI) and Indonesian Agency for Agricultural Research and Development (IAARD)

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 – August 2023

47. Carbon labelling on exported food products from rice cultivation and aquaculture in the Vietnamese Mekong Delta

Keywords: *methane emissions, GHG calculator, carbon footprint*

Brief project outline:

Vietnam is one of the largest food exporters for rice as well as aquaculture products such as shrimps and fish of which the bulk originates in the Mekong Delta. In spite of increasing consumer demand for sustainable food production in Western countries, the Vietnamese food industry as a whole is rather unprepared for this innovation. In this regard, the labelling of product-specific carbon footprints – expressed as the amount of CO_2 equivalents emitted per kg of food –represents one of the key components of sustainable food production

Although some food exporting companies have initiated programs on more sustainable production methods, e.g. in line with the Sustainable Rice Platform Standard.

The research stay will comprise the following activities:

- Assessing the available tools for calculating carbon footprints of rice and aquaculture products
- Compiling a data base on available emission factors of aquaculture (to supplement the existing data base on rice cultivation)
- Applying these tools and emission factors within the regional context of selected food production systems in the Mekong Delta (3-5 case studies for rice and aquaculture, respectively)
- Conducting a survey – supported by the IRRI team – of the key private sector entities involved in food exports on
    - the present status of their documentation of sustainable production e.g. in line with the Sustainable Rice Platform Standard;
    - their perceptions of carbon footprint labelling on their products; and
    - the possible options for shifting toward low-carbon products.

Desired technical skills and/or experience:

- Broad knowhow on GHG emissions/ mitigations
- In depth knowledge on either rice cultivation or aquaculture
- Familiarity with GHG calculation tools
- Optional: Vietnamese language skills

Hosting institution: IRRI

Preferred duration of research visit: 6 months

Preferred dates for research visit: September 2023 - February 2024 (Flexible but must be between January 2023 and December 2024)

AGROFORESTRY

48. Modelling water use efficiency and atmospheric carbon uptake in a coffee plantation

***Keywords**: agroforestry, climate, CO_2 fluxes, coffee, water use*

Brief project outline:

The research stay aims at providing a PhD candidate a hands-on experience in the quantification of greenhouse gases (GHG) (CO_2 and water vapor) in terms of mass exchange between the coffee canopy and the atmosphere using the Eddy-Covariance technique and the use of the information to model the water use efficiency and the uptake of atmospheric carbon to determine the role of the coffee plantation as a sink of CO_2 , considering the changes in the mass and energy balance during the crop cycle across the soil-plant-atmosphere continuum. The analysis will focus on the year-to-year variability, the response of the surface CO_2 and water vapor fluxes response to the establishment of the dry and rainy seasons in Costa Rica and the relevance of crop scale GHG monitoring to develop quantitative indicators suitable to measure the results of mitigation actions. The field work will include training on the use of the different instruments included in the experimental set-up, composed by automatic weather stations, micrometeorological towers, soil moisture and temperature network and physiological measurements that include sap-flow, photosynthesis, hydraulic potential among others.

The combination of field-based GHG monitoring and other in-situ measurements within a modelling framework is developed to build capacity to leverage the use of field data to better support crop planning and management. The activities will keep a focus on the use of present weather and climate data to better understand how future climate scenarios may affect agriculture and the importance of GHG mitigation in agricultural activities. The research stay is planned to include guidance sessions on the physical basis of climate change, capacities, and limitations of climate models, and how to interpret future climate scenarios to assess impacts on agriculture and inform mitigation and adaptation strategies.

The modelling set up includes three components:

a. the implementation of observations in balance models to estimate water use efficiency and carbon uptake;
b. the integration of satellite derived vegetation indices and surface meteorological observations to model water use efficiency and evaluate satellite-based bias in the estimation of evapotranspiration; and
c. introduction to the use of climate projections generated from Regional Climate Models (RCMs) to analyse projected impacts of warming scenarios on temperature and precipitation patterns and their corresponding impact on agriculture.

