FACCE ERA-GAS

MONITORING AND MITIGATION OF GREENHOUSE GASES FROM AGRI- AND SILVI-CULTURE

OVERVIEW OF THE ERA-NET COFUND ACTION

HIGHLIGHTS OF THE JOINT TRANSNATIONAL RESEARCH CALLS

ABSTRACTS OF THE FUNDED RESEARCH PROJECTS



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Contents

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Welcome from the Coordinator

Climate-neutrality by 2050 is a cornerstone of the European Green Deal and enshrined in legislation through the European Climate Law. Under current proposals, the agricultural sector will have to curb emissions by at least 40% by 2030 compared to 2005 levels. Carbon removals will need to increase to -310 Mt of CO_2 equivalents by 2030 from current annual removals of around -268 Mt and the combined land use, forestry and agriculture sector must reach climate-neutrality by 2035 at EU level.

Reducing greenhouse gas (GHG) emissions while maintaining food security and sustainability in a changing climate presents significant challenges for the agriculture and forestry sectors. Climate action will need to be underpinned by accurate and robust monitoring, reporting and verification of GHG emissions, including more accurate emission factors and activity data, as well as better inventories to capture the impact of mitigation measures. It will need to be supported by the rapid development and demonstration of mitigation innovations. To ensure the economic viability of European farms, the profitability and social sustainability of production systems will also have to be considered. Finally, climate action will need to be supported by a policy and economic framework that promotes adoption of measures from farm to fork and across our forestry sector. This will require a coordinated international approach, including innovative GHG mitigation and monitoring solutions that extend beyond the local context.

While the Horizon Europe Framework Programme is an important source of funding for research and innovation in the EU, most research funding is still controlled nationally. In the ERA-NET Cofund FACCE ERA-GAS, we have pooled *national* money from EU funding organisations to fund *transnational* projects in the area of monitoring and mitigation of GHGs from agriculture and forestry. Through enhanced cooperation and better alignment of national research priorities, FACCE ERA-GAS has supported the optimal use of national funds and provided the scale and scope necessary to maximise the impact of funded research on GHG emissions.

Together with the European Commission and partner ERA-NET Cofunds, the FACCE ERA-GAS consortium has funded 27 research projects in agriculture and forestry to date through three major calls. €14.1M was invested in 10 projects by FACCE ERA-GAS partners, the European Commission and the Ministry for Primary Industries, New Zealand, in 2017. In 2018, we joined forces with ERA-NET SusAn and the ICT-AGRI 2 ERA-NET to launch a joint call across 20 EU MS/AC and four international third countries on “Novel technologies, solutions and systems to reduce GHG emissions in animal production systems”, funding 8 projects worth €11M. Then in 2021, we organised a truly international call together with ERA-NET SusAn, ICT-AGRI-FOOD, SusCrop and the Global Research Alliance on Agricultural Greenhouse Gases (GRA), funding 9 projects worth €12.2M and involving partners from around the globe. This clearly demonstrates the benefits of connecting and harmonising activities across European and international initiatives to galvanise efforts and build collaborative action at a large scale.

As the FACCE ERA-GAS project draws to a close, we reflect on the successes of these funded projects over recent years in providing scalable solutions and advice for policy, research and practice and look forward to discovering the future impacts of ongoing projects as they emerge. On behalf of the FACCE ERA-GAS consortium, I invite you to learn more about the projects and some of their impacts in the following pages.

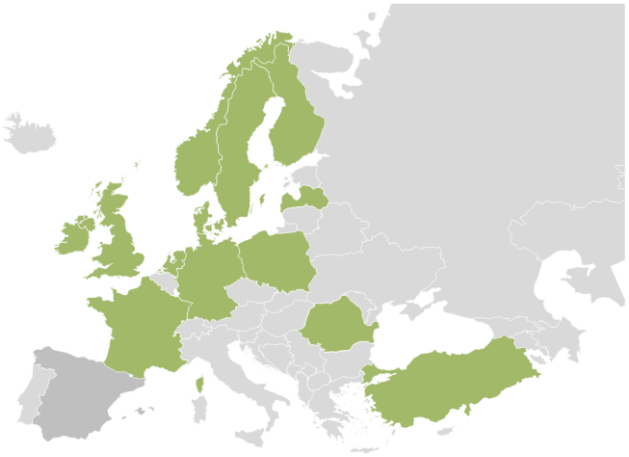
Dr. Raymond Kelly

Why we are here

The agriculture and forestry sectors in Europe face significant challenges in achieving climate neutrality by 2035 while maintaining food and biomass security in a changing climate. As a result, incorporation of abatement strategies into tailored sustainable production systems and the implementation of these strategies on the ground are of the upmost importance. In addition, the inclusion of C sinks as an offsetting option, particularly in forestry and agricultural soils, means that verification of sinks and the impact of management on those sinks is vital.

Who we are

FACCE ERA-GAS is the ERA-NET Cofund for Monitoring & Mitigation of Greenhouse Gases (GHGs) from Agri- and Silvi-culture. The consortium of FACCE ERA-GAS consists of 19 partner organisations from 13 countries: Denmark, Finland, France, Germany, Ireland, Latvia, the Netherlands, Norway, Poland, Romania, Sweden, Turkey and the United Kingdom. Additional partners, including other ERA-NETs, have jointly contributed to research calls. Teagasc, the Irish Agriculture and Food Development Authority, coordinates the ERA-NET.



FACCE ERA-GAS was initiated by the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) and runs from May 2016 to April 2022.

FACCE ERA-GAS receives funding from the European Union's Horizon 2020 Research & Innovation Programme under Grant Agreement No. 696356.

Our aim

The aim of FACCE ERA-GAS is to strengthen the trans-national coordination of research programmes and provide added value to research and innovation on GHG mitigation and monitoring in the European Research Area and New Zealand. By coordinating and aligning research efforts, FACCE ERA-GAS aims to develop enabling technologies and innovative solutions to improve inventories, increase the GHG efficiency of food, feed and fuel production and enhance carbon sinks. FACCE ERA-GAS works closely with other ERA-NETs and reinforces existing collaborations between actors in the research area (e.g. via FACCE-JPI and the Global Research Alliance).

Impact

We create impact by addressing climate change more effectively through targeted transnational efforts. These collaborations generate mitigation and monitoring solutions for the agriculture and forestry sectors that go beyond the local context. At the network level, pooling resources and aligning research priorities supports a more optimal use of national funds and fosters a durable cooperation between partners, in turn supporting a European Research Area built on cooperation, coordination and information exchange.

What we do

FACCE ERA-GAS undertakes a wide range of joint activities with project partners and external collaborators. It launched three research calls; one in 2016 co-funded with the European Commission and further calls in 2018 and 2021 jointly launched with other ERA-NETs to coordinate efforts in areas of mutual interest. These calls help to align thematic priorities across member countries and provide added value to research and innovation on GHG mitigation and monitoring.

Besides launching research calls, FACCE ERA-GAS connects with European and global networks, researchers and early-career scientists and increases engagement with stakeholder communities.

Valorisation of research projects

FACCE ERA-GAS is committed to making an impact and providing solutions to the agriculture and forestry sectors in Europe, based on solid research. This is done through organising events for research projects, partners and key stakeholders in the field, to valorise key research outcomes. Within these events, such as research programme meetings and seminars, synergies are sought within and across research projects. FACCE ERA-GAS funded researchers and stakeholders, such as farmers, foresters, policy-makers and inventory compilers, work together to ensure research contributes towards transformative change for climate action.

GHG Breakfast Clubs

FACCE ERA-GAS ''Breakfast Clubs'' bring together PhDs, post-docs, and other early-career researchers and eminent scientists in the field of greenhouse gas mitigation and monitoring. The aims of the breakfast clubs are to:

- Provide an opportunity for early-career researchers to network with peers
- Hear the latest cutting-edge research
- Benefit from career advice from established professionals in the area

Breakfast club topics included the latest scientific advances in methane and nitrous oxide mitigation and carbon sequestration, as well as presentations on how to secure funding and the power of big ideas in research.

For more information on past and future breakfast clubs, you can check our website.

Workshops on Smart Mitigation of Greenhouse Gas Emissions in Livestock

FACCE ERA-GAS organised workshops jointly with the ERA-NETs SusAN and ICT-AGRI 2 to identify promising approaches to reduce GHG emissions in livestock production. Such workshop help to identify and coalesce research priorities. Topics included:

- Production technology and management (e.g. housing systems;
- Optimal field and grazing management,
- Breeding, physiology, feed & nutrition
- Evaluation of feed chain
- Manure management
- Reducing nitrogen excretion

Future collaborations and long-term strategy

In May 2021, FACCE ERA-GAS released its short and long-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation. It sets both short and long-term strategic aims for the future in the context of the development of Horizon Europe and key research areas. These include topics such as the reduction of carbon footprints through circular biomass chains, carbon farming solutions and carbon neutrality of sustainable food systems. Cross-cutting issues are also considered and include the role of citizens and consumers in achieving social innovation and the need to consider trade-offs and co-benefits for a holistic view of sustainable land management.

A plan is being drawn up for future collaborative actions to ensure that enhanced cooperation will be maintained past the lifetime of the ERA-NET.

What is an ERA-NET Cofund?

ERA-NET Cofunds are a funding instrument under Horizon 2020 designed to support public-public partnerships (P2Ps), including joint programming initiatives between Member States, in their preparation, establishment of networking structures, design, implementation and coordination of joint activities as well as Union topping-up of a trans-national call for proposals.

The 2016 Joint Transnational Research Call

"Monitoring and Mitigation of Greenhouse Gases from Agri- and Silvi-culture"

FACCE ERA-GAS launched a co-funded joint call for transnational research projects in Europe and New Zealand on 4 March 2016. Financial support for this call was provided by funding agencies from 13 European countries and New Zealand, together with co-funding from the European Commission. Each project consortium had to involve partners from at least three different countries participating in the call. The scientific scope of the 2016 call for proposals addressed four research themes:

1. Improving national GHG inventories and monitoring, reporting and verification of emissions;
2. Refining and facilitating the implementation of GHG mitigation technologies;
3. State-of-the-art production systems that are profitable and improve food and forest biomass production while reducing GHG emissions;
4. Assessment of policy and economic measures to support emissions reductions across the farm-to-fork and forest-to consumer chain.

Projects

Title	Acronym	Countries
Combining remote sensing and 3D forest modelling to improve tropical forests monitoring of GHG emissions	3DForMod	FR, FI, NL
Capturing Effects of Diet on Emissions from Ruminant Systems	CEDERS	NL, UK, DK, SE, DE, IE, FI, NZ, FR
Mobilizing and Monitoring Climate Positive Efforts in Forests and Forestry	FORCLIMIT	NO, NL, US, SE, FI, RO
Managing and Reporting of Greenhouse Gas Emissions and Carbon Sequestration in Different Landscape Mosaics	GHG-Manage	IE, DE, FR, PL, NL
Improving National forest inventory-based carbon stock change estimates for greenhouse gas inVENTories	INVENT	NO, LV, DK, SE
Mitigating Agricultural Greenhouse Gas Emissions by improved pH management of soils	MAGGE-pH	NO, IE, DK, DE, SE, FI, FR, NZ, UK
Refining direct fed microbials (DFM) and silage inoculants for reduction of methane emissions from ruminants	METHLAB	IE, FR, NL, NZ, IT
Wise use of drained peatlands in a bio-based economy: development of improved assessment practices and sustainable techniques for mitigation of greenhouse gases	PEATWISE	NO, SE, DK, NL, FI, NZ, DE
Improved estimation and mitigation of nitrous oxide emissions and soil carbon storage from crop residues	ResidueGas	DK, SE, NO, UK, DE, FR
Predicting appropriate GHG mitigation strategies based on modelling variables that contribute to ruminant environmental impact	RumenPredict	UK, NZ, FI, SE, IE, NL, FR

Project acronym 3DForMod

Project duration 01/10/2017 – 30/09/2020

Total requested Budget € 702,000

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NL	Wageningen University and Research (WUR) Prof. Martin Herold

3DForMod

Combining remote sensing and 3D forest modelling to improve tropical forests monitoring of GHG emissions

Challenge

Deforestation and **forest degradation** is considered the second largest source of global anthropogenic greenhouse gases (GHG) emissions. While there is a pressing need to go beyond satellite-based land-use and land-cover change (LULCC) surveys to accurately monitor carbon stocks in the tropics, there is still no operational integrated framework to achieve this goal.

