BOOK OF ABSTRACTS

Series III

ISSN NO. 2737-727X

REFRAMING STRATEGIES FOR LOW CARBON FUTURE IN AGRO-FARMING SYSTEMS

Edited by Mohammad I. Khalil

The 3rd International Symposium on Climate-Resilient Agri-Environmental Systems

ISCRAES 2024

25-28 JUNE 2024 DUBLIN, IRELAND

This book contains all abstracts presented at the conference and published in 2024 by the ISCRAES 2024 Organising Committee in collaboration with Prudence College Dublin

Organising Committee

Convenor

Dr. M. Ibrahim Khalil, Prudence College Dublin and University College Dublin, Ireland.

Members

Prof. Bruce Osborne, University College Dublin and Prudence College Dublin, Ireland.
Prof. Mike Jones, Trinity College Dublin (TCD)
Dr. Paul Leahy, University College Cork (UCC)
Dr. Ken Byrne, University of Limerick (UL)

Scientific Committee

1	Prof. Jorge Pérez Quezada	Universidad de Chile, Chile
2	Prof. Jean Baptiste Ettien	University Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire
3	Dr. Ágnes Szepesi	University of Szeged, Hungary
4	Dr. Anna Wlakiewicz	Institute of Agrophysics, Poland
5	Dr. Junliang Zou	Northwest A&F University, China
6	Dr. Shurpali Narasinha	Natural Research Institute (LUKE), Finland
7	Dr. Xavier Morvan	University of Reims Champagne-Ardenne (URCA), France
8	Dr. Ken Byrne	University of Limerick, Ireland
9	Dr. Cai Andong	Chinese Academy of Agricultural Sciences, China
10	Dr. Victor Rolo Romero	University of Extremadura, Spain
11	Dr. Dinesh Panday	Rodale Institute- Pocono Organic Center, United States

CONTENTS

CRAES TO ISCRAES

The Climate-Resilient Agri-Environmental Systems (CRAES) group was formed by Dr. M. Ibrahim Khalil in cooperation with other University College Dublin (UCD) colleagues through a UCD Earth Institute Strategic Priority Award. The main aim was to foster agri-environmental research, modelling, and technology development, with an emphasis on the need for carbon-neutral and pollution-free agricultural systems that do not compromise food security. These objectives also link to the provision of strategic education and training and address the global challenge associated with climate change and environmental degradation by harnessing UCD's multidisciplinary expertise and engaging with national and international collaborators and stakeholders.

The specific objectives were to:

a. Form a multidisciplinary research group initially with experts from various academic/research disciplines within UCD and now nationally and internationally.
b. Publicise the group in general and its research expertise to attract national and international academics/researchers for collaborations/partnerships.
c. Demonstrate the importance of the group's activities to other academics/researchers and stakeholders for strengthening their engagements and cooperation.
d. Develop the group by co-opting and/or collaborating with relevant experts from national and European/International academic and research organizations.
e. Arrange regular meetings for discussion on project activities, and exchange research ideas, address knowledge gaps and explore collaborative opportunities.
f. Provide the critical mass that is required to respond to national and international research calls for securing funding for innovative research and the development of integrated system models for researchers, policymakers, and end users.

As an important contribution to these activities, a national organising committee was formed to arrange this Third International Symposium on Climate-Resilient Agri-Environmental Systems (ISCRAES 2024). The key theme of this symposium is "Reframing Strategies for Low Carbon Future in Agro-Farming Systems". This is to address the central goals linked mainly to creating a sustainable carbon-neutral farming and food system while preserving agrobiodiversity, boosting the circular economy, and above all Climate Change Mitigation and Adaptation whilst reducing environmental pollution. To achieve goals, like UN-SDGs, EU Green Deals, and Climate Action, a multi-disciplinary systems-based approach involving academic, industrial, and policy-related collaborations for the development of scientific knowledge and advancement of technologies and the exploration of ways for their practical implementation is imperative. This symposium provides a platform to discuss the scientific and technical aspects of the range of cross-cutting issues associated with the environmental impact of agriculture and associated land uses, including public perception, and regulatory and socio-economic factors.

SYMPOSIUM THEMES

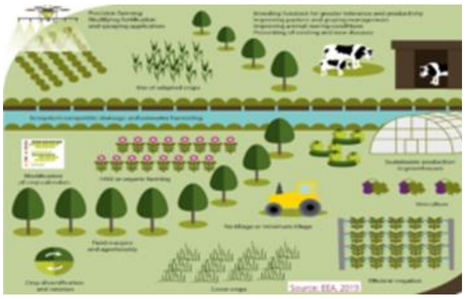
The main objective of the symposium is to bring academics, researchers, and stakeholders together to provide creative and innovative ideas that could provide a basis for the testing and subsequent adoption of strategic ways for implementing sustainable GHG mitigation and environmental solutions taking into account the need for:

- coherent environmental solutions, through a systems-based approach.
- economically viable and socially acceptable options.
- a systems-based decision-support tool.

Grassland Systems

Grasslands (pasture, hay and silage) dominate the total global agricultural area. Livestock is grazed mostly on pasture and meadows. Grazing intensity and fertilizer (organic and inorganic) management play an important role in soil health and productivity while also contributing to a large share of total agricultural GHG emissions and pollutants (e.g., NH_3, NOx, NMVOCs and particulate matters and/or water (e.g., NO_3^- and PO_4^-) through leaching, volatilization, and runoff. Livestock itself accounts for about half of all anthropogenic emissions, i.e. a quarter of methane emissions through gut fermentation and the decay of excreta. The projected increase in livestock numbers will not only impact on the production of manure by ~60% by 2030 but also methane emissions. These environmental pressures warrant adoption of sustainable management for grassland systems that depend on both livestock numbers and the fertilizer form and amount, and their contribution varies on climate conditions, available resources, ecosystem/biodiversity services, and avoidance of events leading to environmental pollution. In this session, the focus is to find solutions to coupled air, water, and soil pollution, referring to both grazed and ungrazed grassland systems.

Climate Change and Agro-farming Policy



Climate change and agro-farming policy play important roles in the mitigation of greenhouse gases and nutrient losses for environmental protection. Climate change has a direct impact on agriculture, causing changes in temperature and precipitation patterns that can affect crop production and soil health. However, agriculture can also contribute to climate change through the production of greenhouse gases. To mitigate the impact of climate change, it is important to formulate policies and adopt practices that promote soil health, increase carbon sequestration, and reduce the use of synthetic chemicals. Agro-farming policy could promote sustainable practices and incentivize farmers or penalize them to reduce the impact of agriculture on the environment and promote sustainable food production.

To do so, several policies linking to improve soil health, reduce greenhouse gas emissions, and increase resilience of agricultural systems to the impacts of climate change can be taken, including (i) Promotion of Sustainable Agricultural Practices (e.g. regenerative agriculture, conservation tillage, and the use of cover crops), (ii) Financial Incentives (e.g. tax credits, grants, and low-interest loans to offset the costs of transitioning to more sustainable practices and encourage widespread adoption,) (iii) Encourage Reduction of Synthetic Chemical Use and measures (integrated pest management practices), to rely on natural methods of pest control, (iv) Implementation of Carbon Sequestration Programmes that incentivize farmers to sequester carbon in the soil, improve ecosystem services, and technical assistance to farmers who want to adopt sustainable practices, (v) Research and Development Investment in Climate-resilient Agriculture (e.g. new crop and livestock verities and efficient irrigation system), (vi) Encouragement of Agroforestry to provide additional benefits such as reducing erosion, improving water quality, and providing habitat for wildlife. This session will inform evidence-based policy and decision-making on economically viable management interventions for climate change mitigation and adaptation as well as environmental pollution reduction without compromising agricultural production emphasizing food security.

Nature-based Solutions in Agriculture

Nature-based Farming Solutions (NBFS) are actions that protect, sustainably manage, and restore natural or modified ecosystems and are likely to have the greatest potential impacts on adaptation and resilience-building. These measures encompass agroforestry, improved land (crop, grass and peat) management, agricultural diversification, integrated water use, and forest management. They take into consideration both traditional and local knowledge as well as scientific evidence to support the optimum use of natural resources for agricultural production, whilst also maintaining or even enhancing native biodiversity. The approaches associated with NBFS include the adoption/promotion of organic agriculture, agroecological approaches, and conservation farming with the objective of reducing the environmental footprint of farming activities.

An emerging approach, directed at these objectives is the use of perennial crops, which have the potential of ensuring the greater capture and conservation of resources through photosynthesis, and improvements in nutrient recycling. A range of alternative management practices, such as mixed cropping, can potentially derive considerable benefits from the integration of perennials, as opposed to traditional seasonal crops. There are six evidence-based ecological principles proposed for the design and implementation of an effective NBFS, including a reduction in biodiversity loss, delivery of location-specific ecosystem services, the use of targeted interventions, strengthening links between people, producers, and nature, and longer-term flexible planning. Hence, this session is centred on Carbon Farming and Nature-based Solutions. The focus will be on how to increase carbon storage, improve/maintain water quality, soil health, biodiversity, and the role of pollinators. Novel pest control methods that have climate, water quality, and nature-related benefits, will also be examined, that minimise carbon loss and contribute to improved farm livelihoods.

Arable Cropping Systems

Globally, there are a large number of arable cropping systems based mainly on the climatic conditions and land types/topography (e.g., dryland/upland, wetland-dryland/upland, and wetland), leading to the adoption of different cropping patterns (e.g., cereal only, cereal-legume, and cereal-vegetable). Arable crops are mainly associated with tillage-related cultivation systems, which vary from region to region, and are among the most important land uses influencing soil properties and causing environmental and ecological degradation. Land use (cereals, vegetables, etc.), soil/land types and management practices(inorganic and organic fertilizers, as well as the addition of organic residues) within a system controls the extent of emission of GHGs, air pollution, and leaching losses. Inappropriate cropping and cultivation techniques, as well as excessive use of fertilizers, can exacerbate these problems. Many soils may be susceptible to erosion, and the loss of organic matter leading to poor structure, biodiversity loss, and pollution due to pesticides and herbicide residues and the accumulation of heavy metals. This session will therefore focus on research work in arable cropping systems that have assessed potential solutions to coupled air, water and soil pollution.

Agro-Forestry systems

Mixed farming systems are very popular in both developed and developing nations, and are generally divided into four systems (i) Agro-pastoral system (arable ley), (ii) Agro-Forestry system, (ii) Silvo-pastoral system, and (iv) Agro-Silvo-Pastoral system. Other than agro-forestry, livestock (cattle, sheep and goats) grazing is common in mixed farming systems. The number of agro-silvo systems associated particularly with beef/meat and dairy production has been increasing globally. In these mixed systems, as in grassland, application of organic and inorganic fertilizers to improve crop/biomass production may increase GHG emissions and environmental pollution. Yet, these systems are thought to increase the use of crop by-products resulting in improved nutrient recycling and reduced methane production.

Accordingly, mixed farming as an approach to satisfy the global demand for food, meat and milk could have some advantages in reducing the environmental and carbon footprints. However, applied research and extension are of critical importance if the environmentally friendly factors of the system are to be adequately exploited. Considering the fundamental change and integration of livestock as a mechanism to promote system flexibility, identification of technologies and policies for simultaneous reduction of GHGs and environmental pollution will be the main focus of this session.

Decision Support Systems in Agro-Farming

Limited field measurements and Excel-based national inventory methods (IPCC Tiers), focussed mainly on the developed nations, are being used for accounting, and form the basis for mitigating the environmental consequences of GHGs, air pollutants, and leaching losses. However, these approaches often struggle with an adequate assessment of the impact of agricultural management practices particularly mixed farming systems. There are substantial difficulties in incorporating any mitigation strategies and are unable to provide immediate feedback on the consequences of management actions/decisions. As measurements covering all ecosystems and soils are not feasible, the use of model-based decision-support tools could be an alternative option in order to cover diverse agricultural systems.

Any verified and validated model should be used as a decision support tool to provide assessments at a unit level but applicable to the regional scale. This would help raise local awareness, provide prospects for actions, aid in refining and implementing emission mitigation techniques, and demonstrate the effects of innovative actions. A further benefit is that they can help to identify environmental hotspots, evaluate indicators of sustainability, provide alternative management scenarios, identify practices having a positive impact on net GHG emissions and the environment and provide options for assessment of the economic effects of interventions at all scales. This will be the topic of this session.

Circular Bioeconomy in Agro-Farming

We are excited to present a thought-provoking theme on the Circular Bioeconomy in Agro-farming! This session aims to explore the transformative power of circular approaches in the agricultural sector and foster sustainable solutions for the future.

Join us as we delve into the concept of the Circular Bioeconomy and its potential to revolutionize agro-farming. Discover innovative practices that minimize waste, optimize resource utilization, and promote ecological balance. Expert speakers will share insights on bio-based inputs and organic waste recycling, focusing on renewable natural capital and replacing the wide range of non-renewable and fossil-based products and their economic benefits. They will showcase successful case studies and their positive impact on climate change mitigation and the environment, leading to profitable precision agriculture.

Be a part of the conversation shaping a sustainable future for agriculture. Together, let's cultivate a Circular Bioeconomy that ensures food security, reduces environmental footprints, and fosters resilient agro-farming systems

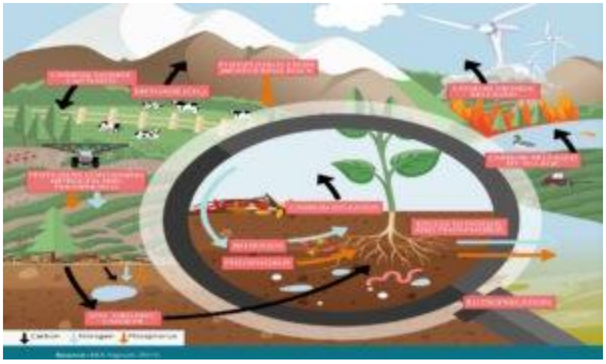
Biodiversity in Agriculture

Introducing an engaging theme content on Biodiversity in Agricultural Systems that covers the variety and variability of animals, plants, and microorganisms. This session explores the critical role of biodiversity in sustainable and resilient agricultural landscapes.

Join us to uncover the profound importance of biodiversity for food production, ecosystem services, and climate resilience. Expert speakers will share valuable insights on enhancing biodiversity in agricultural systems, including soil biodiversity, pollinators, and beneficial insects, as well as agroforestry and cover crops. Discover innovative practices that nurture biodiversity, enhance soil health, and protect natural habitats. Explore case studies highlighting successful implementations and their positive impacts on crop productivity, pest control, and ecosystem balance.

Let's embrace the vital connection between biodiversity and sustainable agriculture, shaping a future where agricultural systems thrive in harmony with nature.

Biogeochemical Processes in Agro-Farming



Agricultural farming systems are complex ecosystems that involve a variety of biogeochemical processes including physical, chemical, and biological. Biogeochemical processes are the underlying mechanisms that govern the cycling of essential elements, such as carbon, nitrogen, phosphorus, and water, within the agricultural ecosystem. By understanding these processes, farmers can make informed decisions on the optimization of fertilizers application, reduce the risk of nutrient losses in water bodies, and minimize greenhouse gas emissions while improving soil health, increasing crop yields, and ensuring sustainable food production.