The research stay aims at providing high-level training for the PhD Candidate on the monitoring of GHG, the relevance of the mass balance for precise estimations of the evapotranspiration and the water use efficiency, good practices in the use of field observations, how to integrate field observations in modelling applications, good practices and validation processes in the use of satellite retrievals for complex tropical terrain and introduction on the use and interpretation of RCM products. It is of interest that the proposed research stay will give strong tools for the PhD candidate

to conduct independent research and develop the capacity to combine observations and modelling to support the development of strategies and policies oriented to reduce the impact of climate change and mitigate GHG in the agriculture sector.

Desired technical skills and/or experience:

- Basic hands-on experience with automatic weather stations
- Use of meteorological data for agricultural applications
- Programming skills (e.g Python, R, Matlab, IDL)
- Knowledge on basic approximations for evapotranspiration and hydrological balance.
- Reasonable understanding of drought development theory
- Aptitude for field work in tropical environments (high humidity and temperature)
- Interest in learning new observational techniques and assimilate state of the art observations in balance models for agricultural applications
- Interest in gaining knowledge on the development of observational based greenhouse gases mitigation strategies
- Knowledge on micrometeorological instrumentations and data analysis techniques (eddy covariance) *Desired but not required

Host institution and location: University of Costa Rica. The PhD Candidate will participate in hands-on training for the monitoring of CO_2 and water vapor fluxes in a coffee plantation located in the Central Valley of Costa Rica. Data analysis and modelling will take place in the main campus of the University of Costa Rica and field work will take place at La Hilda coffee farm.

Preferred duration of research visit: 6 months

Preferred dates for research visit: April 2023 - September 2023

49. Biophysical performance of dynamic agroforestry vs. traditional cultivation systems in cocoa production in Ghana

Keywords: *cocoa, dynamic agroforestry, greenhouse gasses, soil biodiversity, nutrient cycling*

Brief project outline:

Cocoa (*Theobroma cacao*) is an important crop for millions of smallholders in West Africa, and unsustainable cocoa monocultures are the major driver of deforestation in Ghana. An alternative is dynamic agroforestry, a method inspired by nature that integrates cocoa production with regenerative afforestation. However, there is a knowledge gap in terms of greenhouse gas emissions, soil biodiversity and nutrient cycling of dynamic agroforestry vs. traditional cultivation systems in cocoa production.

This project focuses on the potential of dynamic agroforestry to mitigate climate change. The student will conduct on-farm field research in Ghana and analyse both the samples and the data at ETH Zurich in Switzerland. This applied project will provide new knowledge on the effectiveness of dynamic agroforestry to mitigate climate change in in cocoa production

Desired technical skills and/or experience:

- Hands on experience with cocoa production system, particularly agroforestry
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills

Host institution and location: ETH Zurich, Zurich, Switzerland

Preferred duration of research visit: 6 months

Preferred dates for research visit: September 2023 - February 2024

CROSS-CUTTING

50. Evaluating the potential of Community Natural Farming in mitigating greenhouse gas emissions, food security and poverty alleviation in India

Keywords: *greenhouse gas emissions, carbon sequestration, natural farming, nutrient cycling, food security*

Brief project outline:

Under business-as-usual, by 2050, 60% of India's population is likely to experience severe deficiencies in calories, digestible protein, and fat [1]. Increased and more efficient food production is urgently needed, but high production costs, high interest rates, volatile market prices and rising costs of inputs are resulting in depopulation of rural areas. Community Natural Farming (CNF) is a grassroots peasant movement in India that aims to improve viability of farming by reducing input costs, such as for purchased fertilizers, pesticides, and herbicides. In Andhra Pradesh, 523,000 farmers have already converted to CNF, accounting for 13% of the area under productive agriculture [2]. One of recent reports indicate that transition to community natural farming could reduce emissions by approximately 30% from croplands. Little research has been conducted to date on the impact of CNF on GHG reduction, multiple ecosystem benefits and trade-offs. This massive potential of emission reduction is remained untapped particularly in terms of its scalability within India and other parts of the world.