Project aims

3DForMod aimed at integrating advances in 3D forest modelling and very-high-resolution remote sensing technology to improve monitoring of forest aboveground biomass, especially in tropical countries that have signed the Paris Agreement.

- Streamline Terrestrial Lidar Scan (TLS) advanced technology and existing algorithms to derive quantitative structural tree models and upscale parameter extraction on tree volume and biomass distribution; make these data available for analysis
- Improve tree-level above-ground biomass (AGB) allometries for cost-efficient and non-destructive estimation of tropical forest biomass using non-destructive TLS data and modelling, with a special focus on large tropical trees
- Scaling up to plot-level with a controlled propagation of uncertainties in order to assess the impacts of forest degradation on stand structure and biomass and to derive better emission figures
- Linking ground data to remote sensing information to improve the capability and sensitivity of very high-spatial resolution satellite data to estimate biomass on landscape scale and to detect related changes and emissions at regional scales across several tropical test sites

Final aim was the uptake by national GHG monitoring by working with developing country forest monitoring agencies in pilot countries (Cameroon, Surinam and Guyana) for integrating the novel forest measurement

3DForMod

Combining remote sensing and 3D forest modelling to improve tropical forests monitoring of GHG emissions

Key results and outcomes

- Advanced the Terrestrial Lidar Scan technology for the non-destructive extraction of tree volume and tree branching structure (tree architecture) parameters for large tropical trees
- Streamlining of treatment chains and their benchmarking for concrete applications in REDD+ projects (e.g. applied projects with the Guyana Forestry Commission and with the National REDD+ program in the Democratic Republic of Congo)
- Developed new concepts and methodologies for the up-scaling of tropical forest biomass estimations from field measurements to stand, landscape and regional levels

Key publications and products

- Lau, A., Calders, K., Bartholomeus, H., Martius, C., Raumonen, P., Herold, M., Vicari, M., Sukhdeo, H.,Singh, J. & Goodman, R. C. 2019a. Tree biomass equations from terrestrial LiDAR: a case study in Guyana. Forests, 10: 527. https://doi.org/10.3390/f10060527

- Lau, A., Martius, C., Bartholomeus, H., Shenkin, A., Jackson, T., Malhi, Y., Herold, M., Bentley, L. P. 2019b. Estimating architecture-based metabolic scaling exponents of tropical trees using terrestrial LiDAR and 3D modelling. Forest Ecology and Management, 439: 132-145.https://doi.org/10.1016/j.foreco.2019.02.019

- Martin-Ducup, O., Ploton, Barbier, N., Momo Takoudjou, S., Mofack, G. II, Kandem, N., Fourcaud, T., Sonké, B., Couteron, P. & Pélissier, R. 2020. Terrestrial laser scanning reveals convergence of tree architecture with increasingly dominant crown canopy position. Functional Ecology, 34: 2442-2452. https://doi.org/10.1111/1365-2435.13678

- Ploton, P., Mortier, F., Réjou-Méchain, M., Barbier, N., Picard, N., Rossi, V., Dorman, C. Cornu, G., Viennois, G., Bayol, N., Lyapustin, A., Gourlet-Fleury, S. & Pélissier, R. 2020. Spatial validation reveals poor predictive performance of current large scale tropical forest biomass mapping models. Nature Communications, 11, 4540. https://doi.org/10.1038/s41467-020-18321-y

- Olivier Martin-Ducup, Gislain Mofack, II, Di Wang, Pasi Raumonen, Pierre Ploton, Bonaventure Sonké, Nicolas Barbier, Pierre Couteron, Raphaël Pélissier, Evaluation of automated pipelines for tree and plot metric estimation from TLS data in tropical forest areas, *Annals of Botany*, Volume 128, Issue 6, 2 November 2021, Pages 753–766, https://doi.org/10.1093/aob/mcab051

Publications for general audiences and practitioners

- Central African forests are unequally vulnerable to global change, IRD Press Release 21/04/2021, https://bit.ly/3kWOgys

More information

Open and free to use software, data, scripts and maps for tropical tree biomass estimations available at http://3dformod.free.fr/

Project acronym CEDERS

Project duration 01/10/2017 – 30/6/2021

Total requested budget € 1,830,000

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IE	Teagasc, Agriculture and Food Development Authority Dr. Gary Lanigan
NZ	AgResearch Ltd Dr Kirsty Hammond and Dr. C. DeKlein
SE	Swedish University of Agricultural Sciences (SLU) Prof. Pekka Huhtanen
UK	University of Reading (UoR) Dr. Les Crompton

CEDERS

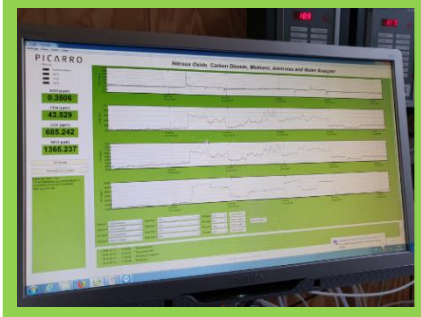
Capturing effects of diet on emissions from ruminant systems

Challenge

Feed management in ruminant production systems strongly affects **agricultural greenhouse gas (GHG) emissions**. However, there are still considerable knowledge gaps in the relationship between diet and emissions.

Project aims

- Develop, expand and refine databases to evaluate dietary mitigation strategies on digestion, excretion, manure composition, and related GHG emissions
- Fill, by experimentation, high-priority knowledge gaps on dietary effects on ruminant and manure emissions
- Evaluate, using monitored farm cases in a modelling platform, the consequences of dietary mitigation measures on total farm GHG emissions
- Improve farm accounting and national inventory methodologies to capture effects of dietary mitigation measures for on-farm GHG emissions



Detail of Picarro system measuring emissions and cows within special emission units

CEDERS

Capturing effects of diet on emissions from ruminant systems

Key results and outcomes

- i) Starch- and fat-supplemented diets mitigate enteric methane, which is generally applied on farms that feed (whole plant) maize or grains, or compound feeds/by-products as opposed to grazing-based farms
- ii) Enteric methane emission decreases with increased feeding quality of roughages and with starch-containing roughages
- A synergistic effect of i) and ii) may be expected from starch- and fat-supplementation on N emissions, however increased in-stall volatile solids produced (faeces), a decreased digestibility and confinement of animals in principle generates a potential CH_4 trade-off to be kept in mind
- It appears feasible to reduce dietary N content (e.g. excluding soy) and fibre content (e.g. starchy roughages or fat-rich feedstuffs) to mitigate both enteric methane and N emissions, but careful diet optimization is pivotal to prevent trade-offs such as compromised digestibility, feed intake and production, and increased manure emissions
- Preliminary results from simulation modelling of emissions of farm cases indicate higher as well as lower enteric methane emission compared to IPCC default values, with lower values typical for intensive feeding conditions under confinement, and higher values for grazing conditions

Key publications

- Van Gastelen, S., J. Dijkstra & A. Bannink. 2019. Are dietary strategies to mitigate enteric methane emission equally effective across dairy cattle, beef cattle, and sheep? Journal of Dairy Science 102, 6109-6130. https://doi.org/10.3168/jds.2018-15785

- Bannink, A., R.L.G. Zom, K.C. Groenestein, J. Dijkstra & L.B.J. Sebek. 2020. Applying a mechanistic fermentation and digestion model for dairy cows with emission and nutrient cycling inventory and accounting methodology. Animal 14:S2, s406–s416.https://doi.org/10.1017/S1751731120001482

- Vibart, R., C. de Klein, A. Jonker, T. van der Weerden, A. Bannink, A.R. Bayat, L. Crompton, A. Durand, M. Eugène, K. Klumpp, B. Kuhla, G. Lanigan, P. Lund, M. Ramin & F. Salazar. 2021. Challenges and opportunities to capture dietary effects in on-farm greenhouse gas emissions models of ruminant systems. Science of The Total Environment, 144989. https://doi.org/10.1016/j.scitotenv.2021.144989

- Ouatahar, L., A. Bannink, G. Lanigan & B. Amon. 2021. Modelling the Effect of Feeding Management on Greenhouse Gas and Nitrogen Emissions in Cattle Farming Systems. Science of The Total Environment, 145932. https://doi.org/10.1016/j.scitotenv.2021.145932

More information

Project acronym FORCLIMIT

Project duration 01/10/2017 – 31/05/2020

Total requested budget € 1,123,000

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Other project participants

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NL	Wageningen University Prof. Gert-Jan Nabuurs
RO	Transylvania University of Brasov Dr. Viorel Blujdea
SE	Swedish University of Agricultural Sciences Dr. Hans Petersson
US	U.S. Forest Service Dr. Ronald McRoberts

FORCLIMIT

Mobilizing and monitoring climate positive efforts in forests and forestry

Challenge

The **mitigation potential** of Europe's forests is significant but is underutilized in the **EU climate policy framework**. European forests offset approximately 13% of European fossil fuel-based emissions. To increase the mitigation in forest landscapes, incentives are needed and the uncertainty regarding implementation and effects of mitigation strategies must be reduced. The FORCLIMIT project addressed these considerations jointly because only by addressing them together can progress be made.

Project aims

The aim of FORCLIMIT was to build and provide the stepping stones of an effective forest-based climate change mitigation strategy. The specific aims were:

- To analyse and suggest improvements in a unified international policy framework that facilitates consistent carbon accounting of forests across countries
- To analyse economic and policy strategies for motivating landowners to undertake efforts for mitigation in forests and further on down the wood value chain
- To add to a monitoring, reporting and verification (MRV) system aimed at improved estimation of soils emissions and sinks, improved emissions and sinks estimates from stand to landscape level and assessment of economic and policy measures

FORCLIMIT

Mobilizing and monitoring climate positive efforts in forests and forestry

Key results and outcomes

- Examination of key mechanisms within the international climate change mitigation (and adaptation) framework
- Analysis of the consequences of new accounting rules on reported emissions and removals for the LULUCF sector – appropriate data at the national scale. Results show that there is a trade-off between setting aside land for biodiversity conservation and storing carbon in forests
- From regional to national and local scales: results show incentives are needed for motivating landowners to undertake climate-friendly actions. Changes to current policy such as encouraging governments to pass benefits aggregated at the national level on to forest owners and other lower-level actors could propel the EU and national-level climate policy frameworks toward more dynamic climate change mitigation.
- Combining soil carbon measurements and modelling for cost-efficient inventories
- Consistent emissions estimation at stand/treatment unit, landowner and landscape levels
- Assessment of economic and policy measures to support Climate Smart Forestry –three case studies (Netherlands, Romania, Sweden)

Key publications

- Ciais, P., Wang, Y., Andrew, R., Bréon, F.M., Chevallier, F., Broquet, G., Nabuurs, G.J.,Peters, G., McGrath, M., Meng, W., Zheng, B., Tao, S. (2020). Biofuel burning and human respiration bias on satellite estimates of fossil fuel CO2 emissions. Environmental research letters: ERL [Web site] 15: 074036. https://doi.org/10.1088/1748-9326/ab7835

- Dutcă I., Mather R., Ioraș F. (2020). Sampling trees to develop allometric biomass models: How does tree selection affect model prediction accuracy and precision? Ecological indicators 117: 106553 https://doi.org/10.1016/j.ecolind.2020.106553