Some of the key biogeochemical processes occurring in agricultural farming systems include: (i) Soil Organic Matter Decomposition: Soil organic matter is decomposed by microbes, which release nutrients and carbon dioxide back into the soil and the major driving factors are temperature, moisture, and the presence of organic matter, (ii) Nitrogen Cycling: Nitrogen is an essential nutrient for plant growth and is involved in a complex cycle of transformation and transformation within agricultural systems including plant uptake or lost to the atmosphere through processes such as volatilization, nitrification or denitrification, causing global warming, (iii) Phosphorus Cycling: Phosphorus is another essential nutrient for plant growth and is involved in a cycling process within agricultural systems including its lost from the soil through processes such as erosion or leaching, responsible for eutrophication, (iii) Carbon Cycling: Carbon is a critical component of the global carbon cycle and is involved in a complex series of processes within agricultural systems to enhance C storage, improve soil health and productivity and offset greenhouse gases, or release back into the atmosphere through processes such as respiration or combustion, showing as a C source, (iv) Water Cycling: Water is an essential resource for agriculture and is involved in a complex cycling process within agricultural systems including facilitating plant nutrient uptake, stored in the soil, or lost through processes such as evaporation or runoff. This session will centre on fundamental aspects of biogeochemical processes occurring in the agricultural systems linking to C, N, P, and others as well as identify the driving variables and the research gaps.

OPENING SPEAKERS

Mr. Charlie McConalogue TD.

Minister for Agriculture, Food and the Marine, Ireland.

Minister Charlie McConalogue, born in Gleneely, Co Donegal, has been serving as Minister for Agriculture, Food and Marine since September 2, 2020. With a background in farming, he pursued studies in economics, Politics, and history at University College Dublin (UCD), where his involvement in politics began. Following work in Fianna Fáil Headquarters and abroad in Australia, he returned to his family farm before he was elected as Donegal County Councillor in 2009. In 2011, he was elected TD for Donegal Northeast.

Before his current role, he held positions including Minister of State at the Department of Justice and Equality, and spokesperson for Children, Education and Skills, and Agriculture, Food, and the Marine.

Dr. David Laborde

Director of the Agri-Food Economics Division (ESA), FAO of the United Nations, Rome, Italy

Dr. David Laborde, Director of the Agrifood Economics and Policy Division (ESA) at the Food and Agriculture Organization of the United Nations, leads economic research and policy analysis to enhance efficient, inclusive, resilient, and sustainable agrifood systems. His work supports better production, nutrition, environment, and life, ensuring that no one is left behind. His research areas cover food and agricultural policies, agribusiness, rural transformation, poverty, resilience, bioeconomy, and climate-smart agriculture.

Previously, Dr. Laborde was a Senior Research Fellow at the International Food Policy Research Institute (IFPRI), focusing on globalization, trade, protectionism measurement, and modelling for achieving Sustainable Development Goal 2. He has developed various models including MIRAGE and MIR AGRODEP for trade policy and environmental issues.

Mr. Juan Lucas Restrepo

Global Director (PA), CGIAR, Montpellier cedex 5, France

Juan Lucas Restrepo is the Global Director of Partnerships and Advocacy at CGIAR and the Director General of the Alliance of Biodiversity International and CIAT. A Colombian and French national, he has 25 years of experience in the agricultural sector, spanning public and private roles.

Restrepo has expertise in policy, value chains, markets, and agricultural research leadership. He has held various governance roles within CGIAR, including positions on the Committee of Genetic Resources Policy and CIAT's Board of Directors. He was Colombia's Vice Minister of Agriculture, Executive Director of AGROSAVA, and Chief Commercial Officer of the National Federation of Coffee Growers. Restrepo holds a civil engineering degree from Universidad de los Andes and an MS in agricultural economics from Cornell University.

ABSTRACTS: OPENING SPEAKERS

Transforming Agrifood Systems for Global Food Security and Climate Resilience: Leading Toward a More Sustainable and Low-Carbon Future

Laborde D.
Agrifood Economics and Policy Division, FAO of the United Nations, Italy.

Today, agrifood systems suffer to deliver global food security and nutrition for 8 billion people. Tomorrow the challenge is to provide nutritious food for 10 billion. It will be a daring task in itself, but in the context of climate change, it gets daunting. Agrifood systems contribute to and at the same time are affected by rapidly changing climate and more frequent extreme weather conditions putting at risk the wellbeing of millions of households, especially the most vulnerable ones. Without efficient and reliable agrifood systems, we cannot deliver on economic stability and provide nutrition to a growing global population. This is why we need to urgently break the silos and put agrifood systems at the forefront of a just transition tackling inequalities within and across nations, while delivering on climate actions. This shift in perspective underscores the critical need to prioritize investments in agrifood systems, not only to assure the right to food but also because agrifood systems are the ones that can reduce efficiently the burden to our nature and climate and deliver a more sustainable and low-carbon future.

To achieve this goal, FAO has envisaged the Global roadmap to achieving SDG2 without breaking 1.5C threshold which involves a multi-year process starting with a comprehensive global vision and developing into a detailed country-level analysis. The roadmap outlines how the transformation of agrifood systems should address food security and nutrition needs and facilitate actions aligned with mitigation, adaptation, and resilience objectives under the larger umbrella of climate action. It encompasses a diverse portfolio of 120 actions grouped into ten domains of actions including livestock, crops, fisheries and aquaculture, clean energy, food loss and waste, forests and wetlands, healthy diets, soil and water, data, and inclusive policies. The ultimate goal of the roadmap is to safeguard the pathway to the 1.5 °C target, ensuring sustainability, and securing the promise of food for today and tomorrow.

Boosting climate action through partnership and collaboration

Restrepo J. L.
CGAIR, France

In a world facing biodiversity loss, environmental degradation, and food insecurity, climate change is the cause and consequence of these interconnected challenges. Different factors impact our climate, including sustainable agriculture practices generating high GHG emissions, driving deforestation, biodiversity loss, and soil degradation. Increasing investment in science and innovation in climate-smart agriculture is crucial to shift towards more sustainable agricultural practices in food systems. Ensuring uptake of these innovations is only possible if those are context-specific and cocreated in collaboration with national stakeholders, including governments, private sectors, and farmers.

PLENARY SPEAKERS

Prof. Pat Dillon

Teagasc, Ireland

Professor Pat Dillon is the Director of Research at Teagasc, responsible for leading the organization's four research programs: Animal & Grassland Research and Innovation, Crops, Environment and Land Use, Food, and Rural Economy and Development. With a B.Ag.Sc. from University College Dublin and a PhD in Grassland Science from UCC, he joined Teagasc's research staff in 1990.

Having served as the Head of the Animal Production Research Centre in Moorpark and the Teagasc Animal & Grassland Research and Innovation program, Professor Dillon is widely recognized as a prominent scientist in sustainable, pasture-based livestock production. His extensive experience in technology development and industry engagement ensures that Teagasc remains a scientific leader in agriculture, food science, and related areas.

Dr. Ada Ignaciuk

OECD, France

Dr. Ada Ignaciuk, Senior Economist/Policy Analyst (Climate Change and Agriculture) at the OECD, previously held a similar role at the Food and Agriculture Organization (FAO). At the FAO, she led the CSA-EPIC team and focused on the economics of climate change and sustainable food production.

Dr. Ignaciuk earned her PhD from Wageningen University, analysing the bioenergy market. With experience at the Kiel Institute for the World Economy and the Netherlands Environmental Assessment Agency, she specializes in quantitative assessment of environmental policies.

At the OECD, she provided scientific, technical, and policy guidance on climate-friendly agricultural policies.

Dr. Jens Leifeld

Agrospcope, Switzerland

Dr. Jens Leifeld heads the Climate and Agriculture Group at Agroscope, Switzerland, having previously led the CO_2 Sources and Sinks team. A Privatdozent at Universität Basel since 2008, he earned his Ph.D. in Soil Science from Ruhr-Universität Bochum, Germany.

Dr. Leifeld's research focuses on quantifying agricultural greenhouse gas emissions, assessing climate change impacts, and exploring adaptation strategies. His group employs advanced methods and modelling to study agricultural soil's role as a carbon source or sink, emphasising sustainable management in organic soils. Additionally, he serves on scientific advisory boards and committees related to peatland monitoring and climate protection programmes at the international level.

ABSTRACTS: PLENARY SPEAKERS

Ireland's Strategy to Reduce Greenhouse Gas Emission from Agriculture by 25% by 2030

Dillon P.
*Teagasc, Ireland. * pat.dillon@teagasc.ie*

Global temperatures have increased by more than 1°C since pre-industrial times. Scientists warn that without increases in both ambition and action, warming will exceed 2°C by the end of the century. These changes have the potential to have a devastating impact on the world's environment and food security. Urgent action is needed in all countries and sectors including agriculture to reduce emissions, increase carbon removals/sequestration and prepare to adapt to the changing climate. In July 2022, the Irish Government set a target for the agriculture sector of a 25% reduction in greenhouse gas emissions (GHG) by 2030 (5.75 Mt CO_2e). In response to this Teagasc launched a Climate Action Strategy in December 2022 setting out a road map on how this can be achieved without influencing the competitiveness of the agri-food sector.

The strategy consisted of three pillars: (1) Signpost Advisory Programme to support the adoption of GHG mitigation technologies on farms; (2) Sustainability Digital Platform to enable farmers to estimate their current emission and removal profile and (3) Virtual Climate Centre to coordinate and accelerate climate research and innovation. Additionally, Teagasc has developed a Marginal Abatement Cost Curve (MACC) that helps stakeholders make informed decisions about how to allocate resources for emissions reductions. It provides insights into the cost-effectiveness of different abatement options and helps identify the least costly ways to achieve a given emissions reduction target. The MACC identified key abatement options to reduce nitrous oxide, which included replacing chemical N with biological fixed N, increasing soil pH, using low-emission slurry spreading, and using protected Urea. Key abatement options to reduce methane emissions included increasing the genetic merit (EBI) of the dairy herd, reducing the age of finishing of beef cattle, slurry amendment, and feed additives.

Advancing agriculture, forestry, and other land use policies: trends and assessments on the mitigation efforts

Ignaciuk A.*
*OECD, Paris, France. * ada.ignaciuk@oecd.org*

Climate change mitigation is a priority for policymakers across many sectors including the AFOLU sectors. This paper conducts a literature review of existing AFOLU mitigation-related policies and policy assessments in OECD member countries and major economies to observe trends. Globally, policymakers use a diverse selection of AFOLU policy instruments to intentionally reduce greenhouse gas (GHG) emissions, in addition to instruments that may have emission mitigation co-benefits. The research, development, adoption, and use of different AFOLU policy instruments with mitigation effects have evolved over time in response to changing knowledge, demands, and pressures from factors including climate change, food systems, and producers.

Additionally, the mitigation effects and cost-effectiveness of these policy instruments are highly dependent on factors including the environment, farm system, and policy design. Therefore, location-specific consideration is necessary by policymakers and by academic and government policy assessments. This paper concludes that academic policy studies are critical to the development, improvement, and assessment of mitigation progress for countries, often filling gaps and leading future changes. However, further policy studies are necessary to ensure emission targets are achieved, particularly evaluations on the mitigation effects of existing policies.

Climate-smart management of agricultural organic soils: Ways ahead

Leifeld J.
*Agroscope, Zurich, Switzerland. * jens.leifeld@agroscope.admin.ch*

Management of former peatlands for agriculture or forestry is globally one of the largest greenhouse gas sources in the land-use sector. The agricultural benefit gained from peatland drainage comes at the expense of irreversible soil degradation, and impairment of important functions such as biodiversity and water storage. Peatland rewetting is increasingly considered a silver bullet to not only reverse the climate burden induced by peatland management but also recover other ecosystem services.

In this plenary presentation, rewetting as well as options to improve the situation of managed peatlands will be analysed for their potential and feasibility. Beyond that, I will address the question of how to get there. In this context, the possible role of carbon farming and other measures to support alternative management options will be discussed.

ABSTRACTS: INVITED EXPERT

Can precision agriculture contribute to the mitigation of agriculture's impact on climate change?

Mounem Mouazen A.*
*Ghent University, Ghent, Belgium. *abdul.mouazen@ugent.be*

Precision management of farm input resources refers to the application of the right rate of input in the right place and time using an integrated solution of sensing, modelling, and control technologies. However, the first requirement for managing the within-field spatio-temporal variability is the accurate measurement and mapping of parameters affecting crop growth and yield. But, the agriculture system even at field or subfield scales is complex, as crops are affected by multiple limiting factors simultaneously, including soil attributes, crop biotic and abiotic stresses, topography and weather conditions. This necessitates an advanced sensing approach consisting of multiple sensor technologies and data fusion to maximize the quality of data collected and the creation of accurate and science-based variable rate recommendations of different farm input resources.

This paper focuses on the potential of multi-sensor and data fusion approaches for variable rate applications. The majority of variable rate recommendations are made using either soil or crop data including yield. According to the agriculture system approach discussed above, recommendations derived with individual input parameters are not the ideal solution. This paper will discuss case studies of variable rate applications based on the fusion of data on soil, crop, present and historical yield, and weather conditions. While this data fusion approach is implemented in map-based variable rate applications, case studies of sensor-based and map-sensor-based will be presented. The case studies include variable rate fertilisation, fertigation, manure applications, seeding, and agrochemical applications. Results of cost-benefit and environmental analyses of the selected case studies will be also presented. Conclusions on how much variable rate technology can potentially contribute to reducing the contribution of agriculture to climate change will be discussed.

Farm Zero C – Attempting to create a climate neutral nature positive commercial dairy farm in Ireland

Connor K. O.*
*University College Dublin, Dublin 04, Ireland. * kevin.oconnor@ucd.ie*

Agriculture provides food for the planet and is a major wealth creator for rural economies globally. The farm is under increased pressure to address the climate emergency by reducing greenhouse gas (GHG) and ammonia emissions whilst increasing biodiversity. The economic model of high-quality food at low prices has led to a focus on increasing productivity, intensification, and movement away from sustainable grass-based systems. We must uncouple food production from GHG and biodiversity loss.

Creating a net zero emissions resilient dairy farm will create a new business model for food production, and feed into a growing environmentally conscious consumer market. To achieve this, we have taken a holistic approach to the farm examining a wide variety of strategies include reducing ruminant emissions, changing grassland management, increasing biodiversity, changing to renewable energy, and performing a Life Cycle Analysis of the farm. Farmers can be leaders in the fight against climate change and enhancing biodiversity, but it requires on-farm data activities that they can see and data that they can trust. Engagement with farmers through the Farm Zero C is an important pillar of the project to promote the two-way sharing of knowledge and translation of research into practice.

ABSTRACTS OF THE SCIENTIFIC SESSIONS

Theme 1: Grassland Systems

Climate-resilient grasslands and the net zero agricultural transition (Keynote)

Donnison I.*
*Aberystwyth University, Wales, UK. * isd@aber.ac.uk*

Sustainable agriculture and land management is important for ensuring that future generations can continue to sustainably produce food, feed, and biobased resources whilst enjoying the countryside. There are a number of megatrends, that particularly relate to grassland agriculture which are: 1) Climate change, and the challenge of adaptation including increasing diversity of the sward to promote resilience; 2) the need to reduce GHG emissions and the opportunity for mitigation through carbon sequestration and negative emission approaches; 3) Adoption of new technologies including genomics, artificial intelligence, and robotics. More specifically, solutions include the development of forage crop varieties that are deeper rooting to increase resilience as well as reducing flood risk and runoff. In addition to such production and public good benefits, varieties with enhanced feed properties, e.g. high sugar grasses, can increase production and reduce the risk of nitrogen pollution. Such production gains should also deliver benefits in terms of fewer greenhouse gas emissions per unit of production.