Transition to CNF systems have considerable GHG mitigation potential:

i. Considerable reduction in N_2O emissions by avoiding mineral fertilizer application and reuse of locally sourced organic residues
ii. Paddy rice water management, residue management and livestock likely to provide massive opportunities in emission reduction
iii. Overall crop yield is likely to be lower, but farmers profit may likely go up due to minimal input costs in CNF [3]
iv. Evaluate potential of CNF to national scale will provide first estimates of massive opportunity with multiple benefits and trade-offs

The student will use existing data on conventional and CNF fields in India to model GHG emissions from both systems using DNDC model. Validate DNDC model at site level and upscale this to national scale. At all stages of the project, the student will have the opportunity to conceptualize models, determine the mode of data collection, data analysis and interpretation. The student will also get to work with integrated process-based models during their PhD.

Desired technical skills and/or experience:

- Experience in applying mathematical models for terrestrial processes across a range of spatial and temporal scales
- Work creatively, independently, and productively
- Work as a member of a large multidisciplinary research team.

References: [1] Ritchie et al.(2018)PLoS.ONE.13(3);e0193766. [2] APZBNF 2018 http://apzbnf.in.[3] Smith et al., 2020, Nature Sustainability

Host institution and location: Information and Computational Sciences Department, The James Hutton Institute, Craigiebuckler , Aberdeen AB15 8QH. Scotland UK

Preferred duration of research visit: 6 months

Preferred dates for research visit: April 2023 - October 2023.

51. The effect of circularity in agriculture on greenhouse gas emissions

Keywords: *circularity, GHG emissions, livestock systems, arable systems, mixed farm systems*

Brief project outline:

The agricultural sector must contribute to enabling the UK to meet its ambitious Net Zero Emissions target for greenhouse gases (GHG) by 2050. Many historical policies, together with market drivers, have resulted in ongoing specialisation of crop and livestock systems; and whilst this may have increased farm profitability, it has led to greater externalisation of environmental costs of food production, e.g. increased emissions of GHGs and ammonia.

Improving resource use efficiency to maintain food output whilst reducing inputs (nutrients, land, energy, and water) is imperative to transition to sustainable food systems. The principle of circular agriculture is critical, and can be defined as the re-use and recycling of resources (e.g. nutrients) within and across the sector.

Whilst much is known about the technical potential for on-farm mitigation strategies to reduce GHG emissions, much less is known about how improving the circularity of material flows between farms can reduce total and product GHG emissions from more integrated farm systems. The research stay will be part of the wider ERA-NET CircAgric-GHG project which brings together a multidisciplinary, world-leading team of scientists with expertise in specialist and mixed crop and livestock farming systems (MCLS), circularity, GHG mitigation, digital agriculture, remote sensing, sustainable land use, and farm socio-economics to help address this knowledge gap.

Desired technical skills and/or experience:

As part of a broader project the research stay can be tailored to previous experience or expertise, but the following are preferred:

- Previous experience of farm modelling and data OR surveying stakeholders
- Ability to work with a larger project team
- Detail focused
- Ability to transfer knowledge between domains

Host institution and location: SNS, Bangor University, Bangor, UK

Preferred duration of research visit: 6 months

Preferred dates of visit: May 2023 - October 2023

52. Transforming to low-emission food systems through community-led co-design and experimental learning in Vietnam

Keywords: *scaling, co-design, participatory research, social learning*

Brief project outline:

There is a plethora of evidence on low-emission agriculture technologies to show the mitigation benefits, however, less community-led research has been conducted to understand the cultural and social norms associated with the practices and the challenges to changing practices. The OneCGIAR Mitigate+ initiative intends to develop 'Living Labs' - which is a new approach to agricultural innovation that brings together farmers, service providers, scientists, local decision makers, and other collaborators to co-develop and test innovative practices and technologies to address agri-environmental issues. Through this iterative and participatory approach, economic experiments are developed together with implementation partners, which are used to enter into a dialogue with and between the participants. These experimental set-ups framed as real-life situations allow participants to experiment with different management options in a low-risk space, learn how fellow community members behave and what consequences the actions can have in the long term. This kind of experience can accelerate a real-life learning process that can lead to collective decision-making that reduces emissions. Building on this process, mitigation strategies and innovations will be discussed with the participants and various stakeholders.