- Petrescu A.M.R., Peters G.P., Janssens-Maenhout G., Ciais P., Tubiello F.N., Grassi G. Nabuurs, G. J. , Leip, A., Carmona-Garcia, G., Winiwarter, W., Höglund-Isaksson, L., Günther, D., Solazzo, E., Kiesow, A., Bastos, A., Pongratz, J., Nabel, J. E. M. S., Conchedda, G., Pilli, R., Andrew, R. R., Schelhaas, M. J. & Dolman, A. A. (2020). European anthropogenic AFOLU greenhouse gas emissions: a review and benchmark data. In : Earth System Science Data. 12, 2, p. 961-1001 41p. https://doi.org/10.5194/essd-12-961-2020

- Nabuurs, GJ , Peter Verweij, Michiel Van Eupen, Marta Pérez-Soba, Helga Pülzl and Kees Hendriks. 2019 Next-generation information to support a sustainable course for European forests. Nature Sustainability. https://doi.org/10.1038/s41893-019-0374-3

- Banja, M., Sikkema, R., Jégard, M., Motola, V., Dallemand, J.-F., 2019. Biomass for energy in the EU – The support framework. Energy Policy 131, 215–228. https://doi.org/10.1016/j.enpol.2019.04.038

More information

Project acronym GHG-Manage

Project duration 01/10/2017 – 30/09/2021

Total requested budget € 1,229,000

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IE	Teagasc, Agriculture and Food Development Authority Dr. Laurence Shalloo
NL	Wageningen University & Research (WUR) Dr. Ronald Hutjes and Dr. Bart Kruijt
PL	Institute of Agrophysics, Polish Academy of Science (GFAR) Dr. Anna Walkiewicz

GHG MANAGE

Managing and reporting of greenhouse gas emissions and carbon sequestration in different landscape mosaics

Challenge

The overall contribution of a combination of different **land uses** to **carbon sequestration** and greenhouse gas (GHG) emissions has been poorly quantified. The objective in this project was to assess the contribution of typical EU landscape mosaics to GHG emissions and carbon sequestration and provide estimates of surface warming effects.

Project aims

- To investigate optimal configurations of landscape elements and management practices that lead to internal compensation of GHG emissions whilst considering their economic impact
- To quantify the effects of important compensating mechanisms on regional to national scale GHG emissions and soil carbon stocks
- To design methodologies to report and verify the effects of landscape scale GHG emission-compensation mechanisms
- To develop a new framework based on remote-sensing, new on-site measurement techniques and modelling efforts that facilitate an accounting of the contribution of different land use mosaics and management practices to GHG mitigation in heterogeneous landscapes
- To integrate information generated into landscape models to improve on-farm and regional GHG assessments

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GHG MANAGE

Managing and reporting of greenhouse gas emissions and carbon sequestration in different landscape mosaics

Key results and outcomes

- Relatively small levels of afforestation could help mitigate and offset on-farm GHG emissions through enhanced carbon sequestration and CH_4 oxidation that are also economically viable
- Development of an optimization model to forecast land-use changes to attain an environmentally and economically sustainable agriculture sector
- Preliminary assessment of albedo effects and their significance
- Identification of emission factors for housing, animal type and manure type
- Tested the operational effectivity of direct flux measurements on small peat meadow plots subjected to different drainage regimes

Key publications

- Hennessy DP, Shalloo L, van Zanten HHE, Schop M, De Boer IJM (2021). The net contribution of livestock to the supply of human edible protein: the case of Ireland. The Journal of Agricultural Science 1–9. https://doi.org/10.1017/S0021859621000642

- Khalil, M.I., S.F. Islam, M. O'Neil and B. Osborne. 2020. Measuring and quantifying greenhouse gas emissions from agricultural activities. In: Deryng, D. (ed.), Climate change and agriculture, Burleigh Dodds Science Publishing,Cambridge, UK, 2020, (ISBN: 978 178676 320 4; www.bdspublishing.com). p1-79. http://dx.doi.org/10.19103/AS.2020.0064.12

- Koebsch, F., Gottschalk, P., Beyer, F., Wille, C., Jurasinski, G., Sachs, T. (2020). "The impact of occasional drought periods on vegetation spread and greenhouse gas exchange in rewetted fens." Philosophical Transactions of the Royal Society B: Biological Sciences 375(1810). https://doi.org/10.1098/rstb.2019.0685

- Graf, A., … Gottschalk, P., … Sachs, T., … Wille, C. … et al. (2020). "Altered energy partitioning across terrestrial ecosystems in the European drought year 2018." Philosophical Transactions of the Royal Society B: Biological Sciences 375(1810): 20190524. https://doi.org/10.1098/rstb.2019.0524

- Huguenin-Elie O., Delaby L., Klumpp K., Lemauviel-Lavenant S., Ryschawy J., Sabatier R. (2018). The roles of grasslands for biogeochemical cycles and biodiversity conservation. In "Improving grassland and pasture management in temperate agriculture". Marshall, A. and Collins, R. (ed.), Burleigh Dodds Science Publishing, Cambridge, UK, 2018, (ISBN: 978 1 78676 200 9; www.bdspublishing.com), http://dx.doi.org/10.19103/AS.2017.0024.01

More information

Project acronym INVENT

Project duration 01/10/2017 – 31/12/2020

Total requested budget € 1,027,000

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NO	Norwegian Institute of Bioeconomy Research (NIBIO) Dr. Johannes Breidenbach, Dr. Rasmus Astrup, Dr. Aaron Smith
SE	Swedish University of Agricultural Sciences (SLU) Dr. Mattias Lundblad, Dr. Erik Karltun, Dr. Johan Stendahl, Dr. Mats Nilsson

INVENT

Improving national forest inventory-based carbon stock change estimates for greenhouse gas INVENTories

Challenge

Forest land in Europe annually sequesters atmospheric carbon (C) comparable to the emissions from the agricultural or industrial process sectors. Despite its importance, the full potential of **C sequestration** on forest land in climate change mitigation strategies is not utilized. In large part, this is due to high uncertainties of C-stock change (CSC) estimates

Project aims

The overall aim of INVENT was improving methodology for estimating forest CSC to be reported at national or sub-national scale, in order to increase accuracy and thus help facilitate the mobilization of the climate change mitigation potential of forest land in Europe.

- To increase the precision in National Forest Inventory based estimates of CSC in forest tree biomass by applying a model assisted framework and using auxiliary data with information on spatial harvest distributions
- To improve accuracy in soil organic carbon change estimates by combining soil inventory data, empirical models, and process model estimates of soil organic carbon changes
- To implement the new methods (from WP1 and WP2) for CSC estimation and to evaluate their impacts in terms of estimated GHG inventory emissions, their applicability in relation to the UNFCCC reporting demands, and their potential for the development of mitigation strategies

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INVENT

Improving national forest inventory-based carbon stock change estimates for greenhouse gas INVENTories

Key results and outcomes

- Optical satellite image-mosaics were used in combination with national forest inventory (NFI) sample plot data and a national land-use map to estimate forest area by tree species. Tree species are important for stratification and thus improving of GHG estimates. As part of this work, forest area estimation was markedly improved. Forest area is a key variable in LULUCF GHG inventories. Methodology was developed that is useful in general for GHG-inventories.
- CSC estimates in the living biomass pool was improved by airborne lidar point clouds in combination with the Landsat-based Global Forest Change (GFC) map, Copernicus Sentinel-2, and NFI sample plot data.
- High-resolution auxiliary data (HRAD) was used to improve soil carbon stock (SOC) / SOC changes.
- Litter fall functions using basal area and tree species as predictor for Yasso modeling were improved and shown to be suitable for NFI upscaling.
- Registrations on forest floor depth legacy NFI data was used to study to what extent stand and site characteristics determine the forest floor magnitude.
- Methods to estimate effect of climate mitigation measures in forests were evaluated and improvements suggested.

Key publications

- Callesen and Magnussen. 2021. TransparC2U – A two-pool, pedology oriented forest soil carbon simulation model aimed at user investigations of multiple uncertainties. Ecological Modelling 453. https://doi.org/10.1016/j.ecolmodel.2021.109603

- Callesen et al. 2021. A High-Resolution Digital Elevation Model in Combination With Water Table Depth and Continuous Soil Redox Potential Measurements Explain Soil Respiration and Soil Carbon Stocks at the ICOS Site Sorø. Frontiers in Forests and Global Change. https://doi.org/10.3389/ffgc.2020.563355

- Butlers, A., & Lazdins, A. (2020). Carbon stock in litter and organic soil in drained and naturally wet forest lands in Latvia. 47–54. https://doi.org/10.22616/rrd.26.2020.007

- Nord-Larsen T., Vesterdal L., Bentsen NS, Larsen JB. Ecosystem carbon stocks and their temporal resilience in a semi-natural beech-dominated forest (2019) Forest Ecology and Management 447, 67-76. DOI https://doi.org/10.1016/j.foreco.2019.05.038

- Rossi, F., J. Breidenbach, S. Puliti, R. Astrup and B. Talbot. 2019. Assessing Harvested Sites in a Forested Boreal Mountain Catchment through Global Forest Watch. Remote Sensing 11(5): 543. https://doi.org/10.3390/rs11050543

More information

Project acronym MAGGE-pH

Project duration 01/08/2017 – 31/07/2020

Total requested budget € 2,269,000

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UK	Natural Environment Research Council (NERC) Prof. Ute-Maria Skiba

MAGGE-pH

Mitigating Agricultural Greenhouse Gas Emissions by improved pH management of soils

Challenge

Climate forcing from plant production is dominated by **nitrous oxide (N_2O) emissions**. Although emissions can be marginally reduced by "good agronomic practice", we need more targeted approaches to make progress. For that, MAGGE-pH concentrates on the **microbial processes** responsible for production and consumption of **N_2O in soils**. Our point of departure is the emerging understanding of how soil pH pervasively controls the $N_2O/(N_2O+N_2)$ product ratio of denitrification.

Project aims

- Develop novel, science-based, and implementable approaches to reduce N_2O emissions from agricultural soils
- Evaluating effects of soil pH on N_2O emissions
- Understand the response of soil processes to soil pH manipulations
- Develop alternative approaches for manure and urea-based fertilizers
- Target the microbial processes responsible for production and consumption of N_2O in soils
- Upscale the mitigation potential of liming
- Develop proposals for policy instruments supporting GHG mitigation by soil pH management

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MAGGE-pH

Mitigating Agricultural Greenhouse Gas Emissions by improved pH management of soils

Key results and outcomes

- Long-term pH management keeping soil pH > 6.5 reduces N_2O emissions
- Calculating CO_2 emissions from lime application as in IPCC (2019) leads to erroneously high CO_2 emissions offsetting the net benefit of N_2O mitigation
- N_2O reduction to N_2 is highly pH sensitive and inhibited by low pH
- Liming acidic soils increases N_2O production by nitrification
- The net effect of liming on N_2O emissions depends on the source process (nitrification vs. denitrification)

Key publications

- Ganasamurthy S, Rex D, Samad MS, Richards KG, Lanigan GJ, Grelet G, Clough TJ, and Morales SE (2021). Competition and community succession link N transformation and greenhouse gas emissions in urine patches. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2021.146318

- Liang Z, Elsgaard L (2021). Nitrous oxide fluxes from long-term limed soils following P and glucose addition: Nonlinear response to liming rates and interaction from added P, Science of The Total Environment 797, 148933,
- https://doi.org/10.1016/j.scitotenv.2021.148933

- The effect of a biochar temperature series on denitrification: which biochar properties matter?, Soil Biology and Biochemistry 135, 173-183,https://doi.org/10.1016/j.soilbio.2019.04.018

- Thers H, Abalos D, Dörsch P, Elsgaard L (2020). Nitrous oxide emissions from oilseed rape cultivation were unaffected by flash pyrolysis biochar of different type, rate and field ageing, Science of The Total Environment 724, 138140, https://doi.org/10.1016/j.scitotenv.2020.138140

- Highton MP, Bakken LR, Dörsch P, Wakelin S, de Klein CAM, Molstad L, Morales SE (2020). Soil N_2O emission potential falls along a denitrification phenotype gradient linked to differences in microbiome, rainfall and carbon availability, Soil Biology and Biochemistry 150, 108004, https://doi.org/10.1016/j.soilbio.2020.108004

- Abalos D, Liang Z, Dörsch P, Elsgaard L(2020). Trade-offs in greenhouse gas emissions across a liming-induced gradient of soil pH: Role of microbial structure and functioning, Soil Biology and Biochemistry 150, 108006, https://doi.org/10.1016/j.soilbio.2020.108006

More information

Project acronym METHLAB

Project duration 01/10/2017 – 30/09/2020

Total requested budget € 1,036,000

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IT	Sacco S.r.l. (SACCO) Dr. Ines Martinez
NL	Wageningen University and Research (WUR) Prof. Wilbert Pellikaan
NZ	AgResearch New Zealand Dr. Graeme Attwood, Dr. Sinead Leahy

METHLAB

Refining direct fed microbials (DFM) and silage inoculants for reduction of methane emissions from ruminants

Challenge

Reducing agricultural greenhouse gas (GHG) emissions is a challenge, particularly as agricultural intensity is increasing globally. METHLAB assesses on-farm lactic acid bacteria (LAB) technologies such as feed supplements and/or silage inoculants, currently used to increase production and improve health of ruminant animals, and refines them with a methane-reducing benefit.