Farming is in the unusual position of being both an emitter of greenhouse gases and having the opportunity to reverse past industrial emissions through land-based greenhouse gas removal approaches. There are different ways of responding to the range of challenges, for example: 1) by doing what we do now but more efficiently, including by developing and adopting the latest varieties, equipment, and agronomies; 2) by using the same grassland crops and maintaining the same landscape but with new uses, for example as feedstocks for grassland based biorefineries, with outputs including proteins for monogastrics (reducing the need for imported soya) as well as industrial feedstocks, platform chemicals, and pharmaceuticals; 3) by development and adoption of new crops and agriculture, with new value chains complementing existing agriculture but addressing new needs and markets. There are exciting opportunities for the future grassland agriculture industry, but with that comes significant change and a need to help the sector navigate these changes.

Total greenhouse gas balance from four-year grassland rotation–Nitrogen fertilizer experiment

Pääkkönen M.*
*University of Eastern Finland, Kuopio, Finland. *minna.paakkonen@uef.fi*
Maljanen M.*
*University of Eastern Finland, Kuopio, Finland. *marja.maljanen@uef.fi*
Lamprecht R.*
*University of Eastern Finland, Kuopio, Finland. *richard.lamprecht@uef.fi*
Kykkänen S.*
*Natural Resources Institute Finland, Maaninka, Finland. *sanna.kykkanen@luke.fi*
Virkajärvi P.*
*Natural Resources Institute Finland, Maaninka, Finland. *perttu.virkajarvi@luke.fi*

Grasslands are an important section of Finland's economy. One-third of Finland's agricultural used land area is grasslands less than five years old as grasslands are typically renewed after three to four years due to winter damage. A high number of grasslands is linked to the meat and dairy industry as over 50% of cattle energy source is silage grass. Nitrous oxide (N_2O) emissions from agricultural soils are mainly linked to nitrogen fertilizer use and these emissions account for 74% of total N_2O emissions in Finland. On the other hand, nitrogen (N) has the strongest effect on grass yield and C uptake. However, less is known about the effect of N fertilization on CO_2 emissions and the effect of N_2O emissions on Nordic short-term leys. With the aim to reduce greenhouse gas (GHG) emissions from agricultural soils, the University of Eastern Finland and the Natural Resources Institute of Finland conducted a full four-year (2019–2023) measuring campaign on experimental plots in mineral soil in Eastern Finland.

To enhance the fertilizer N use efficiency, the effects of different nitrogen fertilizer rates (0, 150, 300 kg N per hectare per year) on crop yield and yearly GHG emissions were studied. We measured annual carbon dioxide (CO_2) exchange, N_2O, and methane (CH_4) emissions with manual chambers during the growing seasons and with the snow gradient method in winters. The daily CO_2 exchange during the growing seasons was modelled based on weekly measurements of GHG and environmental factors and the inclusion of meteorological data. Wintertime CO_2 emissions outside the growing seasons and annual N_2O and CH_4 emissions were determined using fortnightly measurements. Additionally, we performed comprehensive soil analysis five times during the growing season. A full four-year grassland cycle of measured GHGs with renovation year included will be presented with the effects of N-fertilizer rates.

Interactions between plant biodiversity and productivity in semi-natural grasslands

Wingler A.*
*University College Cork, Cork, Ireland. * astrid.wingler@ucc.ie*
Halpin E.*
*University College Cork, Cork, Ireland. *123120888@umail.ucc.ie*
Lynch Milner O.*
*University of Galway, Galway, Ireland. * o.lynchmilner1@universityofgalway.ie*
Hayes M.*
*University College Cork, Cork, Ireland. * shayes@ucc.ie*
Bacon K.*
*University of Galway, Galway, Ireland. *karen.bacon@universityofgalway.ie*
Cawkwell F.*
*University College Cork, Cork, Ireland. * f.cawkwell@ucc.ie*

Semi-natural grasslands are typically managed extensively by grazing or hay cutting and can harbour considerable plant biodiversity. In addition, they provide ecosystem services such as carbon sequestration, erosion reduction, pollinator support, and pests and diseases control. Research for experimental plots (sown grasslands) shows that grassland above-ground productivity and below-ground carbon accumulation increase with plant species richness. However, little is known about how plant biodiversity (species richness and functional diversity) affects the productivity of semi-natural grasslands and their potential to sequester soil carbon.
This research focuses on three Irish grassland habitats: GS1 – dry calcareous & neutral grasslands, GS3 – dry-humic acid grasslands, and GS4 – wet grassland. Botanical surveys in 2023 show that GS1 grasslands had the highest plant species richness, followed by GS4 and GS3 grasslands. The findings were compared to the 2007-2012 Irish Semi-natural Grasslands Survey. Although there was no overall decline in species richness since 2007-2012, species richness declined at some sites. Remote sensing was used to determine the relationship between the Normalized Difference Vegetation Index (NDVI; as a measure of productivity) and biodiversity. Surprisingly, a negative correlation was found between species richness and Landsat NDVI, which was confirmed for NDVI from UAV imagery, suggesting that sites with fewer species had higher productivity.

To determine the role of plant functional diversity in grassland productivity, plant functional traits (leaf area, LA; leaf dry matter content, LDMC; specific leaf area, SLA) were determined and used to calculate community-weighted means of functional strategies. The first results indicate differences in the competitive (C), stress tolerance (S), and ruderal (R) strategies between the grassland habitats, with stress tolerance strategies dominating at GS1 grasslands. Overall, our results indicate that species-rich GS1 grasslands are dominated by stress tolerators with low productivity. Further research will relate plant functional diversity to climate resilience and soil carbon.

Eddy covariance fluxes of GHGs from boreal mixed farming grasslands

Shurpali N.*
*Natural Resources Institute Finland, Maaninka, Finland. * narasinha.shurpali@luke.fi*
Peltola O.*
*Natural Resources Institute Finland, Maaninka, Finland. * olli.peltola@luke.fi*
Semberg S.*
*Natural Resources Institute Finland, Maaninka, Finland. * sanni.semberg@luke.fi*
Manninen P.*
*Natural Resources Institute Finland, Maaninka, Finland. * petra.manninen@luke.fi*
Virkajärvi P.*
*Natural Resources Institute Finland, Maaninka, Finland. * perttu.virkajarvi@luke.fi*

Finland, with a predominantly boreal climate, is known for its milk production with an average yield of 8888 kg per cow in 2022. Grass-based production is the key to sustainable milk and beef production. Grass is the main feed for milk and beef cattle. As a perennial plant, grass is almost the only crop plant that has the potential of preserving soil carbon and a large share of grasslands are carbon sinks. Milk and beef production are tightly connected, and most of the Finnish beef production originates from the milk chain. The growing season is short varying from 105 days in the north to 185 days in the south. The region is characterized by two types of soils: mineral and organic soils. Mineral soils are typically well-drained and have a low organic matter content, whereas organic soils are characterized by high organic matter content and high-water retention capacity. Grasslands are a key component of boreal agriculture and can play a significant role in soil carbon sequestration and mitigation.

With this in view, the Natural Research Institute Finland has initiated a long-term GHG monitoring framework for sustainable grassland management and agriculture across several agricultural research clusters in Finland. Continuous data on GHG fluxes managed grasslands on different soil types are being collected using the eddy covariance technique since 2020. Here, we present seasonal and annual variability in GHG fluxes from three grassland sites of the Maaninka research cluster in eastern Finland during two complete study years (2022 and 2023).

Climate change induces losses of soil macroaggregates and associated OC in Alpine Grassland

Garcia Franco N.*
*Technical University of Munich, Freising, Germany. * noelia.garcia-franco@tum.de*
Wiesmeier M.*
*Bavarian State Research Center for Agriculture, Freising, Germany. * martin.wiesmeier@lfl.bayern.de*
Buness V.*
*University of Agricultural Sciences, Umea, Sweden. * vincent.buness@slu.se*
Kögel-Knabner I.*
Technical University of Munich, Freising, Germany
*Institute for Advanced Study, Garching, Germany. * koegel@tum.de*
Kiese R.*
*Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research, Garmisch-Partenkirchen, Germany. * ralf.kiese@kit.edu*
Dannenmann M.*
*Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research, Garmisch-Partenkirchen, Germany. * michael.dannenmann@kit.edu*

Climate warming is more severe in Alpine and pre-alpine grassland soils compared to lowland regions. In our study we assessed the effect of warming (+1°C, +2°C, and +3°C) on i) SOC stocks; and ii) soil structure in grassland soils of the Northern Limestone Alps in Germany. We translocated plant-soil mesocosms from high (1260 m a.s.l.) and medium elevations (860 m a. s. l.) to low elevation (600 m a.s.l.). Our experimental design combined both site re-location and altitude translocation allowing differentiating between the effects of soil manipulation and climate change. In addition, two different grassland management practices: i) extensive (2 cuts for hay and 67 N kg ha^{-1} yr^{-1} slurry application); and ii) intensive (4-5 cuts for hay and 170 N kg ha^{-1} yr^{-1} slurry application) were carried out on translocated mesocosms.

Four years of warming induced by translocating plant-soil mesocosms along an elevation gradient in Alpine and pre-alpine grassland soils resulted in a rapid decrease of SOC and N stocks (24-25%), particularly under extensive grassland management. These losses were associated with a decrease in the proportion of macroaggregates and the fPOM fraction under both extensive and intensive management. Intensive management with higher manure C return than extensive management (1.598 vs. 0.795 t C ha^{-1} yr^{-1}) only slightly offset the losses of SOC in the plant-soil mesocosms. Optimised grassland management in the form of increased application of organic fertilizers could only partially offset the SOC loss by improved the formation of small macroaggregates.

Theme 2: Climate Change and Agro-farming Policy

Climate Adaptation Policies in the Agriculture Sector at the Subnational Level (Keynote)

Puppim de Oliveira J.*

*FGV, Sao Paulo, Brazil. * jose.puppim@fgv.br*

This presentation introduces a new framework for assessing the effectiveness of the implementation of climate adaptation policies for the agriculture sector at the subnational level. It is based on a recent empirical study. The role of the subnational level in climate policy is highly relevant, especially on the heels of the Paris Agreement (PA) of 2015. However, there is limited literature on climate adaptation policy implementation at the subnational level in the agricultural sector. Climate adaptation policy in agriculture is generally discussed at the national level, and subnational climate adaptation policies rarely address agriculture.

Thus, this framework was developed to fill this gap by establishing an analytical framework based on the two existing literature, which are not connected: climate adaptation policies at the subnational level and adaptation policies in the agricultural sector. The core components of the framework are (i) locally driven initiatives, (ii) locally capable institutions, (iii) legally implementable measures, and (iv) effective intergovernmental relations. It will show some studies that apply this framework and its implications to academia and practice.

Grass production and fodder deficits in Ireland under projected mid-century climatic conditions

Leahy P.*
*University College Cork, Cork, Ireland. * paul.leahy@ucc.ie*

Intensive pasture-based agricultural systems, such as Ireland's, rely on high productivity and long growing seasons. Grass is typically grazed during summer months and during winter months these systems rely on stored fodder, usually silage. Intensively-managed grassland systems may be vulnerable to periodic grass fodder deficits which may develop into so-called 'fodder crisis', leading to severe impacts on agricultural output, animal welfare, and farm incomes. These crises arise due to a number of environmental and non-environmental drivers. Delays, reductions or disruptions in grass growth during the growing season may result in fodder stocks being drawn down and insufficient stock remaining for the subsequent winter season. Multi-annual events are of particular concern.

The goals of this study were to develop an impact-based fodder crisis severity index to classify fodder crisis events in Ireland; to use a data-driven modelling approach to examine the historic incidence of conditions associated with the emergence of fodder crisis; and to use climate predictions coupled with a grass growth model to project future occurrences of such events.
The severity index has been applied to fodder crises in the historic study period of 1946 to 2022. The modelling approach performed well in general with a linear relationship observed between historic model simulations and contemporaneous observations of daily grass growth. Simulations under projected mid-century (2041-2070) conditions indicate a general decrease in grass growth throughout Ireland, with the decrease being strongest in the more extreme RCP8.5 climate change scenario compared to the more likely RCP4.5 scenario. Increases in growth are projected for Spring and decreases are projected for Summer and also in most areas for Autumn.

Measures to improve the resilience of pasture systems are recommended, particularly in light of the projected reductions in autumn growth. These include earlier closure in autumn and the development of early warning systems.

Potential global sequestration of atmospheric carbon dioxide by drylands forestation

Moinester M.*
*Tel Aviv University, Tel Aviv, Israel. * murray.moinester@gmail.com*
Kronfeld J.*
*Tel Aviv University, Tel Aviv, Israel. * joel.kronfeld@gmail.com*
Qubaja R.*
*Arizona State University, Tempe, USA. * rafat.qubaja@gmail.com*

Forestation of global drylands offers the potential for long-term sequestration of atmospheric CO_2. Economic deep-rooted climate-adapted trees and shrubs having medicinal, pharmacological and nutritional values (e.g., Moringa, Jojoba, Creosote, etc.) can be included. Israel's Yatir Forest is a planted Aleppo pine forest growing at the semi-arid timberline, having 280 mm average annual precipitation (with no irrigation or fertilization). The organic and inorganic carbon sequestration rates (assumed representative of global drylands) were measured at Yatir to be 550 g CO_2 m-2 yr-1 (150 g C) organic carbon in the tree's biomass, and ~132 g CO_2 m-2 yr-1 as calcite (CaCO3) precipitates (primarily from root exhaled CO_2 to ~6-meter depth). Soil microbes contribute to precipitating calcite by acting on diffused atmospheric CO_2 (to ~1 meter). The CO_2 combines with soil H2O to form bicarbonate (H CO_3-), which combines with soil Ca2+ to form calcite. The potential maximal efficacy of global forestation for reducing global warming and ocean acidification depends on the maximal area available for sustainable forestation.

The dominant limitation, particularly in the vast desert regions, is the apparent lack of water. However, in many dryland areas, plentiful water is available from immediately underlying local paleowater (fossil) aquifers. Using such water, until now not previously taken into consideration, would yield a functional dryland forestation area of ~9.0 million km^2. This would yield a potential total sequestration rate of at least ~7.0 Gt CO_2 yr^{-1}, divided between 5.0 Gt CO_2 yr^{-1} (organic) and 2.0 Gt CO_2 yr^{-1} (inorganic). Note however that the transformation of bright high albedo deserts to darker forests could reduce the positive projected climate cooling effects attained by as much as ~25%. Summarising, such forests would sequester carbon, produce wood, fruits, and nuts, increase biodiversity, improve soil structure and health, reduce erosion, increase rainfall, improve water quality, and provide wildlife habitat.