The scholarship will comprise the following activities:

- Identifying stakeholders relevant to different mitigation activities through participatory activities such as stakeholder mapping
- Co-design and selection of low-emission technologies that are suitable for the community and environment
- Adapting the experimental design frame for local relevance
- Facilitating experiential learning through experimental games and documenting outcomes
- Institutional analysis of social norms, networks, and governance in relation to low-emission technology

Desired technical skills and/or experience:

- Social science
- Participatory research
- Familiarity with low-emission agriculture technologies
- Preferred: Vietnamese language skills

Host institution and location: International Rice Research Institute, Hanoi, Vietnam

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 - August 2023 (Flexible but must be between January 2023 and December 2024)

53. Developing a digital twin of mixed cropping livestock systems

Keywords: *livestock, methane, farming system models*

Brief project outline:

Mixed crop-ruminant production systems are a case of integration where nutrient circularity is put forward. To increase circularity of nutrients (i.e., C, N) within agricultural systems, the range of solutions will vary from individual, specific measures, to more holistic and integrated approaches.

A digital twin of mixed crop livestock farms from Europe and South America will be developed in INTEGRITY ERA-NET project. A digital twin is a virtual representation of the real-world counterpart combining a model of a system with real-time measurements. It will enable planning and control of operations based on forecasted impact of management alternatives. The INTEGRITY project will focus on how to integrate historical and real-time measurement data with the Agricultural Production Systems sIMulator (APSIM). The project will develop software integration of the APSIM simulation engines, historical sensor data and real-time IoT measurements and add models for predicting daily methane emission at animal level based on simulated or measured feed properties and feed intake.

The student will participate in the software development with special focus on integrating statistical methane prediction models from different agroclimatic zones and production system types based on measurement data in the digital twin. The work is done in collaboration with research institutes Luke (Finland) and INRAE (France). The work involves a paid visit to the research group in France (Dr. Maguy Eugène).

Desired technical skills and/or experience:

- Skills on simulation model or statistical model development
- Experience on programming with either scripting or compiled languages
- Good teamwork skills

Host institution and location: Natural Resources Institute Finland (Luke). Helsinki, Finland.

Preferred duration of research visit: 6 months

Preferred dates for research visit: March 2023 - September 2023

54. Assessment of greenhouse gas emissions from agricultural sources in order to plan for the needs of a low carbon economy at the local level.

Keywords: *agricultural, climate change, inventory, crops, adaptation, greenhouse gas mitigation*

Brief Research Outline:

Agriculture in developing countries has attracted increasing attention in international negotiations within the United Nations Framework Convention on Climate Change for both adaptation to climate change and greenhouse gas mitigation. However, there is limited understanding of potential complementarity between management practices that promote adaptation and mitigation, and limited basis to account for greenhouse gas emission reductions in this sector. The good news is that the global research community could provide the support needed to address these issues through further research linking adaptation and mitigation. In addition, a small shift in strategy by the Intergovernmental Panel on Climate Change (IPCC) and ongoing assistance from agricultural organizations could produce a framework to move the research and development from concept to reality**.**

Agriculture directly contributes 10–12% of global anthropogenic GHG emissions. Many of the same practices that reduce GHG emissions can also improve the efficiency of resource use and create synergy with rural development and food security goals. However, less research has focused on evaluating the influence of management on both GHG mitigation and adaptation to climate change.

This applied project will provide knowledge on:

- Enhancing evidence-based climate change policy development in the agricultural sector.
- Inventory and evaluation of the greenhouse gas emissions from agricultural sources.

This proposal includes both laboratory and fieldwork.