Project aims

- To develop a prioritized list of METHLAB strains with known ability to reduce methane in ruminant animals
- To incorporate METHLAB strains with known ability to reduce methane in ruminants into a product prototype (direct fed microbials (DFM) and/or silage inoculant) to facilitate implementation at farm level
- To evaluate METHLAB strain(s) in ruminants (sheep and dairy cows) to confirm efficacy of methane reduction in vivo and on production parameters (dairy cows)
- To develop an Intellectual Property (IP) Management Plan, established by all participating institutes to address management of IP that will be developed as a result of the work performed

Sampling of silage to test nutritional value and quality; and cows on the animal trial being milked

METHLAB

Refining direct fed microbials (DFM) and silage inoculants for reduction of methane emissions from ruminants

Key results and outcomes

- Development of a useful growth inhibition assay for the methanogen indicator strain Mbb. Boviskoreani in a microtitre plate format based on the ability of this organism to grow on ethanol in the absence of H_2, allowing high throughput of samples using a small sample volume. This assay allows high throughput identification of promising LABs and is an advancement on tools previously available
- A biobank of antimicrobial strains with activity against methane producing bacteria were isolated
- Data was produced on the impact of MethLAB strains for methane reduction on parameters in dairy cows

Key publications

- Doyle, Natasha & Mbandlwa, Philiswa & Leahy, Sinead & Attwood, Graeme & Kelly, Bill & Hill, Collin & Ross, R. & Stanton, Catherine. (2021). The use of feed supplements to reduce livestock greenhouse gas emissions: direct-fed microbials. http://dx.doi.org/10.19103/AS.2020.0077.14

- Huyen NT, Martinez I, Pellikaan W. Using Lactic Acid Bacteria as Silage Inoculants or Direct-Fed Microbials to Improve In Vitro Degradability and Reduce Methane Emissions in Dairy Cows. *Agronomy*. 2020; 10(10):1482. https://doi.org/10.3390/agronomy10101482

- Mbandlwa, P., Doyle, N., Hill, C., Stanton, C., & Ross, R. P. (2020). Bacteriocins: Novel Applications in Food, and Human and Animal Health, https://doi.org/10.1016/B978-0-08-100596-5.23030-8

- Stanton C, Leahy S, Kelly B, Ross RP, Attwood G. (2020). Manipulating the rumen microbiome to address challenges facing Australasian dairy farming. Animal Production Science, https://doi.org/10.1071/AN18611

- Doyle N, Mbandlwa P, Kelly WJ, Attwood G, Li Y, Ross RP, Stanton C, Leahy S. Use of Lactic Acid Bacteria to Reduce Methane Production in Ruminants, a Critical Review. Front Microbiol. 2019 Oct 1;10:2207. https://doi.org/10.3389/fmicb.2019.02207 PMID: 31632365; PMCID: PMC6781651

More information

Project acronym PEATWISE

Project duration 01/11/2017 – 30/06/2021

Total requested budget € 1,939,000

Project Coordinator
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NZ	University of Waikato , New Zealand Dr. David Campbell
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PEATWISE

Wise use of drained peatlands in a bio-based economy: development of improved assessment practices and sustainable techniques for mitigation of greenhouse gases

Challenge

In regions where **peatlands** are common, a high proportion have been drained and used for food and fibre production. Drainage increases the oxidation of the peat leading to greenhouse gas emissions and directly threatens the storage of carbon, one important ecosystem service of natural peatlands. However, peatland cultivation is important in northern Europe and New Zealand, especially for dairy and meat production. Limiting greenhouse gas emissions has become a major environmental objective in peatland management both in Europe and worldwide. PEATWISE has explored ways to reduce emissions while maintaining biomass production or finding new ways of using peatlands with a high-water table.

Project aims

- Review and discuss options for peatland agriculture with reduced greenhouse gas emission
- Test out effects of paludiculture and cultivation options to reduce GHG emissions
- Study protein extracts and potential use of paludiculture crops for feed
- Find out stakeholder opinions and outline recommendations for policy development

Case studies on peatland sites and country factsheets on peatland use policies available on the ERA-GAS website

PEATWISE

Wise use of drained peatlands in a bio-based economy: development of improved assessment practices and sustainable techniques for mitigation of greenhouse gases

Key results and outcomes

- Rewetting can reduce carbon emission, but water levels must be kept stable just below the soil surface, which is in many cases difficult and exclude conventional agriculture.
- Climate change can in the future result in prolonged growing seasons in boreal regions but a warmer and drier soil environment could further increase organic matter decomposition. In dry years, like 2018, peat soils with in general large amounts of water stored in the profile, secured the grass production on many farms when the minerals soils suffered from great yield depression. A change towards land use with higher water tables needs incentives and long-term plans that are adapted to local conditions and socioeconomic constraints.

Key Publications

- Nielsen C.K., Stødkilde-Jørgensen, L., Jørgensen, U. and Lærke P.E. (2021) Effects of harvest and fertilization frequency on protein yield and extractability from flood-tolerant perennial grasses cultivated on a fen peatland. Frontiers in Environmental Science (published online 21 April 2021). https://doi.org/10.3389/fenvs.2021.619258

- Kandel T.P., Karki S., Elsgaard L., Labouriau R. and Lærke P.E. (2020) Methane fluxes from a rewetted agricultural fen during two initial years of paludiculture. Science of the Total Environment 713, 15 April 2020, 136670.
- https://doi.org/10.1016/j.scitotenv.2020.136670

- Norberg, L., Hellman, M., Berglund, K., Hallin, S. & Berglund, Ö. 2021. Methane and Nitrous Oxide Production from Agricultural Peat Soils in Relation to Drainage Level and Abiotic and Biotic Factors. Front. Environ. Sci. 9:631112. Open Access. https://doi.org/10.3389/fenvs.2021.631112

- Campbell, D.I., Glover-Clark, G.L., Goodrich, J.P., Morcom, C., Schipper, L. A., Wall, A.M., 2021. Large differences in CO2 emissions from two dairy farms on a drained peatland driven by contrasting respiration rates during seasonal dry conditions. Science of The Total Environment, 760, 143410. https://doi.org/10.1016/j.scitotenv.2020.143410

Publications for general audiences and practitioners

- Policy Brief #1 Climate Mitigation Measures For Drained Peatlands
- Policy Brief #2 Views of stakeholders on the implications of climate-neutral peatland by 2050
- PEATWISE Case Studies
- PEATWISE Factsheet on peatland use policies from different EU countries

More information

Project acronym ResidueGas

Project duration 01/11/2017 – 30/04/2021

Total requested budget € 1,376,000

Project Coordinator
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ResidueGas

Improved estimation and mitigation of nitrous oxide emissions and soil carbon storage from crop residues

Challenge

Crop residue incorporation is a common practice to increase or restore organic matter in agricultural soils. However, this may increase soil emissions of nitrous oxide (N_2O). ResidueGas addressed the estimation of N_2O emissions from residue amendments, and to what extent these emissions can be offset by increases in soil organic carbon (SOC) stocks with soil residue incorporation.

Project aims

- Propose a new and improved methodology to estimate N_2O emissions from crop residues
- Assess the relative importance of crop residue management for total N_2O emissions and the soil C and N balance for different residue management schemes as a basis for identifying mitigation measures

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Crop residues in policy and practice

ResidueGas held a webinar with stakeholders to apply crop residue utilisation in farming across Europe
Presentations:
https://projects.au.dk/residuegas/stakeholder-webinar/

ResidueGas

Improved estimation and mitigation of nitrous oxide emissions and soil carbon storage from crop residues

Key results and outcomes

- Long-term GHG emissions associated with crop residues are determined by N_2O emissions, not soil carbon storage
- Immature crop residues are more important for N_2O emissions than mature residues, and soil incorporation of immature residues in situations with high soil mineral N should be avoided
- Roots contribute less to N_2O emissions than aboveground immature residues
- Farmers are currently reluctant to effectively manage N_2O emissions from immature residues, in particular through residue removal.
- A simple decision support tool which allows to estimate the effects of residue management for changes in soil C stocks and N_2O emissions

Key publications

- Hansen, J.H., Hamelin, L., Taghizadeh-Toosi, A., Olesen, J.E. & Wenzel, H. (2020). Potential for bioenergy from agricultural residues with sustained soil carbon depends on energy conversion pathway. Global Change Biology Bioenergy 12, 1002-1013. https://doi.org/10.1111/gcbb.12733

- Smith, P., Soussana, J.-F., Angers, D., Schipper, L., Chenu, C., Rasse, D., Batjes, N., van Egmond, F., McNeill, S., Kuhnert, M., Arias-Navarro, C., Olesen, J.E., Chirinda, N., Fornara, D., Wollenberg, E., Alvaro-Fuentes, J., Sanz-Cobena, A., Klumpp, K. (2020). How to measure, report and verify soil carbon change to realise the potential of soil carbon sequestration for atmospheric greenhouse gas removal. Global Change Biology 26, 219-241 https://doi.org/10.1111/gcb.14815

- Schröder, J., Ten Berge, H., Bampa, F., Creamer, R., Cervera, J.G., Henriksen, C., Olesen, J.E., Rutgers, M. & Sanden, T. (2020). Multi-functional land use is not self-evident for farmers: a critical review. Frontiers in Environmental Science 8, 575466 https://doi.org/10.3389/fenvs.2020.575466

- Abdalla, M., Hastings, A., Cheng, K., Yue, Q., Chadwick, D., Espenberg,M., Truu, J., Rees, R.M. & Smith, P. 2019. A critical review of the impacts of cover crops on nitrogen leaching, net greenhouse gas balance and crop productivity. Global Change Biology 25, 2530-2543 https://doi.org/10.1111/gcb.14644

- Xia, L., Lam, S.K., Wolf, B., Kiesen, R., Chen, D., Butterbach-Bahl, K. (2018). Trade-offs between soil carbon sequestration and reactive nitrogen losses under straw return in global agroecosystems. Global Change Biology 24, 5919–5932. https://doi.org/10.1111/gcb.14466

More information

Project acronym RumenPredict

Project duration 01/10/2017 – 31/12/2021

Total requested budget € 1.592.000

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IE	University College Dublin (UCD) Dr. Alan Kelly
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RumenPredict

Predicting appropriate GHG mitigation strategies based on modelling variables that contribute to ruminant environmental impact

Challenge

Ruminant production is responsible for ~ 9% of anthropogenic carbon dioxide emission and 37% of CH_4 emissions. The aims of RumenPredict were to provide a platform for predicting how **host genetics**, **feed additives** or **microbiome differences** may affect **emission phenotypes** and develop genetic/diet/prediction technologies further for implementation to improve nitrogen use efficiency whilst decreasing environmental impact of ruminants.