Agriculture's Greenhouse Gas Emissions in Lower and Upper Middle-income Countries

Fayisa T.*
*University of Warsaw, Warsaw, Poland, and Wollega University, Nekemte, Ethiopia. * t.fayisa@student.uw.edu.pl*
Rokicki B.*
*University of Warsaw, Warsaw, Poland. * brokicki@wne.uw.edu.pl*

The majority of empirical studies examining how the economy influences climate change in developed countries largely focus on carbon dioxide (CO_2) emissions due to its dominance among greenhouse gases (GHGs). However, in developing countries where agriculture contributes

substantially through methane (CH_4) and nitrous oxide (N_2O) emissions, and CO_2 levels are lower than in developed countries, most of the study tends to emphasize only CO_2. This research examines the contribution of agriculture to GHG emissions in developing countries from 1993 to 2021, utilising recently released FAO data and employing the STIRPAT model. The empirical data show that, although the proportion of agri-food emissions to total GHG is declining in these countries, primarily due to the rapid increase in energy emissions in Asia, emissions from the agri-food sector still contribute to over 50% of GHG emissions resulting from changes in land use in Africa, from the farm gate in Asia, and a balance between the two in Latin America.

Our findings indicate a robust positive influence of agricultural emissions on GHGs. A 1% increase in agri-food emissions corresponds to a 0.334% increase in GHGs, while a 1% increase in AFOLU emissions results in a 0.228% increase in GHGs, both statistically significant at 1%. The findings also reveal that emissions from both agri-food and AFOLU significantly and positively impact CH_4 and CO_2. A 1% increase in agri-food emissions corresponds to a 0.158% increase in CH_4 and a 0.525% increase in CO_2 emissions. The study also shows that emissions from the agri-food sector hold greater sway in upper-middle-income countries while emissions from AFOLU activities exert a stronger influence in lower and lower-middle-income countries. Considering the substantial role of the agri-food sector in greenhouse gas emissions, policymakers must acknowledge the diverse regional factors driving agricultural emissions and tailor mitigation strategies accordingly.

CO_2-balance as a tool to optimize carbon storage on farmer's land

Tits M.*
*Soil Service of Belgium, Heverlee (Leuven), Belgium. * mtits@bdb.be*
Verbeeck M.*
*Soil Service of Belgium, Heverlee (Leuven), Belgium. * mverbeeck@bdb.be*
Santy L.*
*Regionaal Landschap Zuid-Hageland, Tienen, Belgium. * luca.santy@rlzh.be*
Justaert K.*
*Regionaal Landschap Zuid-Hageland, Tienen, Belgium. * kristien.justaert@rlzh.be*
Elsen A.*
*Soil Service of Belgium, Heverlee (Leuven), Belgium. * Elsen aelsen@bdb.be*

Every kilogram of carbon stored long-term in soils removes 3.7 kilograms of CO_2 from the atmosphere. Flemish agricultural soils still have an important carbon storage potential, as statistics from the Soil Service of Belgium show. To help farmers better utilize this potential, CO_2 balances were calculated for 30 farms in different agricultural regions and soil types, including arable, livestock, fruit, and mixed farms. The balances provide a detailed carbon and greenhouse gas (CO_2 and N_2O) report of the soil and woody biomass. Information was collected about fields, crops, soils, manure production and use, fertiliser use, liming, and the presence of woody landscape elements. Carbon sequestration was estimated from plant residue and organic inputs, corrected for degradable C-fractions, and the growth of woody biomass. CO_2 and N_2O emissions from soil organic matter degradation and the use of fossil fuels during fieldwork were estimated using literature-based coefficients. Emissions from fertilisers and lime were calculated using IPCC coefficients. Participating farmers received a detailed report quantifying actual carbon storage in their soils and trees, annual carbon sequestration and degradation through field-related activities, and greenhouse gas emissions.

Possible measures tailored to the farm were proposed to tilt the balance in a (more) positive direction, including the incorporation of organic amendments, crop residues or prunings, the adjustment of crop rotations, the creation of permanent grassland, the planting of hedges and agroforestry. Unlike other CO_2 footprinting tools, our calculations were limited to field-related

activities and woody biomass. The impact of livestock (methane emissions, purchase of animal feed, etc.), the footprint of imported and exported products, and the purchase/maintenance of machines and buildings were not included. This method uses readily available data, allowing a reliable and useful estimation of the climate impact of farms.

Prospects of the Low-emission Transformation of Saudi Agricultural Systems

Eltayeb Abdelnour Adam A.*

*National Research and Development Center for Sustainable Agriculture, Riyadh, Saudi Arabia. * adilnour@estidamah.gov.sa*

Abdalla Alrasheed W.*

*National Research and Development Center for Sustainable Agriculture, Riyadh, Saudi Arabia. * alrasheedw@estidamah.gov.sa*

The Saudi agricultural sector faces many challenges that constrain food production; its ability to adapt to climate change, produce more food in an arid environment, control food waste, and landfilling with organic materials. Some of these contribute to high emissions of greenhouse gases (GHGs). This research paper investigates the potential for reducing GHG emissions in Saudi Arabia's agricultural sector. The paper explores the impacts of water, energy, land use, and food demand on GHG emissions. It emphasises sustainable food production and consumption practices and recommends strategies for mitigating and managing GHG emissions. The study employs policy and literature reviews and analyses existing GHG emission datasets for the period 1990-2020. The findings highlight deficiencies in environmental monitoring indicators and suggest mitigation strategies such as climate-smart agriculture, efficient cattle farming, improved nitrogen fertilization, and optimized food supply chains. The study recommends the development of a carbon credit system to incentivize emissions reductions and generate credits for farmers. Overall, the study suggests that the agricultural sector can be reorganised for improved sustainability, supporting Saudi Arabia's ambition to reduce carbon emissions.The potential GHG emission reduction strategies for the Saudi agricultural sector follows:

1- Climate-smart agriculture: Practices that help to improve agricultural productivity, such as the use of drought-resistant crops and improved irrigation techniques.
2- Efficient cattle farming: Practices that reduce methane emissions from cattle production systems, such as improved manure management and breeding programs.
3- Improved nitrogen fertilization: The use of slow-release fertilizers and their application at the right time and amount
4- Optimized food supply chains: Practices that reduce food waste and spoilage, such as improved storage and transportation facilities.

The paper recommends policy frameworks that encourage the widespread adoption of climate-smart agriculture solutions tailored to arid climates and policies that meet the 2023 sustainable development goal targets.

Beyond Mitigation, Adapting to Climate Change: A Bottom-Up Approach to Inform Policy

Mohammadrezaei M.*
*Teagasc, Dublin, Ireland. * mohammad.mohammadrezaei@teagasc.ie*
Henchion M.*
*Teagasc, Dublin, Ireland. * maeve.henchion@teagasc.ie*
Balaine L.*
*Teagasc, Athenry, Ireland. * lorraine.balaine@teagasc.ie*
Meredith D.*
*Teagasc, Dublin, Ireland. * david.meredith@teagasc.ie*
Macken-Walsh A.*
*Teagasc, Athenry, Ireland. * aine.mackenwalsh@teagasc.ie*

In the face of climate change, Ireland faces increasingly variable and extreme weather. Farm businesses are particularly vulnerable to the impacts of these events and there is a growing emphasis in public policy on the need to foster more resilient and sustainable food systems through farm-level adaptation strategies. To this end, understanding farmer behaviour related to the adoption of adaptation measures is crucial in developing tailored climate change policies, initiatives, and farm extension programmes. Farmers are envisaged as accepting of climate-smart management approaches that are tailored to the needs of their farms. To develop policies that underpin this process, a bottom-up approach is needed to promote sustainable farm-level adaptation, where heterogeneous farmers can change their farm management practices by adopting adaptation strategies (addressing local and context-related climate change challenges).

This highlights a need for more aligned and tailored climate adaptation policies, initiatives, and extension programmes aimed at promoting farm-level adaptation to target or considers farmers' psychosocial, economic, and biophysical factors affecting their behaviour. However, the understanding of farm-level decision-making regarding adaptation strategies, with a focus on not only extrinsic motivations such as business, background, and biophysical factors but also intrinsic motivations, namely psychosocial factors, has been understudied, particularly in informing climate adaptation policy in Ireland. This study applies a bottom-up, multi-faceted approach by using the Socio-Ecological Model (SEM) to understand farmers' behaviour change towards adaptation to provide an evidence base for the development of national adaptation policy and extension programmes. This presentation outlines the mixed methods research approach developed to explore farmers' intentions to adapt their farms or farming practices in anticipation of uncertain and extreme weather events and thereby make them more resilient. The findings of advisors' focus groups and farmers' in-depth interviews along with lessons learned for policy and extension programmes will be presented at the conference.

The Australian Agriculture Sustainability Framework advancing global sustainability and climate change policy.

Mahar T.*
*Aust Farmers Federation, Canberra, Australia. * thisistonym@gmail.com*

The sustainability of agriculture is a critical concern at a local, national, and global level. The requirement for a robust policy framework that balances the challenge of reducing environmental footprints, maintaining vibrant rural communities, and promoting sustainable agricultural systems in the face of climate change is vital. Government and industry policy agendas will require actionable insights that demonstrate agriculture's sustainability credentials across various

commodities, fostering a cohesive and cross-commodity policy approach to sustainability is an imperative. In Australia, the Agricultural Sustainability Framework (AASF) is being established as a foundation initiative to articulate and demonstrate the sustainable future of agriculture. It is a collaboration between industry and government that responds to and aims to shape and influence policy. Unlike commodity-specific approaches which focus on on-farm best practices for particular commodities, the AASF provides a comprehensive chronicle of sustainability across the entire agricultural sector. The AASF serves as a nexus for policy development, shared learning, collaboration, and the continuous evolution of agriculture at a national and global level.

This groundbreaking framework not only enhances Australia's sustainability story but also complements the detailed reporting facilitated by global sustainability frameworks. The symbiotic relationship between the AASF and sector-specific approaches will enable a coordinated and robust policy agenda, ensuring that the efforts and progress made by individual producers and commodity approaches, contribute to the overarching but at times competing sustainability goals of the community, government, and the farming industry. The pivotal role of frameworks that advance sustainability and climate change within Australian agriculture, underscores the importance of collaboration, innovation, and alignment with global sustainability standards to ensure the long-term viability of food and fibre production.

Theme 3: Regenerative Agriculture and Nature-based Solutions

Cultivating Tomorrow: Unveiling the Potential of Regenerative Agriculture for Sustainable Agri-Food Systems (Keynote)

Sharma S.*
*IRRI, New Delhi, India. * sheetal.sharma@irri.org*

This presentation endeavours to delve into the intricate principles and operational dynamics of regenerative agriculture. With the persistent escalation in the worldwide food demand, conventional farming techniques are increasingly revealed as unsustainable, resulting in detrimental environmental impacts and diminishing agricultural yields. Regenerative agriculture presents a comprehensive paradigm that not only confronts these pressing issues but also fosters soil vitality, biodiversity conservation, and the fortification of farming communities' resilience. The objective of this exploration is to advocate for the adoption of sustainable and regenerative methodologies in agrifood systems by comprehensively grasping the multifaceted nature of this approach. Through an in-depth analysis of regenerative agricultural practices, we seek to provide insights into their application, efficacy, and potential for transformative impact. By elucidating the principles underpinning regenerative agriculture and showcasing real-world examples of successful implementation, we aim to inspire and empower stakeholders within the agri-food industry to embrace a paradigm shift towards more environmentally harmonious and socially equitable agricultural practices.

Furthermore, this presentation will underscore the imperative of collaboration and knowledge exchange among stakeholders, including farmers, policymakers, researchers, and consumers, to facilitate the widespread adoption of regenerative agriculture in food production systems. By fostering dialogue and sharing best practices, we aspire to catalyze a collective effort towards creating a sustainable and regenerative future for rice farming, one that not only meets the present needs but also preserves the integrity of our ecosystems and enhances the well-being of future generations.

Systemic change for resilient and climate-neutral agriculture - Learnings from European cases

Lebelt L.*
*EIT Climate-KIC, Amsterdam, Netherlands. * laurene.lebelt@climate-kic.org*
Visser S.*
*EIT Climate-KIC, Amsterdam, Netherlands. * saskia.visser@climate-kic.org*

EIT Climate-KIC’s Resilient and Climate Neutral Regions Cluster works to support the transformation of regions towards resilience and climate neutrality, by applying systems innovation approaches. EIT Climate-KIC operates a portfolio of research and innovation activities with a network of partners across Europe, taking a holistic view of regional transitions – of which climate-neutral and resilient agrifood systems are an integral part. EIT Climate-KIC’s agrifood portfolio includes diverse formats of intervention: Deep Demonstration activities, where we orchestrate the participative design and activation of systems transformation strategies with local stakeholders; Research and innovation projects, where we develop knowledge and test new practices with European consortia; and networking activities, where we facilitate communities of practice based on demonstration, sensemaking, and peer-to-peer learning. From these activities, we develop insights, tools, and methodologies to support change at scale.

In this presentation, we will discuss levers and barriers at play in the transition towards a more sustainable and resilient agrifood system, with a focus on Carbon Farming and Nature-Based Solutions in agriculture. We will highlight challenges and success factors identified for the adoption of sustainable and resilient farming practices at scale, looking across the lever of change matrix – including technology, knowledge and data, skills, policy, finance, business models, and stakeholder engagement. For this, we will rely on learnings from several projects, looking both at national initiatives (Ireland Agri-food system Deep Demonstration) and at cross-European experimentation (ClieNFarms, Climate Farm Demo, and CREDIBLE). The presentation will include examples from the field, key learning points, and questions to be addressed collectively.

The combined effect of drought and salinity stress on baobab seed germination

Agbohessou M.*
*Cheikh Anta Diop University, Dakar, Senegal, and University of Abomey-Calavi, Abomey-Calavi, Bénin. * magbohessou@gmail.com*
Salako V.*
*University of Abomey-Calavi, Abomey-Calavi, Bénin. * salakovalere@gmail.com*
Akin Y.*
*University of Abomey-Calavi, Abomey-Calavi, Bénin. * yanakinde22@gmail.com*
Dieng B.*
*Cheikh Anta Diop University, Dakar, Senegal. * birane4.dieng@ucad.edu.sn*
Assogbadjo A.*
*University of Abomey-Calavi, Abomey-Calavi, Benin. * assogbadjo@gmail.com*
Noba K.*
*Cheikh Anta Diop University, Dakar, Senegal. * kandioura.noba@ucad.edu.sn*

The baobab tree (*Adansonia digitata* L.) is an iconic and culturally significant species, known for its resilience and adaptability to harsh environmental conditions. Using a randomized complete design, this study investigated the combined impact of drought and salinity stress on seed germination in three distinct provenances of baobab trees from Senegal. Through a controlled laboratory experiment, we subjected seeds from different regions to varying levels of drought stress (Control: 0; Low: - 4 bars; high: - 8 bars) and salinity (Control: 0; Low: 20mMol; High: 40mMol), monitoring their germination rates. The germination number was recorded daily for 28 days. We performed log-logistic distribution on germination events, analysis of variance (ANOVA) on provenance, treatments of seeds, and generalized linear models.

Results showed a significant effect of drought stress on germination rate. However, salinity stress had a moderate effect on the germination rate. These results emphasize the importance of preserving genetic diversity within baobab populations and highlight the potential consequences of changing environmental conditions on this keystone species. This study not only contributes to the understanding of baobab seed germination but also underscores the necessity of proactive conservation strategies in the face of climate change and increasing environmental challenges. The insights gained from this research have implications for the management and conservation of baobab populations in Africa.