Desired technical skills and/or experience:

- Hands-on experience with climate change adaptation and mitigating.
- Independent thinking and ability to solve the problem
- Time management to ensure each job was done promptly
- Good English language skills are a must

Host institution and location: Climate Change Information Center & Renewable Energy &Export system, 9 Cairo University St., Giza – Egypt

Preferred duration of research visit: 6 months

Preferred dates for research visit: February 2023 – September 2023

55. Developing an Intelligent Greenhouse Management System to Monitor the Greenhouse Gas Emissions

Keywords: *artificial intelligence, sensors, climate control, management*

Brief project outline:

Horticultural cropping and supply chain systems are among the major sectors contributing to climate change via emissions of CO_2 as a result of heating and use of fossil fuels, as well as N_2O emissions through the application of nitrogen fertilizers. Paradoxically, the industry is also vulnerable to the climate change due to adverse effect on product quality in terms of marketable yield, e.g. fruit size, physiological disorders, and defect.

Protected cropping in greenhouse structures play an important role in producing food for the growing global population. Greenhouse based food production units are becoming larger and for meeting the market demand and consumers' requirements, greenhouse operators need to make complicated but informed decisions to optimize production and resource use. An Artificial Intelligence (AI) decision matrix for greenhouse management would be a useful tool to contribute in overcoming the challenges in this sector.

This project will focus on monitoring and managing greenhouse gas (GHG) emission and reducing the carbon cost by establishing a system of controlling the greenhouse climate and crop with AI techniques. The successful candidate will combine sensors and meteorological data to develop AI models to help growers make timely and informed decisions to maximize production and minimize inputs. This project will shed light on the challenges and opportunities for the future implementation of smart farming in low-tech greenhouses which are prevalent in developing countries. The Northern Territory Department of Industry, Tourism and Trade will provide supervision and support for both data analysis and horticultural aspects of the project.

Project outcomes will be published in scientific journals, presented at appropriate international forums and communicated to the commercial industry stakeholders through the communication channels of the funding agencies and the research delivery partners.

Desired technical skills and/or experience:

- Hands on experience in horticulture, particularly greenhouse production systems
- Passion for cross-disciplinary research, independent thinking and innovations
- Computer programming skill or willingness to acquire these skills
- Initiative and problem-solving skills
- Ability to work relatively independently with excellent organizational skills
- Effective teamwork and interpersonal skills
- Sufficient written English and oral communications skills

Host institution and location: Department of Industry, Tourism and Trade of the Northern Territory Government, Australia

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 – June 2023

56. Measuring the contribution of push-pull sustainable intensification technology to climate change mitigation

Keywords: *agroforestry, biomass carbon, soil carbon, carbon dioxide, nitrous oxide, methane*

Brief project outline:

Push-pull technology is a sustainable intensification technology that has been successfully used to improve yield and income in smallholder cereal production systems by controlling insect pests (stem borer, fall armyworm) and striga weed (*striga hermonthica*), and improving soil health through nitrogen fixation and soil moisture conservation. A recent study also shows that push-pull increases crop biomass and can improve soil organic carbon. However, no study has assessed greenhouse gas (GHG) emissions and carbon sequestration and storage in different pools under push-pull system.

The student will (1) conduct an inventory of tree and shrubs and establish biomass carbon using appropriate allometric equations, (2) determine carbon stocks in herbaceous components in the farm, (3) collect and analyse soil samples to establish soil organic carbon, and (4) measure GHG (carbon dioxide [CO_2], nitrogen oxide [N_2O] and methane [CH_4]) fluxes using the static chamber method. The student will relate measurements (biomass carbon, soil, GHG fluxes) obtained to farm productivity. This study will contribute to a holistic approach to quantification of climate change mitigation potential of push-pull technology. The study will be conducted on farms with push-pull in Western Kenya, where the scope of push-pull technology has been expanded to include high value crop as well as other cropping systems such as agroforestry under UPSCALE project .