Project aims

- To test the hypothesis that animal phenotype (nitrogen use efficiency and GHG emissions) is defined by the interaction between host genome and rumen microbiome
- To develop and validate promising feed-based mitigation strategies
- To define minimal requirements for conducting and reporting rumen microbial omics data in order to develop consistent, reliable datasets for analysis of samples generated in RumenPredict and those beyond this project
- To test the existing hypothesis that key genes are upregulated in the rumen/buccal microbiome of high methane emitting ruminants and that these genes could be used as biomarkers to predict GHG emissions in ruminants
- To utilize the information generated within RumenPredict to forecast nitrogen and methane losses from ruminants
- To disseminate aims and results of the project to appropriate stakeholders through workshops and stakeholder/public outreach events

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RumenPredict

Predicting appropriate GHG mitigation strategies based on modelling variables that contribute to ruminant environmental impact

Key results and outcomes

- Cattle naturally rank as high or lower methane emitters, thereby suggesting that methane-based estimated breeding values could be instigated when datasets are increased to confirm this and provide statistical power
- Use of rapeseed oil or red seaweed to reduce methane emissions from ruminants
- Standardisation of sampling and microbiome analysis
- Development of rumen mock communities for rumen microbiome studies
- Mathematical model allowing methane emission predictions validated in vitro and under development for in vivo predictions

Key publications

- Chagas, J.C.; Ramin, M.; Exposito, R.G.; Smidt, H.; Krizsan, S.J. Effect of a Low-Methane Diet on Performance and Microbiome in Lactating Dairy Cows Accounting for Individual Pre-Trial Methane Emissions. Animals 2021, 11, 2597. https://doi.org/10.3390/ani11092597

- Ramin, M.; Chagas, J.C.; Smidt, H.; Exposito, R.G.; Krizsan, S.J. Enteric and Fecal Methane Emissions from Dairy Cows Fed Grass or Corn Silage Diets Supplemented with Rapeseed Oil. *Animals* **2021**, *11*, 1322. https://doi.org/10.3390/ani11051322

- Huws SA, Creevey CJ, Oyama LB, Mizrahi I, Denman SE, Popova M, Muñoz-Tamayo R, Forano E, Waters SM, Hess M, Tapio I, Smidt H, Krizsan SJ, Yáñez-Ruiz DR, Belanche A, Guan L, Gruninger RJ, McAllister TA, Newbold CJ, Roehe R, Dewhurst RJ, Snelling TJ, Watson M, Suen G, Hart EH, Kingston-Smith AH, Scollan ND, do Prado RM, Pilau EJ, Mantovani HC, Attwood GT, Edwards JE, McEwan NR, Morrisson S, Mayorga OL, Elliott C, Morgavi DP. Addressing Global Ruminant Agricultural Challenges Through Understanding the Rumen Microbiome: Past, Present, and Future. Front Microbiol. 2018 Sep 25;9:2161. doi: https://doi.org/10.3389/fmicb.2018.02161

- Effects of intraruminal urea-nitrogen infusions on feed intake, nitrogen utilization, and milk yield in dairy cows. Journal of dairy science. 2018 Oct 1;101(10):9004-15. https://doi.org/10.3168/jds.2018-14617

More information

The 2018 Joint Transnational Research Call

"Novel technologies, solutions and systems to reduce greenhouse gas emissions in animal production systems"

The three ERA-NETs FACCE ERA-GAS, ERA-NET SusAn and ICT-AGRI 2 launched in October 2018 the Joint Call on "Novel technologies, solutions and systems to reduce greenhouse gas emissions in animal production systems". The call invited proposals for applied transnational research projects addressing at least two of the themes within the scientific scope, with the overall objective of reducing greenhouse gas emissions in animal production systems in Europe and beyond. The projects' potential impact should be relevant for the mitigation of GHG emissions within the coming 5 - 10 years. The scientific scope centred around three themes:

1. The ''holistic theme'': Agroecological approach to whole animal production systems

2. The "technical theme": Technical options for the monitoring and mitigation of GHG emissions from animal production systems

3. The "societal theme": Social and/or economic approach to livestock production and consumption of animal products

Projects

Title	Acronym	Countries
Climate Care Cattle Farming Systems Countries	CCCFarming	NL, IT, LV, PL, LT, FR, USA, BR, IL, DE, UK
Enabling Smart Livestock Farming Technologies for Environmental Sustainability using Blockchain	FarmSustainaBl	GR, RO, DK
Grass To Gas: Strategies to mitigate GHG emissions from pasture based sheep systems	GrassToGas	UK, FR, UY, NO, IE, NZ, TR
Precision Livestock Farming (PLF) Technologies to Reduce Greenhouse Gas (GHG) Emissions Intensity of Pasture-based Cattle Systems	GrASTech	BE, FR, UK
Manure management for methane mitigation - Improved inventory modelling to support policy actions	M4Models	DK, DE, NL, SE
Mitigating greenhouse gas emissions from livestock systems	MELS	DE, IE, DK, NZ, FR, CL, PL, GR
Decision support system for sustainable and GHG optimised milk production in key European areas	MilKey	DE, PL, GR, BE, IE, FR, NO
Seaweeds and seaweed-ingredients to reduce enteric methane emissions from pasture-based sheep, cattle and dairy cows	SEASOLUTIONS	IE, NO, CA, SE, DE, UK

Project acronym **CCCFarming**

Project duration 01/01/2020 – 31/06/2023

Total requested budget € 1,726,000

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Other project participants

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LV	Latvia University of Life Sciences and Technologies (LLU)
DE	Justus Liebig University Giessen (JLU)
PL	Polish National Research Institute of Animal Production (NRIAP)
LT	Lithuanian Institute of Animal Science (LUHS)
UK	Scottish Rural University College (SRUC)
FR	French Livestock Institute (IDELE) French National Research Institute for Agriculture, Food and Environment, (INRAE)

Associated partners

US	University of Kentucky (KU)
BR	Federal University of Lavras (UFLA), Brazil
IL	ARO Volcani Center (ARO), Israel

CCCFarming

Climate Care Cattle Farming Systems

Challenge

The **cattle sector is a major source of greenhouse gas (GHG) emissions** resulting from methane (CH_4), nitrous oxide (N_2O) and carbon-dioxide (CO_2) emissions taking place throughout the **production chain.** Almost two-thirds of all GHG-emissions from the cattle sector take place within the farm gate (in particular rumen fermentation, manure handling and land cultivation) and almost one-third by the production of inputs (especially fertilizers and concentrates). The remaining part of emissions occurs during the transport and processing of the output.

CCCFarming focusses on the processes within the farm itself, thus at about two-thirds of the GHG emissions. It will investigate the interaction with the input and output segments of the chain when this is relevant, for instance when a trade-off in emissions takes place.

Project aims

- To develop climate-smart cattle farming systems reducing GHG and ammonia emissions while maintaining the social-economic outlook of the farm business
- To gather field data about the nitrogen, phosphorus and carbon balances from 62 farms and estimates of GHG emissions by using state-of-the-art sensor technologies (especially within the housing) and well calibrated empirical modelling approaches
- Examine the socio-economic and political aspects of the possible interventions identified
- Develop holistic farm systems which are targeted at meeting the socio-economic and environmental goals. Develop a set of good practices and techniques to be combined in farm systems, to be checked and evaluated on pilot and experimental farms

CCCFarming

Climate Care Cattle Farming Systems

Initial results and outcomes

- Measurement discussions with each farmer, measured emissions in the stable and compared their nutrient management with three different tools
- Experimental or field study farms about feeding strategies, breeding, housing systems, grassland and manure management and related GHG and ammonia emissions
- Created guidelines and a video to take air samples in the barns
- Report about gas measurement techniques
- Data collection for nutrient tools
- Data collected with farmers about farm characteristics and opinions on measures to reduce ammonia and GHG emission for a final description of all farms

Key publications

- P.W.G. Groot Koerkamp, P.J. Galama and A. Kuipers. Climate-Care-Cattle farming systems: introduction and first results of the CCC farming project // Book of Abstracts of the 72nd Annual Meeting of the European Federation of Animal Science: Davos, Switzerland, 30th August – 3rd September, 2021 / Wageningen Academic Publishers The Netherlands, 2021. ISSN 1382-6077, e-ISBN: 978-90-8686-918-3, DOI: https://doi.org/10.3920/978-90-8686-918-3 , 2021, No. 27, P. 496
- L. Fehmer, J. Herold, P. Engel and S. König. Individual cow methane emissions in freewalk farming systems and associations with breeding traits // Book of Abstracts of the 72nd Annual Meeting of the European Federation of Animal Science: Davos, Switzerland, 30th August – 3rd September, 2021 / Wageningen Academic Publishers The Netherlands, 2021. ISSN 1382-6077, e-ISBN: 978-90-8686-918-3, DOI: https://doi.org/10.3920/978-90-8686-918-3 , 2021, No. 27, P. 499.

More information

Watch the project video here: https://youtu.be/hWez7LTlQDQ

Project acronym **FarmSustainBl**

Project duration 01/10/2019 – 30/09/2022

Total requested budget € 674,000 €

Project Coordinator
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Other project participants

RO	Beam Innovation SRL, BEAM
	Beia Consult International SRL, BEIA
GR	Division of Farm Structures and Agricultural Machinery, Agricultural University of Athens, AUA
DK	SDU Software Engineering, Mærsk Mc-Kinney Møller Institute, University of Southern Denmark, SDU

FarmSustainaBl

Enabling Smart Livestock Farming Technologies for Environmental Sustainability using Blockchain

Challenge

Farming livestock – cattle, sheep, goats, pigs and chickens – contributes around 6 billion tonnes of greenhouse gases (carbon dioxide, methane and nitrous oxide) to the atmosphere each year. While estimates vary, this could represent up **to 18% of global emissions** and at the same time, the consumption of meat, milk and eggs is projected to grow by 70% by 2050.

FarmSustainaBl ambition is to **reduce greenhouse gases emissions** of animal production systems in Europe by applying **precision livestock farming technologies.**

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Project aims

- Raise awareness among the livestock farming community on the importance of new technologies and innovations on reducing greenhouse gas emissions and mitigating climate change impact
- Develop a holistic solution that combines blockchain technology together with smart monitoring technologies for a more efficient, environmentally and economically sustainable livestock farming
- Create a web-based platform with stakeholders that will collect and analyse all the aforementioned data for providing recommendations to the livestock farming stakeholders in order to take management decisions for reducing GHG emissions

FarmSustainaBl

Enabling Smart Livestock Farming Technologies for Environmental Sustainability using Blockchain

Initial results and outcomes

- Overview of modelling and simulation approaches for decision support tools as well as optimisation approaches and associated data collection challenges
- Testing of and identification of best machine-learning models for forecasting air pollutant concentrations
- Definition of system requirements for a decision support platform
- Overview of the challenges and opportunities of data-driven decision support tools in the livestock sector

Key publications

- M. Dobrea et al., "Machine Learning algorithms for air pollutants forecasting," 2020 IEEE 26th International Symposium for Design and Technology in Electronic Packaging (SIITME), 2020, pp. 109-113, doi: https://doi.org/10.1109/SIITME50350.2020.9292238
- P. Niloofar, S. Lazarova-Molnar, D. P. Francis, A. Vulpe, G. Suciu and M. Balanescu, "Modeling and Simulation for Decision Support in Precision Livestock Farming," 2020 Winter Simulation Conference (WSC), 2020, pp. 2601-2612, doi: https://doi.org/10.1109/WSC48552.2020.9383975
- M. Bălănescu et al., "Decision Support Platform for Intelligent and Sustainable Farming," 2020 IEEE 26th International Symposium for Design and Technology in Electronic Packaging (SIITME), 2020, pp. 89-93, doi: https://doi.org/10.1109/SIITME50350.2020.9292196
- D. A. Thumba, S. Lazarova-Molnar and P. Niloofar, "Data-driven Decision Support Tools for Reducing GHG Emissions from Livestock Production Systems: Overview and Challenges," 2020 7th International Conference on Internet of Things: Systems, Management and Security (IOTSMS), 2020, pp. 1-8, doi: https://doi.org/10.1109/IOTSMS52051.2020.9340217