A review of defining regenerative agriculture for Ireland's tillage sector

Johannes Kriek C.*
*University College Cork, Cork City, Ireland. * hannokriek@gmail.com*

Ireland's agricultural sector is the leading source of greenhouse gas emissions and the main cause of land transformation. A promising solution to tackle the agricultural sector's sustainability challenges is regenerative agriculture (RA). However, its slow adoption is attributed to unclear Irish and sectoral context-based definitions, practices, and certifications. This is partly due to a lack of a formal definition, no clear agreement on sustainability indicators, and the absence of an agreed framework for practical implementation to be applied to different agricultural systems within Ireland. This leads to different concepts regarding outcomes, a variety of practices employed, and a need for clarity in the application of practice-based, principle-based, or outcome-based approaches. There has been a push to address these challenges, with a robust corporate shift in Ireland’s drink and food industry and an appeal to local and regional growers to embrace RA practices. This is particularly evident with multinational alcoholic beverage corporations increasingly leading the way with a focus on their respective value chains towards sustainability and carbon neutrality in their malt barley and grain supply chains.

Yet, in the absence of formal Irish regulation, and standardised practical implementation, there are growing concerns about the success of these efforts and the increased risk of greenwashing in introducing RA from competing corporate sectors. This research addresses the need for more scientific literature on RA within Ireland by taking a context-based approach to studying a specific crop within the country, focusing on Ireland's spring barley sector. Using an extensive literature review this approach will provide valuable insights and guidance for farmers, policymakers, and stakeholders seeking to adopt RA practices and systems for malt barley and tillage within Ireland and beyond. The review will lead to defining RA in spring barley in Ireland and developing farm-level sustainability indicators tailored explicitly to the Irish context.

Scaling NBS for resilient agriculture systems

Lebelt L.*
*EIT Climate-KIC, Amsterdam, Netherlands. * laurene.lebelt@climate-kic.org*
Keesstra S.*
*EIT Climate-KIC, Amsterdam, Netherlands. * saskia.keesstra@climate-kic.org*
Zimmer D.*
*EIT Climate-KIC, Amsterdam, Netherlands. * daniel.zimmer@climate-kic.org*

Wider application of nature-based solutions (NBS) in agricultural systems would deliver multiple societal benefits and contribute to both climate resilience and nature restoration. However, there is limited experience in scaling solutions beyond local contexts. As part of the European Topic Center on climate change adaptation and LULUCF (ETC-CA), EIT Climate-KIC, CMCC, and associated ETC partners have studied a corpus of case studies to collect learnings on the levers and barriers to the adoption of Nature-Based Solutions in Europe. This includes insights on NBS assessment frameworks, scaling frameworks, and the socio-economic levers and barriers involved in NBS deployment.

These learnings have been collected in an EEA briefing (Scaling nature-based solutions for climate resilience and nature restoration1), and more recently in an ETC publication (ETC-CA Technical Paper 3/23 Economic enabling conditions for scaling of Nature Based Solutions2). Several of the case studies reviewed pertain to the agricultural sector. In this presentation, we will explore two cases in more detail:

Case 1: River catchment restoration
Thematic area: Agriculture and river catchment restoration
Location: Tullstorpsån, southern plains of Sweden (Skåne County)

Case 2: Peatland restoration
Thematic area: Paludiculture
Location: Mecklenburg-West Pomerania, Germany

[1] Lebelt, Laurène; Breil, Margaretha; Budding-Polo Ballinas, Monserrat; Castellani, Chiara; Keesstra, S.D.; Veerkamp, Clara; Turunen, Ville; Zimmer, Daniel; Martire, Salvatore; Enyedi, Eva; Hoogeveen, Ybele; Vanneuville, Wouter - EEA Briefing no. 21/2023 - Title: Scaling nature-based solutions for climate resilience and nature restoration

[2] Breil, Margaretha; Castellani, Chiara; Keesstra, Saskia; Zimmer, Daniel; Nieminen, Hanna; Trozzo, Chiara & Galluccio, Giulia. Economic enabling conditions for scaling of Nature-Based Solutions. ETC CA Technical Paper published 2023 via European Topic Centre on Climate Change Adaptation and LULUCF, (ETC CA).

Analyzing Actylcolinesterae Genes Expression and Function in *Spodoptera litura*

Abdalla M.A Salim*
*Yunnan Academy of Agricultural Sciences, Kunming, China *morkaz21@yahoo.com*

Acetylcholinesterase (AChE, EC 3.1.1.7) plays a crucial role in terminating synaptic transmission by hydrolyzing the neurotransmitter acetylcholine (ACh) in all animals. AChE is a primary target for organophosphate (OP) and carbamate (CB) insecticides. This study employed RNA interference (RNAi) through dsRNA injection to silence the AChE genes and investigate their function in the sixth larval instar of *Spodoptera litura*. Quantitative real-time PCR analyses revealed that both genes were expressed throughout all developmental phases and were predominantly transcribed in the pest's brain. Phylogenetic analysis demonstrated that both SlAce genes clustered into two major groups (AChE1 and AChE2), with SlAce1 being distinct from SlAce2. Injecting larvae with dsRNA targeting the two SlAce genes suppressed their expression, resulting in higher mortality and affecting pupation and appearance compared to control larvae.

SlAce2 encodes the primary AChE responsible for acetylcholine hydrolysis and non-cholinergic functions in female breeding, embryo progression, and progeny development, while SlAce1 may have an additional role in non-cholinergic functions. Significant larval mortality occurred after Ace gene silencing in *S. litura*, highlighting its insecticidal effectiveness and suggesting the potential of RNAi-based bio-insecticides.

Theme 4: Arable Cropping Systems

CO_2 emissions from winter wheat-summer maize soil in the North China Plain (Keynote)

Li F.*
*Chinese Academy of Sciences, Beijing, China. * lifadong@igsnrr.ac.cn*

Currently, agricultural soils are a non-negligible source of CO_2 emissions, accounting for 10% of total global greenhouse gas emissions approximately. Cropland management practices can affect soil microbial activity by changing soil structure, which in turn leads to different soil CO_2 emissions. However, studies on the mechanisms of CO_2 emissions from agricultural soils are still inadequate, especially at the microscopic scale and continuous monitoring, while the delineation of the sources of CO_2 emissions from soils is also controversial. In this study, we selected summer maize (*Zea mays* L.)-winter wheat (*Triticum aestivum* L.) fields in the North China Plain to conduct field experiments, starting from summer maize sowing at the end of June 2018 and ending at the beginning of November 2022 (summer maize harvesting). The experiment was conducted to compare two tillage practices (CT: conventional tillage and NT: no-tillage), two straw return methods (NS: no return and SM: return), and two N fertilizer levels (MN medium N: 180 kg N ha^{-1} and HN high N: 210 kg N ha^{-1}). The daily soil CO_2 emission dynamics were monitored continuously using a real-time in situ automatic monitoring system; soil respiration components were split using the root removal method, and the daily dynamics of soil temperature and humidity in the assimilation chamber were monitored.

In addition, soil physicochemical properties, soil microbial community structure and function, and crop biomass were measured during each growing and harvesting period to analyse the effects of different cropland management practices on soil respiration and its components and their underlying mechanisms. This study elucidated the effects of different cropland management practices on soil CO_2 emissions and respiration components and revealed the underlying mechanisms using soil physicochemical properties and microbial community structure.

Development of an Integrated Farming Systems Bio-economic Model for HOLOS-IE

Chatzichristou A. A.*
*University College Dublin, Dublin 04, Ireland, and Teagasc, Moorepark, Ireland. *tasos.chatzichristou@teagasc.ie*
Herron J. D.*
*Teagasc, Moorepark, Ireland. * jonathan.herron@teagasc.ie*
Wallace M.*
*University College Dublin, Dublin 04, Ireland. * michael.wallace@ucd.ie*
Necpalova M.*
*University College Dublin, Dublin 04, Ireland. * magdalena.necpalova@ucd.ie*
Khalil M.I.*
*University College Dublin, Dublin 04, Ireland, and Prudence College Dublin, Dublin 22, Ireland. *ibrahim.khalil1@ucd.ie*
Osborne B.*
*University College Dublin, Dublin 04, Ireland. * bruce.osborne@ucd.ie*

Global agriculture faces significant sustainability challenges, including rising greenhouse gas (GHG) emissions, water pollution, and land degradation, with uncertain economic implications. In response to the increase in global temperature, EU authorities have set an ambitious goal for net zero emissions by 2050. Integrated farming systems could bridge the gap between economic and environmental sustainability, improving farmers' livelihoods. In Ireland, in particular, where the majority of emissions stem from enteric fermentation, better integration of crop and livestock systems might provide a desirable balance of emission reduction and economic performance. To investigate the potential of system integration, we developed the economic component of a systems-based framework, HOLOS-IE, an established Life Cycle Assessment tool intertwined with enterprise budgeting methodology (revenues and costs). Production inputs are combined in a circular fashion instead of linear, taking into account synergies between production enterprises (e.g., feed and manure).

HOLOS-IE encompasses an array of crop and livestock enterprises, facilitating the evaluation of mixed farming systems. It calculates the gross and net margins of every enterprise, as well as total farm income. Subsidy payments associated with farming practices and forestry are also included in the model, as well as costs and returns from renewable energy production. Preliminary results illustrate potential synergies between production resources that impact revenues, costs, and emissions. Nutrient upcycling creates the opportunity of minimising waste and input requirements. In addition, local feed production is expected to aid in shortening supply chains, by reducing transportation costs (economic and environmental). In conclusion, HOLOS-IE is an agricultural system-based model that calculates emissions and the economic performance of farms allowing for the assessment of integrated systems. It is a tool that paves the path towards supporting farmers with decision-making, authorities with policy planning, and restructuring the agricultural sector towards enhanced environmental and economic sustainability.

This project is funded by ERA-NET (ReLive) through Teagasc and the Department of Agriculture, Food and the Marine, Ireland, and collaborating with the HOLOS-IE project funded by the Science Foundation Ireland (SFI) through the Government of Ireland and European Commission Resilient and Recovery Facility (22/NCF/FD/10947).

Assessing diversified crop rotations for climate change mitigation and adaptation in Canada

Qian B.*
*Agriculture and Agri-Food Canada, Ottawa, Canada. * budong.qian@agr.gc.ca*
Smith W.*
*Agriculture and Agri-Food Canada, Ottawa, Canada. * ward.smith@agr.gc.ca*
Jégo G.*
*Agriculture and Agri-Food Canada, Quebec, Canada. * guillaume.jego@agr.gc.ca*
Qi J.*
*Agriculture and Agri-Food Canada, Ottawa, Canada. * qi.jing@agr.gc.ca*
Grant B.*
*Agriculture and Agri-Food Canada, Ottawa, Canada. * brian.grant@agr.gc.ca*
Crépeau M.*
*Agriculture and Agri-Food Canada, Quebec, Canada. * marianne.crepeau@agr.gc.ca*

Diversified crop rotations have beneficial influences on soil structure and soil organic matter, which can help improve crop water and nutrient use efficiencies. Also, specific crops may respond more favourably to climate change, depending on local environments, than others. Therefore, region-specific crop rotation diversification in a changing climate may act as an adaptation measure to increase resiliency in the face of climate change and meanwhile, it may support sustainable agricultural production by reducing greenhouse gases (GHG) emissions, mitigating climate change, and increasing profits. Agroecosystem models include robust processes for simulating the impacts of climate change on cropping systems and can be further calibrated and improved using field trials for diverse rotations.

We used long-term field experiments in diverse regions across Canada to calibrate and evaluate multiple agroecosystem models including DayCent, DNDC, DSSAT, and STICS for simulating crop productivity, soil organic carbon changes, GHG emissions, and nutrient/water use efficiencies. Diversified crop rotations were simulated by these models and assessed for their crop productivity and environmental performance under the current and future climate scenarios to identify region-specific optimal crop rotations with a suite of beneficial management practices for mitigating and adapting to climate change.

Evaluation of Brassica napus Nitrogen Use Efficiency: Tracing Soil- and Fertilizer-Derived Nitrogen

McCannell R. M.*
*University of Saskatchewan, Saskatoon, Canada. * rmm716@mail.usask.ca*
Vail S.*
*Agriculture and Agri-Food Canada, Saskatoon, Canada. * sally.vail@agr.gc.ca*
Congreves K. A.*
University of Saskatchewan, Saskatoon, Canada. kate.congreves@usask.ca
Arcand M. M.*
*University of Saskatchewan, Saskatoon, Canada. * melissa.arcand@usask.ca*

Brassica napus (canola) is a major field crop in Western Canada and requires substantial nitrogen (N) fertilization for optimal yields. However, high rates of nitrogen application to agricultural soils risk nitrogen losses and represent wasted inputs and costs. Improvement of canola nitrogen use efficiency (NUE) can reduce N inputs while satisfying crop N demand and can minimize costly N

losses. This research takes on a holistic approach that considers soil N for determining NUE metrics among a diverse set of experimental canola hybrids and corresponding parental lines. Using urea enriched with the ^{15}N-isotope allows for the direct determination of the proportion of N sourced from the soil versus the fertilizer in the canola. In addition, plant samples taken throughout the growing season at different growth stages and partitioned by their components will give insight into understanding plant N partitioning throughout the growing the season and final recovery of N in the seed.

Preliminary findings from the 2022 growing season indicate that at most, 23% of the N in the mature canola plant was derived from the fertilizer and there were no significant differences between canola lines for N derived from fertilizer. Despite low residual soil N at the field sites, it remained the primary contributor to canola N uptake, even for the irrigated site. The canola seed yields were low which may have limited N uptake because of subpar crop productivity and limited plant development. No differences between canola lines were found for the total N derived from fertilizer but there were variances for the total N derived from the soil suggesting differences between lines in soil N scavenging abilities. Further evaluations of the data will explore patterns amongst the canola lines for NUE metrics and in-season N cycling while also discerning differences and similarities between lines.

Seasonal changes in reflectance and vegetation biophysical properties of wheat, rape, and maize

Hallik L.*
*University of Tartu, Tartu, Estonia. * lea.hallik@ut.ee*
Hallik O.*
*Tartu Jaan Poska Gymnasium, Tartu, Estonia. * oliveralbert.hallik@gmail.com*

Sentinel-2 MSI is an optical satellite mission dedicated to high spatial resolution land services. It provides data with 10 m and 20 m pixel sizes in visible, near-infrared and shortwave-infrared spectral regions. We studied seasonal changes in surface reflectance (Level-2A products) and vegetation biophysical properties (Level-2B products) of three common crops: winter wheat, rapeseed, and maize. The Estonian national satellite data centre ESTHub was used to access Sentinel-2 data. The ESTHub processing platform Calvalus version 2.15 (built by Brockmann Consult GmbH) was used to download bottom-of-atmosphere (BOA) surface reflectance. SNAP Biophysical Processor within Calvalus was used for generating Level-2B products: Leaf Area Index (LAI), Canopy Chlorophyll Content (CCC), and Canopy Water Content (CWC). Destructive sampling was used for ground validation in agricultural production fields around Tartu Observatory (Southern Estonia; 58° 15′ 55.43″ N, 26° 27′ 58.57″ E). Ground measurements corresponded to four cloud-free Sentinel-2 MSI images taken on 2023-06-20, 2023-06-30, 2023-07-20 and 2023-08-07. In general, the SNAP biophysical processor demonstrated its ability to provide robust estimates of leaf area index (LAI), canopy chlorophyll content (CCC), and canopy water content (CW) across different crops and growth stages.