More information: https://doi.org/10.1080/17583004.2022.2035823; https://doi.org/10.1016/j.fcr.2020.107911

Desired technical skills and/or experience:

- Knowledge of smallholder farming systems in East Africa
- Knowledge of ecological surveys and/or measurement of greenhouse gases
- Excellent written and oral English language
- A team player with capacity to work with people from different backgrounds

Host institution and Location: Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya

Preferred duration of the research visit: 6 months

Preferred dates of the research visit: To be confirmed with supervisor

57. Soil respiration, microbial biomass, and plant root growth to assess belowground carbon cycling in a semi-arid Kenyan rangeland

***Keywords**: livestock, CO_2, pastoral system, carbon sequestration, below-ground biomass, vegetation*

Brief project outline:

African rangelands store large amounts of carbon in their soils. However, it remains unclear how the dynamics of plant root growth and microbial growth and activity contribute to soil C storage. The present study will be located at ILRI's Kapiti Research Station and Wildlife Conservancy. The study site is equipped with an Eddy Covariance (EC) tower that measures ecosystem CO_2 exchange above the canopy.

To support the EC measurements, the successful candidate will measure soil respiration (i.e., soil CO_2 emissions), microbial biomass, and plant root growth in the EC tower footprint. These data will help to dissect the contribution of soil respiration to total ecosystem CO_2 exchange. Furthermore, they will help to understand the role of soil microorganisms and plant roots for soil carbon cycling in pastoral rangelands. The project is linked to the MITIGATE+ initiative, the LCSR initiative, and the EU-DeSIRA ESSA project for climate-smart agropastoral ecosystem transformation (https://www2.helsinki.fi/en/projects/climate-smart-agropastoral-ecosystem-transformation-in-east-africa).

Desired technical skills and/or experience:

- Experience in GHG emissions measurement and soil analysis
- Knowledge of pastoral livestock production systems in developing countries
- Experience in setting up and conducting field experiments
- Excellent written and spoken English is a requirement; experience with peer-reviewed publications would be a plus

Host institution: International Livestock Research Institute (ILRI), Nairobi, Kenya

Preferred duration of research visit: 6 months

Preferred dates for research visit: Flexible start date but preferably start in early 2023

58. Testing manure management interventions for their potential to reduce greenhouse gas emissions and nutrient leaching losses in smallholder systems

***Keywords**: livestock, methane, nitrous oxide, carbon dioxide, smallholder farmer, mixed crop-livestock, nutrient cycling, waste management, fertilizer*

Brief project outline:

Livestock manure is an important fertilizer and source of plant nutrients in smallholder farming systems in Africa. However, if the manure is not stored and managed well, nutrients are prone to gaseous and leaching losses. This leads to greenhouse gas (GHG) emissions and groundwater pollution. In this project, we will test the effect of manure management interventions to reduce nutrient losses and GHG emissions from the manure and improve the manure fertilizer value. The experiment will be conducted at ILRI's Mazingira Centre for Environmental Research and Education (Nairobi). The successful candidate will set up the manure trial and measure manure CH_4, N_2O and CO_2 emissions, leaching of dissolved organic carbon (DOC), nitrate (NO_3^-), ammonium (NH_4^+) and phosphate (PO_4^{3-}), and manure nitrogen and fibre concentration. The candidate will summarize the findings in a peer-reviewed publication. The results will be used to develop manure management interventions for sustainable nutrient management in smallholder farming systems in Africa. The project is linked to the MITIGATE+ initiative, the SNV NEADAP program, and multiple ongoing research activities at ILRI to develop sustainable and climate-smart manure management practices.

Desired technical skills and/or experience:

- Experience in GHG emissions measurement and soil, water, or manure analysis
- Knowledge of mixed crop-livestock production systems in developing countries
- Experience in setting up and conducting field experiments
- Excellent written and spoken English is a requirement; experience with peer-reviewed publications would be a plus

Host institution: International Livestock Research Institute (ILRI), Nairobi, Kenya

Preferred duration of research visit: 6 months

Preferred dates for research visit: Flexible start date but preferably start in early 2023

59. Comparing cattle and sheep bomas regarding greenhouse gas emissions, nitrogen leaching, and effects on vegetation regrowth in a Kenyan rangeland

***Keywords**: livestock enclosure, corral, kraal, manure, N_2O, CH_4, pastoral system, nutrient cycling*

Brief project outline:

In African pastoral systems, livestock are usually housed in mobile or permanent corrals ("bomas" in Kiswahili or "kraals" in Afrikaans) where manure accumulates and is often not removed. Livestock excreta are a source of methane (CH_4) and nitrous oxide (N_2O) emissions and groundwater pollution. N_2O emissions from cattle bomas are estimated to contribute up to 5% of total N_2O emissions from the African continent. At the same time, bomas can be used for rangeland restoration if they are moved around the landscape because they provide essential nutrients for plant growth, and abandoned bomas are hotspots for plant and wildlife biodiversity.