More information

Watch the project video here: https://youtu.be/HB_0KbVyH6M

Project acronym GrasstoGas

Project duration 01/11/2019 – 31/10/2023

Total requested budget € 1,497,000

Project Coordinator
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Other project participants

FR	French National Research Institute for Agriculture, Food and Environment, (INRAE)
UY	National Agriculture Research Institute, INIA, Uruguay
NO	Norwegian University of Life Sciences, NMBU
IE	TEAGASC - Agriculture and Food Development Authority Sheep Ireland CLG
NZ	AgResearch, AGRES, New Zealand
TR	International Center for Livestock Research and Training, ICLRT, Turkey

Associated partners

UK	Texel Sheep Society
NO	The Norwegian Association of Sheep and Goat Breeders (NSG)

GrasstoGas

Strategies to mitigate GHG emissions from pasture-based sheep systems

Challenge

Global agreements to **lower methane emissions** pose **an economic challenge** in countries where pastoral production is a major economic driver. Strategies for mitigation are needed, particularly if global demand for meat and milk is to continue increasing in the next decades. Effective mitigations solutions are required for **sustainable sheep production systems**

Project aims

- Validating predictors of feed intake and methane emissions
- Understanding the links between indoor and outdoor feed efficiency and methane emissions
- Investigating the opportunity of using genetics and genomics (animal and microbiome) to reduce methane emissions in pasture-based sheep systems
- Quantifying the economic and environmental benefits of, a) more feed-efficient, and b) lower GHG-emitting sheep (linked to their microbiome)
- Deliver applied, sustainable solutions to reduce emissions from methane for the international sheep breeding community.

GrasstoGas

Strategies to mitigate GHG emissions from pasture-based sheep systems

Initial results and outcomes

- Male sheep that were divergently selected for feed efficiency had rumen volumes that were larger in more feed-efficient individuals than less efficient ones. The difference was even more pronounced when rumen volumes were expressed as per kg of liveweight.
- The analysis of plasmatic NMR spectra from divergent individuals showed that efficient animals have a higher relative concentration in citrate than the less efficient ones, this difference being observed under two different diets (100% concentrate vs. 1/3 concentrate + 2/3 forage).
- Preliminary information confirmed that ruminal microbiota, considered alone, does not help in predicting with confidence classes of feed intake or residual feed intake. These results were obtained with 277 animals and need to be confirmed.
- In Norway, initial findings indicate that body size (weight) is the largest predictor of feed intake and that there were no differences between the improved Norwegian White vs native breed when expressed per kg live weight.
- New data on benchmark CH_4 emissions emanating from different gas-measuring platforms suggest there are significant differences between the Greenfeed platform (France) compared to the Portable accumulation chambers (Norway, NZ, Ireland, Uruguay). The reasons for this are not yet understood.

Key publications

- Edel O' Connor, Nóirín McHugh, Tommy M Boland, Eoin Dunne, Fiona M McGovern, Investigation of intra-day variability of gaseous measurements in sheep using portable accumulation chambers, *Journal of Animal Science*, Volume 99, Issue 8, August 2021, skab132, https://doi.org/10.1093/jas/skab132
- F. McGovern, B. Garry, P. Creighton, N. Galvin, D. Hennessy, E. Kennedy, N. McHugh, M. O'Donovan, M. Beecher, Validating the n-alkane technique for determining herbage dry matter intake in sheep offered perennial ryegrass harvested at varying growth stages and seasons, *Animal Feed Science and Technology*, Volume 279, 2021, 115025, ISSN 0377-8401, https://doi.org/10.1016/j.anifeedsci.2021.115025

More information

Watch the project video here: https://youtu.be/p6QjWFELh0c

Project acronym **GrASTech**

Project duration 1/10/2019 - 31/07/2023

Total requested budget € 1,317,700

Project Coordinator
Flanders Research Institute for agriculture, fisheries and food (ILVO), Belgium

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Other project participants

UK	Dairy Research Centre (SRUC)
	University of Strathclyde (Strath)
FR	French National Research Institute for Agriculture, Food and the Environment (INRAE)
	French Livestock Institute (IDELE)

GrASTech

Precision Livestock Farming (PLF) Technologies to Reduce Greenhouse Gas (GHG) Emissions Intensity of Pasture-based Cattle Systems

Challenge

European cattle farmers are facing increased demand for pasture-based and environmentally friendly products. Although **feeding strategies** to reduce greenhouse gas (GHG) emissions have been studied intensively, strategies for **grazing systems** are under-researched. The lack of easy-to-implement technologies for methane measurement with grazing cattle complicates the necessary large-scale studies.

Project aims

- To identify best practices for management of grassland, supplementation and grazing to reduce GHG emissions
- Perform life cycle analysis of diverse grazing systems
- Provide analysis of farmers' attitudes towards uptake of technology and GHG emission reduction strategies
- Develop precision livestock technologies to measure GHG emissions for use in grazing cattle and identify which PLF technologies are best suited for use with grazing cattle

Grazing experiment setup

GrASTech

Precision Livestock Farming (PLF) Technologies to Reduce Greenhouse Gas (GHG) Emissions Intensity of Pasture-based Cattle Systems

Initial results and outcomes

- Results from a first grazing trial have shown that the methane production in the grazing treatments was around 12 % lower than in confinement. Fat and protein corrected milk production was not different between treatments, implying that the methane intensity (g CH_4/kg fat and protein corrected milk) was around 10 % lower in grazing treatments. The lowest value was found for the treatment with higher corn silage inclusion in the partially mixed ration

- An in-depth review of current and near-to-market precision livestock farming tools was created. This review focused on technologies for estimating methane emissions in housed or grazing cattle and techniques to measure different aspects of production efficiency in cattle, including feed intake, fertility, growth and health and welfare

- Identification of a number of new methodologies for the measurement of methane in both controlled and in-field environments

- INRAE and IDELE collaborated to carry out the first grazing trial in spring 2021 aiming to test three levels of maize silage and soyabean meal supplementation on grazing dairy cows. Animal production (milk yield, milk composition, body weight, individual herbage intake, individual supplement intake), behaviour (grazing, rumination, position) and health (ruminal temperature) data analysis are in progress

More information

Watch the project video here: https://youtu.be/2y28qpqNVxw

Project acronym M4Models

Project duration 1/12/2019 – 30/11/2022

Total requested budget €1,147,300

Project Coordinator
Aarhus University (AU), Denmark

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Other project participants

SE	Bioprocess Control Lund University (LU)
	Research Institutes of Sweden (RISE)
DE	Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)
NL	Wageningen University and Research (WUR)

M4Models

Manure management for methane mitigation - Improved inventory modelling to support policy actions

Challenge

Manure management is a main source of methane (CH_4) emissions. Mitigation options such as biogas treatment exist, but effects cannot be verified and are not accounted for in inventories. In this project, a new method to estimate CH_4 emissions from manure is being used to investigate farm-level greenhouse gas mitigation, and for upscaling to national inventories.

Project aims

- Evaluation of in-vitro method for estimation of CH_4 emissions at farm level
- Quantification of CH_4 emissions and N-availability of liquid manure including reduction measures
- Estimates of greenhouse gas reduction at the operational level through integration into operational models
- Improvement of CH_4 emission estimates and greenhouse gas reduction potentials for national emission inventories

M4Models

Manure management for methane mitigation - Improved inventory modelling to support policy actions

Initial results and outcomes

- A new in-vitro method for estimating methane production rates in each partner country has been tested, modified and used for on-farm monitoring in each partner country. Experiences with the methodology were discussed in online meetings, and recommendations point to larger sample sizes and avoidance of sieving
- A prototype incubator has been developed. Quantification of methane and carbon dioxide production at low temperatures has been achieved, and a portable system for on farm use is planned
- The manure temperature was monitored on multiple farms during a full year as support for model development. The project has successfully tested ultrasound level transmitters for documentation of the slurry level
- The potential of an excretion model to predict the fraction of degradable volatile solids VSd was investigated. Predicted VSd was sensitive to diet. Calculated methane emission compared well with experimental results using the in vitro assay, and with in situ methane production The effects of storage period and temperature on residual biogas potential has been investigated; with 90 d storage, up to 66% of the biogas potential was lost. These results will be used for mitigation scenarios in WP 4
- A farm monitoring program on 4-5 pig and cattle farms was conducted during 2020-2021. Manure samples representing barn and outside storage were collected and methane production rates determined using the in vitro assay. Results are used for derivation of model parameters to calculate methane emissions from manure
- A questionnaire was developed for a survey of farms represented in the monitoring program in each country
- Farm model development: Currently, information to set up country specific model farms is being acquired from individual partners with assistance from local experts. Model farms will be ready for use from spring 2022. Farm models will be used for setting up farm scale mitigation scenarios in WP4.
- Activity data are compiled from each partner country in WP5 to be used for upscaling of revised estimates of methane emissions from manure management
- Meetings with stakeholder groups will be held during spring 2022 to inform about project results

More information

Watch the project video here: https://youtu.be/HBXyhH_mo88

Project acronym MELS

Project duration 01.12.2019-30.11.2022

Total requested budget € 1,069,900

Project Coordinator
Leibniz Institute for Agricultural Engineering and Bioeconomy, ATB, Germany
Prof. Barbara Amon

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Other project participants

IE	TEAGASC - Agriculture and Food Development Authority
	Cork University Business, CUBS
DK	Aarhus University, AU
FR	French National Research Institute for Agriculture, Food and the Environment, INRAE
PL	University of Zielona Góra, UZG
GR	Agricultural University of Athens, AUA
NZ	AgResearch, AgR, New Zealand
CL	Instituto de Investigaciones Agropecuarias, INIA, Chile

MELS

Mitigating greenhouse gas emissions from livestock systems

Challenge

The EU Effort Sharing Agreement and the Paris Agreement create challenging targets for GHG emission reductions and represent respectively short and long term existential threats to livestock production systems. The MELS project will build on the Global Research Alliance DATAMAN project by collating additional **data on emissions** from manure management and activity /ancillary data. The data will be used to generate functional relationships between emissions and activity/ancillary variables, enabling a **refinement of national inventories** and better assessment of the cost-effectiveness of a range of mitigation measures.

Project aims

- To improve the methodologies available to national inventory compilers to estimate the direct and indirect greenhouse gas (GHG) emissions from livestock production systems, with a particular emphasis on manure management and grassland management
- To assist inventory compilers in estimating and documenting the impact of mitigation measures relevant to livestock production systems on the emissions reported within national inventories
- To provide improved algorithms and emission factors for use in farm-scale GHG decision support systems (DSSs)
- To develop an open-access prototype farm-scale GHG DSS
- To improve methods to assess the costs and savings associated with mitigation measures at the farm and national scales.