Based on our data, the biophysical processor tends to overestimate LAI values for LAI <1.5 and underestimate LAI values for LAI >2. The biophysical processor also shows a tendency to underestimate canopy chlorophyll content (CCC) and overestimate canopy water content (CW). The overestimation of CW can be expected, as CW is a measure of the water content in leaves, not in the entire aboveground biomass.

Modelling global high-protein crop cultivation suitability across SSPs 245, 370 & 585

Huffe T.*
*University College Cork, Cork, Ireland, and Teagasc, Johnstown Castle, Wexford, Ireland. *111742749@umail.ucc.ie*
O'Sullivan L.*
*Teagasc, Johnstown Castle, Wexford, Ireland. * lilian.osullivan@teagasc.ie*
Holloway P.*
*University College Cork, Cork, Ireland. * paul.holloway@ucc.ie*

The challenge of feeding a burgeoning human population, while attempting to mitigate significant climatic changes, soil degradation, carbon emissions, and methane pollution, is an impending global concern. To identify areas where optimal conditions for cultivating high-quality, human-grade, protein plants could be grown on a worldwide scale, we used species distribution modelling (SDM). Combining climate, elevation, slope, and aspect variables alongside dominant FAO soil types we projected the global suitability of four plant species, (*Lupinus angustifolius* LA – lupins, *Lolium perenne* LP – perennial ryegrass, *Pisum sativum* PS – dun pea, and *Vicia faba* VF – faba bean). The results were extrapolated across three shared socioeconomic pathways (SSP) 245, 370, and 585, and across two timescales, 2041-2060 and 2061-2080. Three-fold cross-validation was performed, with resulting high accuracy AUC results of LA 0.911, LP 0.753, PS 0.940, and VF 0.830 respectively. Percentage contribution, permutation importance, and spatial jack-knifing were calculated for each species to test the variables' in-model importance.

Our results showed that each species is highly sensitive to forecasted conditions, showing diversification across, but also within SSPs, across timescales. The species least suitable across all parameters was PS, while the most stable across SSPs and parameters was LP. Global suitability shows LP as the most suitable, followed by VF, LA, and finally PS. These results can inform agronomists, seed merchants, and production partners long term to begin planning for the shift towards plant-based, high-protein isolates and flours and secondary products.

Quinoa as a climate resilient crop for dryland agro farming system

Abbas G.*
*COMSATS University Islamabad, Islamabad, Pakistan. * g.a92pk@gmail.com*
Murtaza B.*
*COMSATS University Islamabad, Vehari, Pakistan. * behzadmurtaza@cuivehari.edu.pk*
Amjad M.*
*COMSATS University Islamabad, Vehari, Pakistan. * drmuhammadamajd@cuivehari.edu.pk*
Saquib M.*
*University of Agriculture, Faisalabad, Faisalabad, Pakistan. * drhmsab@yahoo.com*

Climate change is causing drastic reductions in crop yields around the globe due to an increase in soil salinity, drought, and heat stress. Quinoa (*Chenopodium quinoa* Willd) is regarded as an important food security crop under the climate change scenario. A field experiment was conducted on saline soil under arid climatic conditions to explore the effects of soil salinity, drought, and heat stress on two quinoa genotypes (Puno and Titicaca). The combined stress of salinity, drought, and high temperature caused more decline in plant growth and grain yield compared to individual stresses. Under the combination of three stresses, plant biomass, and grain yield declined by 35, 40%, and 34 and 42% in Puno and Titicaca, respectively compared to control plants. Stomatal

conductance and relative water contents declined in the same trend in both genotypes. Shoot Na concentration was the highest whereas, K concentration was the lowest in both genotypes when drought and heat stress were combined with salt stress.

Grain mineral contents (Ca, Mg, Fe, Zn, Cu, K, and Mn) decreased more under the combination of salinity with drought and heat stress. Grain protein, lipid, and carbohydrate contents were not affected by salinity alone but decreased when salinity was combined with drought and heat stress. Puno produced more biomass and grain yield with better grain quality than Titicaca; hence, it is a better genotype for cultivation on saline soils under dry land farming systems facing drought and heat stress.

Sustainability challenges for Irish agriculture: Herbicide-resistant grass weeds

Bhaskar V.*

*Teagasc, Carlow, Ireland. * vijaya.bhaskar@teagasc.ie*

Hennessy M.*

*Teagasc, Carlow, Ireland. * michael.hennessy@teagasc.ie*

Dermot Forristal P.*

*Teagasc, Carlow, Ireland. * dermot.forristal@teagasc.ie*

Ireland's cropping systems are herbicide-dependent due to the Atlantic-influenced climate, coupled with recently adopted practices such as winter cropping, earlier autumn sowing, and non-inversion tillage. At a time when the diversity of herbicide types is declining, this poses a significant challenge with increasing incidence of critical grass weeds and evolving resistance to high-risk ACCase/ALS inhibitor herbicides. As part of the ECT and EVOLVE grass-weed projects, resistance (phenotypic and molecular) testing was conducted on populations submitted by growers/advisors who suspected herbicide resistance or collected through surveys, from 2019 to 2023. The results indicated that 33 of 134 *Avena f*atua (spring wild oats) were ACCase-resistant due to mostly Ile-1781 and/or Asp-2078 mutations; 19 of 34 *Alopecurus myosuroides* (black grass) were ACCase- and/or ALS-resistant. ACCase Ile-1781 or ALS Pro-197 mutations predominate; and 12 of 20 *Lolium multiflorum* (Italian ryegrass), were ALS-resistant and associated mostly with a Pro-197 mutation. Besides, 8 of these populations were also ACCase-resistant and associated with target-site (Ile-1781 and/or Asp-2078) or metabolism-based non-target-site resistance; and 7 Poa annua (annual meadow grass) were ALS-resistant due to Pro-197 or Trp-574 mutations. Poa annua exhibits natural tolerance to some ACCase inhibitors due to the inherited Ile-1781 mutation

Screening of broadleaf weeds was initiated in 2022. Three *Stellaria media* (common chickweed) (Trp-574), and two *Papaver rhoeas* (common poppy) (Pro-197), were ALS-resistant. A *Chrysanthemum segetum* (corn marigold) (Pro-197), and a *Veronica persica* (common field-speedwell) (Trp-574) had confirmed ALS-resistant, which was previously unknown. Herbicide-resistant strains, especially multiple-resistant *A. myosuroides* and *L. multiflorum* pose a serious threat to the arable sector and continued monitoring is essential. It is necessary to develop integrated weed management (IWM) strategies suited to our climate and cropping systems to tackle this potential sustainability threat.

Theme 5: Agroforestry systems

Climate resilience across a European agroforestry experimental network: from concept to practice (Keynote)

Hond-Vaccaro C.*
*Agroscope, Zürich, Switzerland. * christina.vaccaro@agroscope.admin.ch*
Herzog F.*
*Agroscope, Zürich, Switzerland. * felix.herzog@agroscope.admin.ch*
Olave J.*
*AFBI, Hillsborough, United Kingdom. * rodrigo.olave@afbini.gov.uk*

Agriculture is facing an increasing challenge to continue to meet the demands of food, fuel and forage provision in the face of climate change, with rising temperatures worldwide. Agroforestry, the inclusion of woody elements in agriculture, can potentially improve the resilience of agricultural production to weather extremes. However, the empirical evidence for these expected benefits is surprisingly scarce; therefore, a number of long-term research trials across Europe have been used to quantify biophysical indicators of agroecosystem resilience to climate change. The research combines field experimentation, process, and geospatial modelling to investigate climatic scenarios. Livestock experiments in different biogeographic zones have been conducted to evaluate the effect of agroforestry on animal welfare and productivity. Aboveground floral and faunal biodiversity and belowground soil microbial biodiversity have been measured in terms of composition, abundance in order to understand the longer-term impact of agroforestry on ecosystem functioning and potential resilience to climate change.

Two biophysical models (Yield-SAFE and Hi-sAFe) have been used and calibrated with key indicators to predict and compare environmental resilience of agroforestry systems. These methods have also included economic outputs via financial and resource simulation modelling (Farm-SAFE) to evaluate the cost-benefit performance of agroforestry systems. Using the above information and scientific data, virtual baselines have been created and have been used to explore climate change scenarios in agroforestry systems, by a series of management and climate scenarios changes including daily and historical weather observations for future climate model simulations. In addition, this network of long-term agroforestry sites across Europe has allowed scientific assessments to determine the resilience of the systems under current and expected future climatic conditions, bringing together different approaches and standardised methodologies from real field experiments to modelling, with calibration of real-life data to virtual experiments, resulting in key recommended interventions towards sustainable agricultural production systems in Europe.

Modelling Land-use change through Agroforestry pig production systems in Ireland

Shin M.*
*University College Dublin, Dublin, Ireland. * mika.shin@ucd.ie*
Leonard B.*
*University College Dublin, Dublin, Ireland. * brian.leonard@ucd.ie*
Adenauer L.*
*Self-employed Consultant, Paris, France. * lucie.adenaeuer@googlemail.com*
Mullan S.*
*University College Dublin, Dublin, Ireland. * siobhan.mullan@ucd.ie*

The global demand for protein is rising while enhancing pig health and welfare, minimizing environmental impact, and ensuring economic sustainability. Outdoor pig production systems, especially those embracing agroforestry practices, are positioned to address these challenges. In Ireland, 0.2% (310 farms) of farms are in pig production, and production is increasing over time. The 'One Welfare' framework recognizes the interconnectedness of animals, humans, and their environment, prompting a need for alternative pig production systems like agroforestry. Despite lower afforestation rates in recent years, transitioning to alternative land use with agroforestry is hindered by barriers in initial land use decisions. This study aims to explore how such a shift may impact pig welfare in the Irish agricultural sector. To assess the economic and environmental implications of agroforestry as an alternative land use, the FABLE model is employed. This model offers a consistent framework for economic and environmental indicators in a land-use context. A literature review identifies key variables influencing land use change and environmental performance in agroforestry pig production systems. Additional data on outdoor and agricultural pig farming will be collected. The FABLE calculator, used globally by the FABLE Consortium, will incorporate agroforestry pig production to generate land-use change pathways.

Variables related to emissions, feed, pig farm management, and feed are associated with land use change. The environmental performance of agroforestry pig production is expected to improve compared to conventional systems. The FABLE calculator will help model alternative land-use scenarios, considering the uptake of agroforestry for high-welfare outdoor pig production. The study aims to evaluate the implications of agroforestry systems for pig farming on Irish agricultural economic and environmental indicators. The scenarios developed align with the Food Wise 2030 strategy, providing insights for policymakers to consider national-level policies and financial support for farmers to prioritize animal welfare and address climate change priorities.

Creating an Agroforestry Module for HOLOS-IE Digital Platform to Assess Carbon-Neutral Farming

Siddique M.*
*University College Dublin, Dublin 04, Ireland. * mahjabin.siddique@ucdconnect.ie*
Collier R.*
*University College Dublin, Dublin 04, Ireland. * rem.collier@ucd.ie*
Sen B.*
*University College Dublin, Dublin 04, Ireland. * badhan.sen@ucd.ie*
McPherson A.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * aaron.mcpherson@agr.gc.ca*
Pogue S.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * sarah.pogue@agr.gc.ca*
Kröbel R.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * roland.kroebel@canada.ca*
Osborne B.*
*University College Dublin, Dublin 04, Ireland. * bruce.osborne@ucd.ie*
O'Brien P.*
*Climate Change Advisory Council, Dublin 14, Ireland. *p.obrien@epa.ie*
Khalil M. I.*
*University College Dublin, Dublin 04, Ireland, and Prudence College Dublin, Dublin 22, Ireland. * ibrahim.khalil1@ucd.ie*

Planting trees on land used for agriculture (crops, grasses and livestock grazing) is known as agroforestry, a sustainable land management technique that offers several environmental, socio-economic, and ecosystem advantages. The mitigation of climate change is facilitated by farms minimising their environmental impact by reducing greenhouse gases (GHGs) and capturing and storing carbon in trees and soils while maintaining biodiversity. The HOLOS-IE digital platform's Irish/EU-focused Agroforestry module seeks to assess GHG emissions and carbon footprint, optimise farmland usage, and promote best practices - all in line with Climate Action Plans. The methodical approach involved creating a foundational Agroforestry High-Level Design, followed by a backend code implementation through a detailed class diagram.

To comprehend the interplay between frontend and backend, we constructed a sequence diagram. We have dedicated our efforts to refining the information related to tree species specific to Ireland. Utilising the Carbon Assessment Protocol (v2.0) ensured species-specific biomass calculation, while Ireland's National Forest Inventory 2022 findings guided annual change assessments. Our calculations meticulously account for crucial factors such as tree height and diameter. Successfully implementing calculations for allometry i.e. Aboveground Biomass, and Belowground Biomass prompted a critical evaluation of our architecture, leading to planned enhancements. We aim to extend our analysis to a yearly basis, incorporating variables such as management practices including logging, soils, climate, and tree spacing for more comprehensive results. Our future roadmap includes refining results by incorporating more driving variables, with a particular focus on management practices for increased accuracy in our model and contributing to the ongoing evolution of HOLOS-IE and the Agroforestry Systems.

This project is funded by the Science Foundation Ireland (SFI) through the Government of Ireland and the European Commission Resilient and Recovery Facility (22/NCF/FD/10947). We acknowledge the collaboration with ReLive funded by ERA-NET through the Department of Agriculture, Food and the Marine, Ireland, and Agriculture and AgriFood Canada.

Agroforestry: a response to climate change adaptation and mitigation in Northern Ireland

Olave R.*
*Agri Food and Biosciences Institute, Belfast, United Kingdom. * rodrigo.olave@afbini.gov.uk*
McAdam J.*
Irish Agroforestry Forum, Drumshanbo, Ireland
*Queen's University Belfast, Belfast, United Kingdom. * rodrigo.olave@afbini.gov.uk*

Agroforestry systems have been investigated by AFBI (Agri-Food and Biosciences Institute) in Northern Ireland since 1989 to explore the potential of integrating agriculture and forestry on the same land base. The research has shown that agroforestry can deliver favourable economic returns whilst potentially increasing biodiversity, reducing agricultural pollution, improving soil porosity, and increasing soil carbon sequestration. In these long-term agroforestry trials, trees, livestock, and grassland outputs and their agroecological interactions have been compared for over 35 years, to quantify biophysical indicators of agroecosystem resilience to climate change. The growth of trees and various parameters such as forage quality, herbage mass and intake, and parameters related to animal productivity and animal welfare have been assessed to evaluate the resilience of productive agroforestry systems.

Current research in AFBI is now using biophysical models and genomics tools to explore and understand those environmental interactions and compare the systems to adjacent permanent grassland, cropland, and forested control sites to examine their variation and productivity changes in terms of economic outputs. Results show that historical changes in land use and land management within these systems can affect wider land use functioning, resulting in positive regulating processes such as soil nutrient cycling and carbon sequestration. Further examination of the data is underway to provide insights into wider multifunctionality of trees to assess the potential of incorporating agroforestry systems into ruminant livestock systems in Northern Ireland and the rest of the UK to adapt and mitigate against climate change.