In this study, we will measure CH_4 and N_2O emissions from cattle and sheep bomas, compare the risk for nutrient leaching, and monitor vegetation regrowth after boma abandonment. The study will be located at ILRI's Kapiti Research Farm and Wildlife Conservancy in Machakos, Kenya. Results will be used to develop greenhouse gas (GHG) emission factors and to make recommendations for improved rangeland management and will be published in a peer-reviewed publication. The project is linked to the MITIGATE+ initiative, the LCSR initiative, and the EU-DeSIRA ESSA project for climate-smart agropastoral ecosystem transformation (https://www2.helsinki.fi/en/projects/climate-smart-agropastoral-ecosystem-transformation-in-east-africa).

Desired technical skills and/or experience:

- Experience in GHG emissions measurement and soil nutrient analysis
- Knowledge of pastoral livestock production systems in developing countries
- Experience in setting up and conducting field experiments
- Excellent written and spoken English is a requirement; experience with peer-reviewed publications would be a plus

Host institution: International Livestock Research Institute (ILRI), Nairobi, Kenya

Preferred duration of research visit: 6 months

Preferred dates for research visit: Flexible start date but preferably start in early 2023

60. Modelling and predicting SOC sequestration potentials of SLMP watersheds in Ethiopia

Keywords: *carbon, land management practices, NDC*

Brief project outline:

Soil organic carbon (SOC) is the largest pool of carbon in terrestrial ecosystems and increasing the total amount of carbon stored in soils is widely considered a way to alleviate the anthropogenic increase in CO_2 in the atmosphere. Many international initiatives exist to increase SOC, e.g. the 4 per 1000 initiative on Soil for Food Security and Climate launched by the French Ministry of Agriculture at the United Nations Framework Convention for Climate Change Conference of the Parties (UNFCCC COP 21) and the Land Degradation Neutrality programme run by the United Nations Convention to Combat Desertification (UNCCD). As a part of those international commitments, nations also committed to reduce emissions in their Nationally Determined Contribution (NDC) and to achieve Land Degradation Neutrality (LDN) targets, respectively. Against this background, Ethiopia invested more than US$ 1.2 billion per year over the past 10 years for various Sustainable Land Management Program (SLMP) in four regions of the Country. Reversing degradation has the potential to contribute to carbon sequestration – aboveground and in the soil – and hence to mitigate climate change. However, the lack of proper guidance on estimating and monitoring as well as where to implement what technologies is the main challenge to achieve the NDCs.

This project focuses on:

1. Modelling and mapping SOC sequestration potential of SLMP watersheds in Ethiopia; and
2. Identifying the types and placement of optimal land management practices to enhance SOC in the highland of Ethiopia.

This proposal involves both field work and modelling exercise.

Desired technical skills and/or experience:

- Ability to work independently and in team
- Good scientific writing skill for high impact journals
- Modelling experience using large spatial dataset
- R (or python) programming

Host institution and location: Alliance Bioversity-CIAT, Ethiopia Office, Addis Ababa

Preferred duration of research visit: 6 months

Preferred dates for research visit: January 2023 - June 2023

61. Evaluating integral sustainability of livestock and arable farms in the EU ClieNFarms project

Keywords: *GHG mitigation, climate solutions, integral sustainability, agriculture*

Brief project outline:

The Farm to Fork Strategy, which is at the heart of the European Green Deal, aims to address the challenges and accelerate the transition to sustainable food systems. The importance of avoiding trade-offs between greenhouse gas (GHG) mitigation measures and other aspects of environmental, economic and social sustainability is well recognized. Understanding interrelated effects of climate solutions on different aspects of sustainability is complicated, because of the complexity and wide variety of farming systems. In the EU-funded ClieNFarms project (2022-2025) locally relevant climate solutions will be developed and scaled to reach climate-neutral farms in agricultural systems of 13 European countries. ClieNFarms will develop an original network of 20 case-studies (namely the Innovative Systemic Solution Space - I3S) around Europe integrating a large range of local conditions and production systems.