MELS

Mitigating greenhouse gas emissions from livestock systems

Initial results and outcomes

- Enriching of DATAMAN database with emission data from studies referring to Mediterranean countries, Eastern Europe, China and South America
- Emission data processed (e.g. quality check, emission factor derivation and estimation) and rendered available for further ongoing analysis. Functional relationships being generated between emissions and activity data/ancillary variables
- Emission mitigation data were identified and further categorized according to the type of mitigation strategies implemented
- A review of the existing, country-specific GHG accounting tools. An overview on the status of GHG and NH_3 emissions estimation methods for manure management systems and managed soils has been carried out including MELS partners and Brazil and China
- Inventory compilers of the MELS partner countries have been contacted: they will be invited to participate in a survey on improved methods to obtain activity data, which is currently under development
- Working together with transnational organizations representing farmers, co-operatives and industry. Teagasc worked with the European farmer and co-operative organization (COPA COGECA) to arrange a consultation on what the body needs from farm-scale GHG Decision Support System

Key publications

- Amon, B., Cinar, G., Anderl, M., Dragoni, F., Pierer, M. K., & Hörtenhuber, S. (2021). Inventory reporting of livestock emissions: the impact of the IPCC 1996 and 2006 Guidelines. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac0848
- van der Weerden, T. J., Noble, A., de Klein, C. A., Hutchings, N., Thorman, R. E., Alfaro, M. A., Amon, B., Beltran, I., Grace, P., Hassouna, M., Krol, D., Leytem, A. B., Salazar, F., Velthof, G. L. (2021). Ammonia and nitrous oxide emission factors for excreta deposited by livestock and land-applied manure. Journal of Environmental Quality. https://doi.org/10.1002/jeq2.20259

More information

Watch the project video here: https://youtu.be/EdBBVNVwZVg

Project acronym MilKey

Project duration 1/12/2019 – 30/11/2022

Total requested budget € 2,283,800

Project Coordinator
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Other project participants

PL	Institute of Environmental Engineering, UZG Poznan University of Life Sciences, PULS
GR	Division of Agricultural Structures and Agricultural Machinery, AUA
BE	Flanders Research Institute for agriculture, fisheries and food, ILVO
IE	TEAGASC - Agriculture and Food Development Authority, TEAGASC School of Agriculture & Food Science UCD, UCD
FR	French National Research Institute for Agriculture, Food and the Environment, INRAE
NO	Department for Economics and Society, NIBIO
FR	French Livestock Institute, IDELE

MilKey

Decision support system for sustainable and GHG optimised milk production in key European areas

Challenge

European **dairy production systems (DPS)** face many challenges across the three pillars (3P) of sustainability. European regions are highly diverse and complex, and region-specific concepts for DPS are required.

The MilKey project will develop a whole system concept (a holistic approach) for achieving 3-pillar sustainability of DPS **targeted to key European regions**. Greenhouse gas (GHG) mitigation is a core aim of MilKey, accompanied by other environmental impacts, and analysis of economic and social factors influencing the functioning of this sector.

Project aims

- Analysis of the drivers and the sustainability aspects of dairy production systems in key European regions
- Assessment of the 3-pillar sustainability on case study dairy production systems
- Assessment of the 3-pillar sustainability interactions, emission mitigation potentials and key GHG mitigation techniques
- Development and demonstration of an online monitoring tool for barn climate and emission control
- Development of the MilKey platform for information and communication on key sustainability parameters of European dairy production systems
- Provision of assistance to dairy farmers in improving the 3-pillar sustainability of their dairy production systems

MilKey

Decision support system for sustainable and GHG optimised milk production in key European areas

Initial results and outcomes

- Developed a trend monitoring system and emission monitoring system separately. Both systems have been compared with a reference measurement technique
- Environmental and economic sustainability indicators have been defined (environmental and economic indicator handbooks), and a data collection template for technical, environmental and economic description of case study farms have been delivered
- Detailed protocols for the data collection and multi-criteria sustainability assessment, including the handbooks of environmental and economic sustainability indicators, the data template and the data collection guide have been delivered
- Multicriteria decision tree (DEXi) with scaling factors for environmental and economic pillar has been developed
- Framework (structure and types of contents) of the Milkey platform has been developed
- Dissemination to policy advisory bodies (UNECE Task Force on Reactive Nitrogen, Task Force on Emission Inventories and Projections)

Key publications

- Díaz de Otálora X, del Prado A, Dragoni F, Estellés F, Amon B. Evaluating Three-Pillar Sustainability Modelling Approaches for Dairy Cattle Production Systems. Sustainability. 2021; 13(11):6332. https://doi.org/10.3390/su13116332

- Pochwatka P, Kowalczyk-Juśko A, Sołowiej P, Wawrzyniak A, Dach J. Biogas Plant Exploitation in a Middle-Sized Dairy Farm in Poland: Energetic and Economic Aspects. *Energies*. 2020; 13(22):6058. https://doi.org/10.3390/en13226058

- Amon, B. (2020). Livestock housing and manure storage. Chapter 2 of the Guidance Document on Sustainable N Management of the Task Force on Reactive Nitrogen. https://unece.org/fileadmin/DAM/env/documents/2020/AIR/EB/ECE_EB.AIR_2020_6-2008239E.pdf

More information

Watch the project video here: https://youtu.be/O7-Xw9gF9aU

Project acronym **SEASOLUTIONS**

Project duration 01/01/2019–31/01/2023

Total requested budget 1,969,000 €

Project Coordinator
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Other project participants

UK	Agri-Food and Biosciences Institute (AFBI) Queen's University Belfast (QUB)
DE	Friedrich-Loeffler-Institut (FLI)
IE	Institute of Technology Sligo (ITS)
NO	SINTEF, Norway The Norwegian Institute of Bioeconomy Research (NIBIO)
SE	Swedish University of Agricultural Sciences (SLU)
CA	Agriculture and Agri-Food Canada (AAFC)

SEASOLUTIONS

Seaweeds and seaweed-ingredients to reduce enteric methane emissions from pasture-based sheep, cattle and dairy cows

Challenge

The drive to become more efficient is viable and well in the food industry and this trend has been altered in recent years by the challenge of making our advancements more environmentally friendly. Reducing methane emissions from cows, cattle and sheep is one of the biggest challenges to face the agricultural sector in the last decade. The SEASOLUTIONS project is committed to making a positive impact on **methane emissions** in agriculture by positively affecting the rumen and **rumen microbiota** using **seaweeds** and seaweed-derived ingredients to reduce methane emissions and improve ruminant health.

Project aims

- To develop novel, science-based, and implementable approaches to reduce methane emissions from sheep, beef cattle and dairy cows through seaweed additions to animal diets
- To explore more futuristic options based on emerging knowledge and technologies and by monitoring rumen pH and methane emissions using sensor technologies and capture of this data from animal trials using ICT technologies
- To characterise and select native seaweeds for in vitro and animal trials based on their bioactive and safety profiles
- To evaluate effects of seaweeds on total methane gas production using different in vitro rumen fluid models and animal trials
- To examine the positive nutritional contributions of algae in the diets of sheep, cattle and dairy cows and the impact on milk and meat
- To understand the mechanisms of action evoked by seaweed inclusion in the diets of sheep, beef cattle and cows in terms of the underlying role of the rumen microbiome
- To explore novel options for methane reduction and to develop feed ingredients for use by farmers to reduce emissions and improve animal health and nutritional efficiency
- To recommend adequate policy instruments to secure implementation of the recommended animal diet management

SEASOLUTIONS

Seaweeds and seaweed-ingredients to reduce enteric methane emissions from pasture-based sheep, cattle and dairy cows

Initial results and outcomes

- Characterisation of 74 native and harvestable seaweeds and generation of 27 seaweed ingredient extracts. These seaweeds and extracts were characterised for their constituent composition and the amount of protein, ash, lipid, carbohydrates (glycomic analysis), fibre, peptides, polyphenols, phlorotannins, lipids, bromoform and iodine were quantified using characterisation methods

- Selected seaweeds and extracts were assessed for their ability to reduce methane emissions in in-vitro models. Extruded pellets containing active seaweed extracts were also made and characterised for bioactivities

- The first animal trial started in May 2021 at Teagasc Athenry. This sheep study involved 140 cull ewes less than 18 months old (n=20) that were lowland crossbreeds (70-80 kg in weight). Initial results indicate that the seaweed and extract selected reduced emissions by 12-14%

Key publications

- Abbott DW, Aasen IM, Beauchemin KA, Grondahl F, Gruninger R, Hayes M, Huws S, Kenny DA, Krizsan SJ, Kirwan SF, Lind V, Meyer U, Ramin M, Theodoridou K, von Soosten D, Walsh PJ, Waters S, Xing X. Seaweed and Seaweed Bioactives for Mitigation of Enteric Methane: Challenges and Opportunities. Animals. 2020; 10(12):2432. https://doi.org/10.3390/ani10122432

More information

Watch the project video here: https://youtu.be/109EswriDGE

The 2021 Joint Transnational Research Call

“Circularity in mixed crop and livestock farming systems, with emphasis on greenhouse gas mitigation”

The four ERA-NETs FACCE ERA-GAS, SusAn (Sustainable Animal Production Systems), ICT-AGRI-FOOD and SusCrop (Sustainable Crop Production) have coordinated and aligned efforts in areas of mutual interest and established a joint transnational funding initiative in the field of agricultural greenhouse gas research, focusing on circularity in mixed crops and livestock farming systems with emphasis on climate change mitigation and adaptation. Proposals under this call had to incorporate four key elements:

1. Mixed crop-livestock farming systems
2. Address monitoring and mitigation of greenhouse gases from agriculture or agroforestry
3. The inclusion of an Information and Communication Technology (ICT) dimension, for example the use of sensors, communication technologies, data analytics, modelling, robotics, precision farming or decision support systems
4. Take a systems-approach in mixed crop-livestock farming systems

Projects

Title	Acronym	Countries involved
Strategies for circular agriculture to reduce GHG emissions within and between farming systems across an agro-ecological gradient	CircAgric-GHG	NO, KE, ES, IE, DE, IT, ZA, UK
Connecting sustainable agroecosystems and farming with circular bioeconomy and new technologies	ConnectFarms	IT, BG, LT, EE, ES, PL, TR
Multi-criteria assessment, decision support and management tools for sustainable circular mixed farming systems for dairy production	DairyMix	DE, IE, IT, PL, FR, NO, BE, AR
Integrated crop-ruminant livestock systems as a strategy to increase nutrient circularity and promote sustainability in the context of climate change	INTEGRITY	AR, ES, FI, UK, NZ, PE, UY, FR, IE
Mitigation and adaptation through better biomass cycling in crop livestock systems of north and western Europe	MI BICYCLE	NL, DK, UK, FR
Balancing production and environment	PROENV	DK, NO, ES, IT
Back to the Future: reintegrating land and livestock for greenhouse gas mitigation and circularity	ReLive	IE, FR, NL, DE, ES, FI, PL, EE, NZ, CL
Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity	SENSE	UK, NL, DE, IT, BR, AR, UY
Solutions for GHGs emissions mitigation for the mixed farming systems across different European climates	Solution4Farming	RO, PL, ES, FI

CircAgric-GHG

Strategies for circular agriculture to reduce GHG emissions within and between farming systems across an agro-ecological gradient

Challenge

Over the past decades, **European farms have trended towards specialisation** and high per ha yields but have become increasingly dependent on external inputs to compensate for declining recycling of nutrients. Meanwhile, farms in **sub-Saharan Africa** less specialized, have **low inputs** and **yields** and much **higher vulnerability** to climate change compared with European farms. More efficient (re)cycling of resources (nutrients, water, energy and land) across the agri-food sector and enhanced resilience, is imperative to deliver food security whilst respecting ecological boundaries and rural livelihoods. In Europe, **re-coupling (direct and/or remote) of livestock and crop systems** could play an important role in more efficient (re)cycling of resources across livestock and crops, and food value chains. In Africa, integrating sustainability and resilience objectives with enhanced food security could avoid some of the trade-offs currently experienced in Europe (e.g., high GHG emissions and N pollution).

Approach

CircAgric-GHG will draw upon state of the art knowledge, research methods and models to assess how circular practices can deliver sustainable food systems Using farm typologies as a baseline, the extent of existing circular practice implementation will be evaluated Promising practices to enhance circularity will be proposed across typologies and agro-ecological zones. High-resolution modelling of resource cycling and GHG emissions at farmland landscape level will be undertaken using process and farm models, with remote sensing of particularly uncertain land-use emission fluxes using novel satellite and drone technology. LCA will be applied to integrate modelling outputs into environmental footprints of food production, developing a novel framework for future projects. Farm scale modelling will also inform a marginal abatement cost curve and a decision support tool, enabling robust comparison of GHG abatement efficacy of specific circular practices.