Quantifying carbon sequestration in soil and woody biomass with CARAT

Baens E.*
*Soil Service of Belgium, Leuven, Belgium. * ebaens@bdb.be*
Pardon P.*
*ILVO, Merelbeke, Belgium. * paul.pardon@ilvo.vlaanderen.be*
Coussement T.*
*Soil Service of Belgium, Leuven, Belgium. * tcoussement@bdb.be*
Vanneste T.*
*University of Gent, Gent, Belgium. * thomas.vanneste@ugent.be*
Verheyen K.*
*University of Gent,, Gent, Belgium. * kris.verheyen@ugent.be*
Elsen A.*
*Soil Service of Belgium, Leuven, Belgium. * aelsen@bdb.be*
Reubens B.*
*ILVO, Merelbeke, Belgium. * bert.reubens@ilvo.vlaanderen.be*

Quantifying carbon (C) sequestration in soil and woody biomass by agroforestry systems is not easy due to the influence of many elements. The CARbon Agroforestry Tool “CARAT” enables users to quantify above- and below-ground C stocks in agroforestry systems and predict how these stocks change over a 30-year period. It is an online, user-friendly tool where the user defines a virtual rectangular plot by entering the dimensions manually or by selecting an existing field on a map integrated in the tool. A grid subdivides the field into 1 m² cells, and trees can be added manually in each grid cell. A range of 20 tree species is available; the tool currently simulates systems consisting of high pruned solitary trees. Field-specific soil parameters can be specified to improve simulation accuracy.

For each simulated tree, the woody biomass and associated carbon stock are modelled based on species-specific growth curves and allometric relations for solitary growing trees. To assess the evolution of soil organic carbon (SOC), annual leaf fall is quantified for each grid cell using the leaf fall distribution model of Ferrari and Sugita (1996). The labile, resistant and humidified fractions of leaf litter are determined using the method of Peltre et al. (2012). These fractions are then used to deduce the decomposability of the leaf material. This in turn feeds into the RothC-model to quantify the transfer of organic C from the leaf litter to the soil. The output made available to the user is a map displaying the heterogeneity in SOC due to the presence of trees, along with an estimate of above- and below-ground carbon stocks at the field level and their evolution over time. This way, farmers, advisors, and/or policymakers can be aided in quantifying C sequestration in agroforestry systems for purposes such as financial C valuation.

Effect of ecological intensification on SOC sequestration potential of Mediterranean wood pastures

Rolo Romero V.*
*University of Extremadura, Plasencia, Spain. * rolo@unex.es*
Carrascosa Becerril A.*
*University of Extremadura, Plasencia, Spain. * alejandro_carrascosa@unex.es*
Moreno Marcos G.*
*University of Extremadura, Plasencia, Spain. * gmoreno@unex.es*

Mediterranean silvopastoral systems are an outstanding example of nature conservation and environmental services provision. However, in the last decades, there is an increasing concern about their long-term sustainability due to the low productivity of the system. An increasing trend of land abandonment has been observed in areas less suitable for farming. At the same time, other farms are being intensified to maximize returns. In this context, new management practices, that fall within the scope of ecological intensification, are being put in place. Among them, rotational grazing or the sowing of legumes are the most common. In addition to maximizing plant productivity, these practices seek to boost SOC sequestration. This study aims to assess the effect of rotational grazing and legume sowing on SOC sequestration as compared to land abandonment and continuous grazing. We also estimated the effect of trees by comparing zones with and without tree presence. We estimated SOC sequestration potential by applying the RothC carbon model. Above- and below-ground pasture biomass and tree litter were measured during three consecutive years to assess C inputs in each treatment. Initial SOC was measured, and a spin-up run was carried out to reach baseline conditions in each plot.

The results showed a significant and positive trend of SOC with time in plots subjected to rotational grazing and legume sowing. As opposed to control and abandoned plots that showed a negative trend. The effect was dependent on the habitat, as no temporal trend was observed under trees, agreeing with the commonly observed buffer effect of trees in these systems. Our results highlight the potential of ecological intensification to meet both productive and climate targets in the Mediterranean silvopastoral systems.

Theme 6: Decision Support Systems in Agro-Farming

Crop Modelling and Decision Support for Climate-Resilient (Keynote)

Hoogenboom G.*
*University of Florida, Florida, USA. * gerrit@ufl.edu*

Crop simulation models play a key role in determining the potential impact of climate change on agriculture. They can be used to determine adaptation scenarios for maintaining or improving yield while optimizing resource use and minimizing environmental impact. In addition, they can provide options for climate change mitigation, especially as it relates to greenhouse gas emissions, and help assess the potential for carbon sequestration. The Cropping System Model (CSM) of the Decision Support System for Agrotechnology Transfer (DSSAT; www.DSSAT.net) is one of the most widely used crop simulation models across the globe. It was originally developed to address food security in developing countries but is now used extensively for climate change and climate variability applications.

We will present a brief overview of DSSAT and its underlying computer models for the simulation of growth, development, and yield for over 40 crops. We will also highlight example applications for climate-resilient systems. Although modelling of agricultural systems is extremely complex, it also provides opportunities for evaluating alternate scenarios for decision-makers. Thus, computer models play a key role for decision support to advance climate-resilient agriculture.

Effects of manure application on productivity and soil-C storage in grasslands – a modelling by DNDC

MENG X.*
*University College Dublin, Dublin 04, Ireland. * xiaoyi.meng@ucd.ie*
Osborne B.*
*University College Dublin, Dublin 04, Ireland. * bruce.osborne@ucd.ie*
Khalil M.I.*
*University College Dublin, Dublin 04, Ireland, and Prudence College Dublin, Dublin 22, Ireland. * ibrahim.khalil1@ucd.ie*

This study provides a comprehensive assessment of the environmental sustainability and mitigation potential of grasslands, emphasizing the need to balance their role as carbon sinks with potential adverse effects from increased greenhouse gas (GHG) emissions. Employing the Denitrification-Decomposition (DNDC) process-based model, we evaluated GHG fluxes in a long-term grassland silage experiment featuring seven treatments, including different amounts of pig and cow manure, mineral treatment, and control. Using daily weather data, site-specific soil properties, and land management information, the DNDC model simulated N_2O, CO_2, CH_4, water-filled pore space (WFPS), soil temperature, biomass, and soil organic carbon (SOC) dynamics.

The model successfully captured N_2O emissions and soil temperature, as evidenced by root mean square error (RMSE) values ranging from 6.8 to 66.5 for N_2O emissions and 5.7 to 12.4 for soil temperature (0-10cm) across all treatments in 2016. To assess the potential impacts of climate change on grassland ecosystems over the next three decades, we incorporated baseline and various climate change scenarios. This approach allows us to anticipate the effects of current and future impacts on ecosystem carbon dynamics. Our findings contribute to a nuanced understanding of the intricate interplay between grassland ecosystems and climate change, offering valuable insights for sustainable land management practices and policy decisions.

HOLOS-IE: Bridging Gaps for Sustainable Agriculture and Carbon Neutrality

Khalil M.I.*
*University College Dublin, Dublin 04, Ireland, and Prudence College Dublin, Dublin 22, Ireland. *ibrahim.khalil1@ucd.ie*
Sen B.*
*University College Dublin, Dublin 04, Ireland. * badhan.sen@ucd.ie*
Siddique M.*
*University College Dublin, Dublin 04, Ireland. * mahjabin.siddique@ucdconnect.ie*
Osborne B.*
*University College Dublin, Dublin 04, Ireland. * bruce.osborne@ucd.ie*
O'Brien P.*
*Climate Change Research Council, Dublin 14, Ireland. * p.obrien@epa.ie*
Collier R.*
*University College Dublin, Dublin 04, Ireland. * rem.collier@ucd.ie*

Agriculture, with its significant environmental footprint, particularly in greenhouse gas (GHG) emissions, is a key focus for achieving climate action goals such as carbon-neutral farms by 2050. To achieve a sustainable future, strategies must address GHG mitigation and increased carbon sequestration. Process-based models (PBMs) and whole-farm models (WFMs) emerge as potential solutions, each offering unique strengths. PBMs, exemplified by DNDC, excel at analysing specific agricultural practices, providing insights into emissions factors (EFs) tailored to farm contexts. However, their reliance on site-specific calibration and opaque source code can limit wider application. WFMs offer a holistic view of farm ecosystems, facilitating assessments of mitigation strategies and pathways to carbon-neutral farms. Yet, their data-driven nature and complexity can be challenging, especially for smaller farms. Bridging this gap involves integrating insights from PBMs into WFMs to enhance accuracy and realism in farm-level assessments, enabling targeted intervention strategies and precise estimations of environmental impact.

Digital platforms like HOLOS-IE (www.ucd.ie/holos-ie) play a crucial role in facilitating this integration. With a user-friendly interface, HOLOS-IE simplifies complex modelling processes, empowering stakeholders to understand their agri-environmental footprint and reduce it through informed choices. Automation of soil and climate parameters, along with integration of default inputs/EFs from PBMs, reduces input requirements, enabling active monitoring and management of carbon footprints for more sustainable agricultural practices. This paper introduces a preliminary version of HOLOS-IE, paving the way for HOLOS-EU's wider application across Europe. By providing accessible environmental assessment tools, we empower farmers and stakeholders to participate in combating climate change and fostering a sustainable future for agriculture.

This project is funded by the Science Foundation Ireland (SFI) through the Government of Ireland and the European Commission Resilient and Recovery Facility (22/NCF/FD/10947). We acknowledge the collaboration with ReLive funded by ERA-NET through the Department of Agriculture, Food and the Marine, Ireland, and Agriculture and AgriFood Canada.
.

Helping farmers to reduce emissions using the Holos model – a Canadian experience

Kroebel R.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * roland.kroebel@agr.gc.ca*
Pogue S.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * sarah.pogue@agr.gc.ca*
McPherson A.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * aaron.mcpherson@agr.gc.ca*
Mantle P.*
*Agriculture and Agri-Food Canada, Lethbridge, Canada. * pamela.mantle@agr.gc.ca*

The Holos™ model is a whole-farm model software that is developed by Agriculture and Agri-Food Canada (AAFC) on the basis of the Canadian National Greenhouse Gas Inventory Report (NIR). It calculates the emission sources of Canadian crop and livestock farms and is applicable across the different ecoregions of Canada. For this purpose, the model uses NIR-based Canada-specific (where applicable) emission factors, and global emission factors otherwise, but implements them as dynamic calculations (rather than static results as in the NIR) so that user-explored changes in selected management practices will show a change in the emission estimates. The model also includes a vast array of default data that are continually improved to represent common farm practices as closely as possible.

From the start of the Holos program (in 2004), the model was developed as a farmer education tool, but model uptake remained low. Thus the 'Sustainability of Canadian Agriculture' workshop/conference event was developed to invite farmers, their representatives, academics, and decision-makers to share their visions and ideas, in addition to providing Holos™ model training and showcasing model application studies. Further, we engaged educators to utilize Holos™ as a teaching tool at Canadian universities. A number of stakeholder review groups were also organized to help design the interface and to inform model feature developments.

Open-source release and government emission reduction targets both tremendously increased the interest in Holos. Eleven out of 14 farmer-led Canadian Living Laboratories choose to use the HolosTM model to report the emission reduction achievements. There are also several projects that aim to add new features and components to the model, and the model is increasingly adapted for the fledgling carbon credit market. Farmers increasingly make use of the model, due to market pressures, but also for its ease of use and the transparency provided.

Technical support systems for decision-making in precision agriculture in greenhouse

González Hernández V.*
*Universidad de Almería, Almería, Spain. * victore@ual.es*
Pérez Mesa J.*
*Universidad de Almería, Almería, Spain. * juancarl@ual.es*
De Burgos Jiménez J.*
*Universidad de Almería, Almería, Spain. * jburgos@ual.es*
Galdeano Gómez E.*
*Universidad de Almería, Almería, Spain. * galdeano@ual.es*

This work addresses the interaction between supporting technologies in agriculture and sustainability, encompassing ethical and social considerations. It provides a detailed overview of current and emerging technologies and their impact on various facets of sustainability, specifically focusing on greenhouse precision agriculture in the southeast region of Spain. The methodology used combines a literature review and expert interviews, based on the analysis of qualitative data, to obtain a comprehensive understanding of the subject. The results identify three primary clusters of interrelated themes: the first relates to the countryside, water saving, sensor utilisation, and environmental improvement; the second addresses cooperative enterprises, robotic applications, labour reduction, consequent cost improvement, and economic sustainability; and the third, albeit of lesser importance, links artificial intelligence with ethical concerns such as control, use, and technological dependence on data.

In summary, the application of assistive technologies is expected to positively impact economic and environmental sustainability, overshadowing the social dimension. This imbalance suggests that social and ethical aspects could be subordinated to more immediate benefits. The results also suggest that the need for future investments could create polarization in the sector. However, not all farmers and companies can afford these investments, potentially leading to progressive deterioration and even abandonment of agricultural activities in some cases.

Theme 7: Biodiversity in Agriculture

Farmland pollinators and pollination: influence of policy and practice (Keynote)

Stout J.*
*Trinity College Dublin, Dublin 04, Ireland. * stoutj@tcd.ie*

Flower-visiting insects, like bees and hoverflies, provide pollination services to both crops and wild plants in agricultural landscapes. However, these insects are facing decline due to agricultural intensification, the widespread use of agrochemicals, and the loss and degradation of suitable foraging and nesting habitats. This decline has become well-publicised, and both international and EU-level biodiversity frameworks and targets highlight the restoration of pollinators as a key ambition. The successful restoration of pollinators on farmland requires an understanding of complex networks of interactions between pollinators and local and landscape-level factors, including quantity and suitability of floral resources, type, and location of habitat features, pesticide use and residues, and threats from disease and parasites. At the same time, farmers need to maintain yields to sustain food production and their own livelihoods.

This presents a challenge for policymakers, and the design of agri-environmental schemes, as well as for the farmers implementing pollinator action on the ground. Whole-farm and context-specific landscape-scale approaches are required, as well as monitoring to determine success. Examples of these approaches from Irish farming landscapes will be presented

The relationship between plant diversity and ecosystem condition in results-based agri-environment schemes

Byrne D.*
*Atlantic Technological University, Sligo, Ireland. * dolores.byrne@atu.ie*

High Nature Value farmland (HNVf) supports biodiverse, semi-natural habitats through extensive farming practices. In Ireland, these habitats are under threat due to both land intensification and abandonment. Results-based payment schemes (RBPS) have been piloted through European Innovation Partnerships (EIPs) to support and protect semi-natural farmland habitats and biodiversity targets. This research examined the relationship between an RBPS scoring system for the protected Hen Harrier (*Circus cyaneus*) raptor species, and semi-natural grassland plant communities, diversity, and ecological condition. The suitability of fields for the Hen Harrier was assessed by the RBPS using multi-criteria scorecards, comprised of result indicators and scores ranging from 0 (not suitable) to 10 (highly suitable). Detailed vegetation surveys and environmental data were collected for semi-natural grassland fields (n=30) that had a range of scores. Data was analysed using Nonmetric Multidimensional Scaling ordination and each field was assigned to a vegetation type based on vascular species composition using the Irish Vegetation Classification ERICA (Engine for Releves to Irish Communities Assignment) tool.