In this ambitious project, Wageningen Research (WR) is leading the evaluation of integral sustainability of climate solutions. WR is seeking assistance from a CLIFF-GRADS student in evaluating the integral sustainability of a large number of livestock and arable farms participating in the ClieNFarms project. As part of our WR team, the PhD student will collate and analyse data from different European tools for integral sustainability evaluation and will assist in on-farm measurements of GHG emissions and carbon sequestration. The PhD student will involve in the measurement and analysis of soil organic carbon of the I3S located in the Netherland. This work could potentially lead to a collaborative scientific publication.

Desired technical skills and/or experience:

We are looking for:

- An enthusiastic PhD candidate with a background in agricultural science
- Extensive experience with data analyses (at least Microsoft Excel)
- Teamwork skills
- Speaking and writing fluent English.

Host institution and location: Wageningen Livestock Research, the Netherlands.

Preferred duration of research visit: 6 months

Preferred dates for research visit: Approximately March 2023 - August 2023 (there is some flexibility).

FORESTRY SYSTEMS

62. Experimental assessment of tree diversity effects on tropical dryland forest restoration and implications for climate mitigation in Tigray, northern Ethiopia

***Keywords**: restoration, climate change, tree diversity*

Brief project outline:

Many people are highly dependent on dryland biodiversity. Drylands present challenges to plant and animal survival, but many species have evolved with special adaptation strategies to cope with the variable water supply and climate change. These lands have great biological value and are home to many of the world's food crop and livestock species. However, scientific information on ecology, vegetation development, species trait, productivity and ecosystem services, utilization, and indigenous species management are still required to properly plan and restore these dryland resources against the changing climate. On the other hand, testing the relationship between tree species diversity, productivity, and resilience in forests is difficult owing to the inability to control variables within these complex ecosystems. Hence, long-term controlled experiments (>= 8 years) of higher plant diversity is essential to study the relationship between tree diversity and ecosystem functioning, a gradient of species number ranging from single-species stands to multispecies mixtures.

Therefore, the overall aim of this research is to investigate the effect of tree species mixture and shading on tropical dry forest restoration success by assessing IDENT Ethiopia, a tree diversity experiment in dry Afromontane forest. The experiment is located in Mekelle University, Endayesus Campus, close to the tree nursery. IDENT-Ethiopia tree diversity experiment is part of the International Diversity Experiment Network with Trees, with experiments on the American, European and now also African continent. The experiment is organized with 9 native woody species distributed over 270 plots and three blocks, each with a shaded and un-shaded treatment. Within each (shaded and unshaded) treatment, gradients were created by manipulating species richness (SR) and functional diversity (FD)to test whether mixed or monoculture better adapt to the changing climate.

This experimental site was established three years ago and has passed three growing seasons since, now in its 4th growing season. Growth monitoring is done every year and for some parameters every three months. As a part of their research stay, students can compare the emission and mitigation potentials from the adjacent crop fields, livestock farm and the experimental forest wood lot, with all three sites being adjacent. As the experiment is also part of the international IDENT experiment, students can also get data from the different sites outside Ethiopia to do comparable studies.

Desired technical skills and/or experience:

- Hands on experience with seedlings and long-term biodiversity experiment
- Independent thinking and ability to resolve problems
- Organized and meticulous
- Effective teamwork and interpersonal skills
- Basic Amharic and Tigrigna skills are desirable but not essential

Host institution and location: Mekelle University, Institute of Climate and Society, Main Campus, Mekelle, Ethiopia

Preferred duration of research visit: 6 months.

Preferred dates for research visit: September 2023 – February 2024