Higher RBPS-scoring grassland fields are associated with positive indicator species cover, number of positive indicator species, bryophyte cover, and floristic diversity indices. Lower scoring fields were linked to negative indicator species cover, rush cover, and higher Ellenberg Nitrogen and Reaction values. Our results show that an RBPS scoring system developed to incentivise ecological conditions for a target raptor species can reflect wider plant diversity in semi-natural grasslands. RBPS multi-criteria assessments can therefore reward multiple ecosystem services beyond their target, which can be harnessed to support native plant species and other taxa and maintain and enhance extensive management and grazing regimes

Supporting rural economies with a results-based agri-environment scheme in halting biodiversity decline

O'Neill H.*
*ACRES Breifne, Manorhamilton, Ireland. * hagen.oneill@acresbreifne.ie*
Carlier J.*
*ACRES Breifne, Manorhamilton, Ireland. * julien.carlier@acresbreifne.ie*
Sullivan C.*
*ACRES Breifne, Manorhamilton, Ireland. * caroline.sullivan@acresbreifne.ie*

As part of the 2023–2027 reform of the EU Common Agricultural Policy (CAP) Strategic Plan, Ireland introduced a national-scale results-based agri-environmental scheme called Agri-Climate Rural Environment Scheme (ACRES). This five-year scheme aims to address biodiversity decline while delivering income support for farmers. ACRES has two streams, ACRES General and ACRES Co-operation (CP). ACRES CP is a new departure as it moves away from the traditional action-based agri-environmental schemes to a hybrid result-based approach. Using a habitat scorecard system, farmers receive payments for habitats that score between 4 and 10 on a 10 point scale. It also provides funding for supporting actions to improve habitat scores if necessary. There are eight priority areas across the country for the CP stream. These are predominantly High Nature Value farmland areas with high-status water quality. There are ~21,000 farmers participating. CP teams are in place to assist farmers in maximising ecosystem service delivery. The Hen Harrier Programme Ltd delivers these services to three regions, ACRES Breifne, ACRES Munster South Connacht, and ACRES Leinster for almost 10,000 farmers. Scorecards are assigned to fields based on the habitat (grassland, peatland, scrub/woodland) and farm advisors score the fields.

The CP team then assists farmers to maximise payments and scores through bespoke targeting of management advice (to limit threats and pressure and maximise ecological integrity) and actions support. Each area had a Local Area Plan developed based on national priorities and local assets. In conjunction with scores from season one of the scheme, we outline how the teams will assist farmers in delivering biodiversity, water quality, and carbon sequestration through advice, campaigns for addressing specific issues and supporting specific farmer's issues.

Protecting farmland biodiversity

Kavanagh S.*
*Teagasc, Wexford, Ireland. * saorla.kavanagh@teagasc.ie*
Stout J.*
*Trinity College Dublin, Dublin, Ireland. * stoutj@tcd.ie*
Fitzpatrick U.*
*National Biodiversity Data Centre, Waterford, Ireland. * ufitzpatrick@biodiversityireland.ie*

The Protecting Farmland Pollinators EIP identified small actions that farmers can take that will allow biodiversity to coexist within a productive farming system. Farmers in Ireland recognise the importance of pollinators, but farmland has experienced a wide-scale loss of wild pollinators over the last fifty years. By working closely with 40 farmers, management practices that benefit bees and hoverflies on Irish farmland were identified, and an evidence-based whole-farm pollinator scoring system was developed. Using a whole farm pollinator scorecard, farmers received ‘pollinator points’ each year based on the amount and quality of pollinator-friendly habitat maintained and/or created. Farmers also received a results-based payment that related to these pollinator points.

Irish farms have great potential to improve both the quantity and quality of biodiversity friendly habitats without negatively affecting farm productivity. Thirty-one farmers increased their score between year one and year three of the results-based payment. Each farm type (arable, beef, dairy, and mixed) increased their median score over the three years and arable and dairy farms showed the largest increase. Pollinator species richness and abundance varied across farm type. A positive relationship between pollinator species richness and pollinator points was found.
This project has helped farmers better understand and engage with nature on their land and has created a measurable system for improving habitats for biodiversity on farms that is accessible to all and has the potential to be rolled out on a wider scale.

Maximising recycling-derived fertiliser use and closing the nutrient cycle

Ludgate R.*
*Munster Technological University, Cork, Ireland. * robert.ludgate@mtu.ie*
Power N.*
*Munster Technological University, Cork, Ireland. * niamh.power@mtu.ie*

For sustainable agriculture, dependency on fossil-based fertiliser imports must be reduced and increased use of Recycling Derived Fertilisers (RDFs) is required. EU importation of nitrogen (N), phosphorus (P) and potassium (K) fertilisers are becoming increasingly uneconomical and environmentally unsustainable, with pricing directly linked to the cost of energy, mining, synthesis, and geopolitical developments further impacting these costs. Russia and Ukraine have historically been the main suppliers of N, with P imports largely coming from Morocco, this exposes stakeholders, particularly farmers, to adverse economic forces outside of their control.

When farmers were asked what is important to them when choosing a sustainable mineral fertiliser substitute, research to date has shown that cost and price remain prominent factors. Fertiliser content, quality, and composition were also seen as principal factors, indicating farmers were interested in high-quality fertilisers at a good price. The same stakeholders noted the most important qualities of an RDF were an appropriate nutrient ratio matching the crop requirement most desirable, with high organic matter content also seen as important.

Embedding a Living Labs ethos is important in all research activities. This will involve delivering joint value to all involved stakeholders and learning from those involved in a real-life setting, with active user involvement for co-creation to deliver a joint strategy for RDF supply chain adaptation and improvement to increase RDF product use. A series of workshops and surveys will be used to further investigate the complex mix of factors affecting the use of RDFs and market development. Supply chain factors are considered important as well as attitudes towards and lack of knowledge of RDFs amongst the farming community. Resource owners, fertiliser producers, traders & farming communities will benefit from this research allowing a harmonised RDF market to develop, contributing to future food supply security.

Theme 8: Biogeochemical Processes in Agro-Farming

The role of soil fauna in the transition towards sustainable agriculture (Keynote)

Willem Van Groenigen, J.*
*Wageningen University, Wageningen, Netherlands. *janwillem.vangroenigen@wur.nl*
Calogiuri T.*
*Wageningen University, Wageningen, Netherlands. * tullia.calogiuri@wur.nl*
Ferron L.*
*Wageningen University, Wageningen, Netherlands. * laura.ferron@wur.nl*
Hagens M.*
*Wageningen University, Wageningen, Netherlands. * mathilde.hagens@wur.nl*
Koopmans G.*
*Wageningen University, Wageningen, Netherlands. * gerwin.koopmans@wur.nl*
Sonntag E.*
*Thuenen Institute for Organic Agriculture, Thuenen, Germany. * enno.sonntag@wur.nl*
Vos H.*
*Wageningen University, Wageningen, Netherlands. * hannah.vos@wur.nl*
Vidal A.*
*Wageningen University, Wageningen, Netherlands. * alix.vidal@wur.nl*

The need for a transition towards more sustainable forms of agriculture while maintaining high productivity is broadly acknowledged within the scientific community. However, the exact form that such sustainable agriculture should take is much less clear. There are at least two different, largely disconnected, narratives with respect to the transition towards sustainable agriculture. The first one is ecology-focused, placing central emphasis on the role of soil biota in optimizing soil nutrient cycling and providing ecosystem services. Typical terms associated with this narrative are “learning from nature” and “regenerative agriculture”, and typical challenges relate to replenishing nutrients that are removed by harvest, as well as addressing a yield gap compared to conventional agriculture. The second narrative is circularity-focused and emphasizes the return of nutrients and carbon from society to the soil through “circular amendments” such as sludges, fly ash, and recovered salts including struvite and vivianite. Typical terms associated with this approach are “valorization” and “utilizing waste streams”, and typical challenges related to poor nutrient availability in some amendments as well as contamination with e.g. heavy metals or microplastics.

In my talk, I will argue that we need a combination of both approaches to ensure truly sustainable agriculture – combining the optimization of the role of soil biota of the first approach with the emphasis on circular amendments of the second approach. This means that, in agricultural soil ecology, we should focus much more on interactions between soil organisms and circular amendments and much less on traditional roles that are associated with natural systems. I will give a few examples of such novel roles of soil organisms in agricultural systems, with an emphasis on the central role of earthworms.

N_2O emissions from agricultural peat – phosphorus a key variable influencing spatial variation

Maljanen M.*
*University of Eastern Finland, Kuopio, Finland. * marja.maljanen@uef.fi*
Zheng Y.*
*University of Eastern Finland, Kuopio, Finland. * yu.zheng@uef.fi*
Pääkkönen M.*
*University of Eastern Finland, Kuopio, Finland. * minna.paakkonen@uef.fi*
Voigt C.*
*Universität Hamburg, Hamburg, Germany. * carolina.voigt@uni-hamburg.de*
Louhisuo A.*
Natural Resources Institute Finland, Kuopio, Finland
Virkajärvi P.*
*Natural Resources Institute Finland, Kuopio, Finland. * perttu.virkajarvi@luke.fi*

Nitrous oxide (N_2O) is about 300 times as strong a greenhouse gas as carbon dioxide (CO_2). Drained organic soils are known to be hotspots for CO_2 but also for N_2O emissions. Understanding the factors that influence N_2O emissions is crucial to mitigate these emissions. Spatial variation in the emission rates of N_2O in soils can be significant due to the diverse biological, chemical, and physical conditions that affect the production and consumption of these gases. We measured N_2O emissions at 28 locations across a 7-hectare agricultural peat soil used for growing grass and cereals in Eastern Finland in eight campaigns including winter and growing season. During the growing season chamber method was used and during winter with deep snow cover the emissions were measured using the snow gradient method. In addition to N_2O fluxes, several soil parameters were measured from each sampling location.

Among measured soil parameters, plant-available phosphorus concentration was identified as a limiting factor and a critical determinant of spatial variations in N_2O emissions, whereas soil mineral nitrogen concentration did not correlate with measured N_2O emission rates. Additionally, our study demonstrated that soil ploughing and fertilisation practices significantly amplified N_2O emissions, leading to pronounced temporal variations in N_2O emission rates.

DayCent model calibration to assess the long-term impact of the animal slurry application on grassland in Ireland: Performance, sensitivities and scope for improvement

Qi Z.*
*University College Dublin (UCD), Dublin 04, Ireland. * zizhou.qi@ucdconnect.ie*
Jonathan H.*
*Agri-Food and Biosciences Institute (AFBI), Belfast, United Kingdom. * jonathan.holland@afbini.gov*
Osborne B.*
*University College Dublin (UCD), Dublin 04, Ireland. * bruce.osborne@ucd.ie*
Gallego Lorenzo L.*
*University College Dublin (UCD), Dublin 04, Ireland. * laura.gallego-lorenzo@ucd.ie*
Necpalova M.*
*University College Dublin (UCD), Dublin 04, Ireland. * magdalena.necpalova@ucd.ie*

Measurement of changes in soil organic carbon (C) under various management practices at the field scale poses significant challenges due to inherent spatial and temporal variability. The

ecosystem biogeochemical models offer a robust framework for simulating nutrient cycling, soil C and greenhouse gas emissions, and thus can be used to identify and evaluate long-term effects and strengths of climate change mitigation strategies. DayCent is a coupled soil-plant dynamic model that has been widely used to simulate long-term ecosystem responses to changes in soil management and climate in the US. Its application to agricultural systems in Ireland enquires a calibration and evaluation for common management practices across a range of pedo-climatic conditions. The objective of this study was a) to calibrate the DayCent model with several types of field data and to evaluate its performance in simulating soil C and soil N_2O emissions; b) to explore relationships between model parameters and types of field data. We aimed to simulate the effects of a long-term application of dairy, pig and mineral fertilizers on grass yields, soil organic C and nitrogen stocks and soil N_2O fluxes in a long-term permanent grassland at Hillsborough.

To improve model performance under Irish conditions, 53 parameters were selected. The mineral fertilizer treatment data from 1970 to 2022 were used to calibrate parameter values ensuring an equal contribution of different data types to the overall model error at the beginning of the process driven by the PEST parameter estimation software. All remaining treatments, differing in the rate and type of animal slurry application, were used in the independent model evaluation. The performance of the calibrated model has been substantially improved for soil C stock (rRMSE=0.14, r2=0.58, d=0.81) compared to the default model (rRMSE=0.24, r^2=0.31, d=0.46) across all validation treatments. Similarly, an improvement has been observed for annual soil N_2O emissions from the validation treatments (rRMSE=0.77, r^2=0.62, d=0.77) compared to the default model (rRMSE=1.70, r^2=0.59, d=0.71). In conclusion, DayCent successfully simulated the long-term dynamics of soil C and N stocks, annual N_2O emissions, grass yields, soil water content, and soil temperature across varying nutrient application rates and therefore might become a robust tool for optimizing nutrient management strategies under Irish conditions.

ACKNOWLEDGEMENTS

We would like to thank all the organisations that support ISCRAES 2024.

epa Research

Provides environmental data and assessments to inform decision-making and enforces effective regulation and compliance systems

www.epa.ie

MEET IN IRELAND

Focuses on making bringing a meeting, conference, or incentive trip to Ireland easy and enjoyable.

www.failteireland.ie

HOLOS-IE

Towards a System-based Digital Platform for Agricultural Land Use Planning, Management Decisions, and Inventory Reporting

www.ucd.ie/holos-ie

ReLive

Back to the Future: Reintegrating Land and Livestock for Greenhouse Gas Mitigation and Circularity.

www.relive-era.net

MDPI

Academic Open Access Publishing
since 1996

crops an Open Access Journal by MDPI
grasses an Open Access Journal by MDPI
land an Open Access Journal by MDPI
plants an Open Access Journal by MDPI
horticulturae an Open Access Journal by MDPI
agronomy an Open Access Journal by MDPI
climate an Open Access Journal by MDPI

MDPI, one of the largest publishers in the world, publishes over 390 peer-reviewed, open-access scientific journals.

www.mdpi.com

UCD Earth Institute

PRUDENCE COLLEGE DUBLIN

The UCD EI fosters multidisciplinary research and works with stakeholders to address environmental challenges.

www.ucd.ie/earth

The PCD aims to provide advanced education and training, as well as conduct research to meet global needs.

www.prudencecollege.ie

ISCRAES 2024 Organisation Assisted by

Badhan Sen
HOLOS-IE Team, UCD School of Agriculture and Food Science, Ireland

Mahjabin Siddique
HOLOS-IE Team, UCD School of Computer Science, Ireland

Aideen Barry
HOLOS-IE Team, UCD School of Agriculture and Food Science, Ireland

Xiaoyi Meng
True-Soil Team, UCD School of Agriculture and Food Science, Ireland

Alberto De Los Santos Castellanos
Spain (Prudence College Dublin)

Alejandro Moreno Regana
Spain (Prudence College Dublin)

Loukas Ortega
Polytechnic Institute UniLaSalle
France (University College Dublin)

ISCRAES

2024