Meanwhile, stakeholder dialogue via workshops and focus groups will identify systemic lock-ins and levers pertinent to wide-scale deployment of circular practices, culminating in a Transition Roadmap. Scenario analysis will then integrate farm-scale abatement with macro resource flow and land-use change consequences of promising practices. Consequential LCA will be applied to evaluate the technical potential for circular scenarios to meet 2030 Farm to Fork and 2050 climate neutrality targets, with the screening of major ecosystem services effects.

Coordinator

Norwegian Institute of Bioeconomy Research, NIBIO, Norway

Dr Vibeke Lind

Project Duration

1 March 2022 - 28 February 2025

Project partners

The International Livestock Research Institute, Kenya
Basque Centre For Climate Change, Spain
University of Limerick, Ireland
Teagasc, Agriculture and Food Development Authority, Ireland
Karlsruhe Institute of Technology, Germany
University of Milan, Italy
University of Pretoria, South Africa
Bangor University, United Kingdom
University of Oslo, Norway

ConnectFarms

Connecting sustainable agroecosystems and farming with circular bioeconomy and new technologies

Challenge

The ConnectFarms project will develop approaches **to increase in a sustainable way integrated crop-livestock production while benefiting soil resilience to stress and climate change**. This will include an extensive toolbox for farmers and stakeholders addressing crop-livestock integration, precise farming, organic amendments, reuse of residues in circular economy and sustainability improvements of farming practices. A set of recommendations for sustainable strategies leading to environmentally sound production in compliance with the Farm to Fork strategy will be given. Emphasis will be given to new approaches based on science and nature-based solutions to manipulate crops, livestock, soil and plant microbial communities to maximize positive ecological interactions and enhance ecosystem services.

Approach

The ConnectFarms concept is highly interdisciplinary and joins together expertise from many research fields, to achieve an integration of crop, livestock and ICT to obtain ecosystem services in agreement with the needs of sustainable agriculture. Partners will work in experimental sites in all partner countries – Bulgaria, Estonia, Italy, Lithuania, Poland, Spain and Turkey. Focused aspects of the project will concern agriculture and soil fertility, crops and livestock, amendments and biochar for soil health, welfare and sustainability for animals, precision farming, life cycle and ecosystem services assessment and stakeholder involvement.

The ambition of the project is to contribute to innovative strategic food systems by targeting enhanced agricultural technology, food processing and preservation innovation, environmental issues, and ultimately human health. ConnectFarms explores the interaction between arable crops, e.g. barley and pulses with farm animals of high relevance, sheep and chicken. The connection is maintained through triangulation - crops become feed for animals, residues become amendments, amendments feed and boost crops and animals. The sustainable use of biochar is our keystone to improve both plant and animal farming in a circular economy approach.
The project is highly interdisciplinary as it includes:

- Ecological and agronomic studies;
- Soil and crop management to improve diversity and functionality;
- Studies of ecosystem services such as C sequestration, nutrient cycling, and pest control.

Coordinator

Consorzio Interuniversitario Nazionale per le Scienze Ambientali, Italy
Prof Nelson Marmoroli

Project duration

1 December 2021 - 30 November 2024

Project partners

Agricultural University, Bulgaria
Lithuanian Research Centre for Agriculture and Forestry, Lithuania
University of Tartu, Estonia
CIEMAT, Spain
NEIKER, Spain
Warsaw University of Life Sciences, Poland
Niğde Ömer Halisdemir University, Turkey
University of Milano - Consiglio per la Ricerca in Agricoltura el'Analisi dell'Economia Agraria, Italy

DairyMix

Multi-criteria assessment, decision support and management tools for sustainable circular mixed farming systems for dairy production

Challenge

DairyMix will use **multi-criteria assessment,** and develop **decision support**, **modelling and management** tools for sustainable circular mixed farming systems for dairy production. Dairy production systems (DPS) are an essential backbone of European agriculture. DPS produce high quality protein essential for humans. They can convert fibrous feed resources that could not be utilized by humans or converted to human food by monogastric animals. However, this desirable level of circularity is currently met only to a very limited extent with most dairy systems heavily relying on external input such as concentrate feeds and mineral fertilizers.

Approach

DairyMix applies a systems approach for sustainable dairy production systems that are targeted to key European regions and beyond. DairyMix is structured in five work packages. **Case studies,** data from the extensive DATAMAN database, Eurostat data and data from OTICE, the online barn climate and emission control tool will be collected and analysed. Data analytics uses linear statistics as well as supervised machine learning algorithms, like ridge regression, random forests, support vector machines and artificial neural networks. **Data analysis** will assess the potential of currently known **mitigation measures** as well as the potential of precision farming technologies that are not yet fully developed. On farm decisions with respect to barn climate, emission reduction and improved animal welfare will be supported by the ICT-based tool OTICE. These data are then fed into a detailed modelling analysis on carbon and nutrient utilization and circularity of mixed farming systems for dairy production. This will be brought together for a **multi-criteria assessment of mixed farming systems** for dairy production based on indicators for circularity and efficient resource use. DairyMix will host an interactive web application to analyse farm data and to evaluate effects of changes in farming practice at farm and regional level with regard to environmental, economic and societal sustainability indicators. This output will have farmers and other stakeholders in the primary sector as target group, and will also be relevant for society and policy makers.

Coordinator

Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany

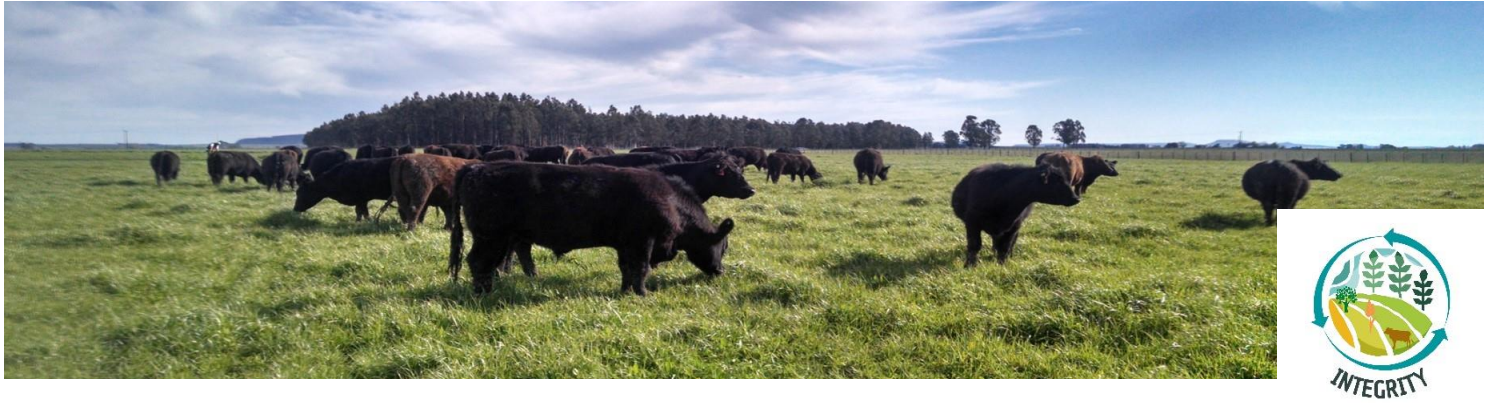
Prof Barbara Amon

Project Duration

1 March 2022 – 28 February 2025

Project partners

Teagasc – Agriculture and Food Development Authority, Ireland
University of Milan, Italy
University of Zielona Góra, Poland
French National Research Institute for Agriculture, Food and the Environment, INRAE, France
Norwegian Institute of Bioeconomy Research, Norway
Ruralis - Institute for Rural and Regional Research, Norway
Flanders Research Institute for agriculture, fisheries and food, ILVO, Belgium
Instituto Nacional de Tecnología Agropecuaria, Argentina



INTEGRITY

Integrated crop-ruminant livestock systems as a strategy to increase nutrient circularity and promote sustainability in the context of climate change

Challenge

Different degrees of integration between the crops and livestock components of a system may have advantages or disadvantages, so **trade-offs** among economic (productivity, efficiency), environmental (nutrient cycling, soil health, greenhouse gas (GHG) emissions), and social (work arduousness and organization, household networks) indicators will be identified. Gaps in knowledge regarding impacts of the integration need to be addressed to fully understand the mechanisms that reduce GHG emissions and/or increase soil C sequestration and nutrients (i.e. C, N) use efficiency in mixed production systems; and what would be the impact of proposed interventions with a broader and holistic perspective.

Approach

These interventions will be specifically designed for each situation and will be evaluated experimentally to quantify their impact, not only through direct and specific effects but also in a broad sense addressing the circularity within the agricultural systems by different modelling tools. Standardized evaluation approaches and procedures across the different partners will allow direct comparison of the relative impact of new management alternatives. Stakeholders' involvement through the process will certainly help to focus on applicable new practices and facilitate their adoption by farmers. INTEGRITY will:

- Investigate different management practices at diverse agricultural systems to enhance nutrient circularity, production efficiency and reduce C footprint;
- Identify the potential improvement of C footprint by increasing the inclusion of by-products in ruminants feeding programs;
- Evaluate the management of carbon circularity and climate change mitigation and adaptation in mixed crop ruminant livestock systems through system approach assessment and Information and Communication Technology.

INTEGRITY also includes agent-based modelling to understand the decision-making process and other emergent properties of mixed crop-livestock production systems.

Coordinator

National Institute of Agricultural Technology, Argentina

Dr Claudia Faverin

Project Duration

1 March 2022 - 28 February 2025

Project partners

Agencia Estatal Consejo Superior de Investigaciones Cientificas, Spain
Natural Resources Institute Finland, (Luke), Finland
Agri-Food and Biosciences Institute, United Kingdom
AgResearch, New Zealand
Bravo Universidad Nacional Agraria La Molina, Peru
National Agricultural Research Institute of Uruguay, INIA, Uruguay
French National Research Institute for Agriculture, Food and Environment, INRAE, France
Queens University Belfast, United Kingdom
Teagasc, Agriculture and Food Development Authority, Ireland

MI BICYCLE

Mitigation and adaptation through better biomass cycling in crop livestock systems of north and western Europe

Challenge

Farms and farming systems in North and Western Europe are generally highly specialised, with little integration between crop and livestock production within farms and between farms within a region. Yet, improved integration, be it at farm or landscape level, offers substantial potential for enhanced circularity of utilization of biomass, especially for co-products (e.g. residues, manure, waste). The main objective of this research project is **to co-design locally improved, innovative circular crop and livestock systems in North and Western Europe**. To reach this objective, we will assess alternative utility options of biomass and co-products in integrated crop-livestock systems at field, farm and landscape levels.

Approach

Alternatives will be assessed in terms of nutrient cycling, greenhouse gas emissions, carbon sequestration and agricultural productivity. It is hypothesized that co-product utilisation options can be identified that are beneficial in terms of climate change mitigation and lead to more resilient and adapted systems. We will apply our systems approach and participatory and quantitative methods in four European case study regions situated in the Netherlands, Denmark, Scotland and France. All four case regions are characterised by highly specialized crop and livestock farming systems, with innovation and transition pathways towards integration of crop and livestock production being initiated. We expect these pathways to benefit from a systematic, science-based and participatory assessment of current and alternative utilisation options of co-products across crop and livestock activities and farms, in a landscape context.

The project takes a systems perspective, distinguishing activity (field and livestock units), on- and inter-farm integration and landscape levels. Using focus group discussions, current and alternative co-product utilisation options will be gathered for each of the case studies. These will be quantitatively assessed in terms of nutrient cycling, greenhouse gas emissions, carbon sequestration and productivity. Using literature and participatory inputs we will add semi-quantitative assessments of social and economic performance of utilisation options. The environmental, economic and social indicators will be brought together in a management guide for on- and inter farm integration. Finally, a serious game will be developed to explore opportunities for enhanced circularity of crop-livestock integration and co-product utilisation at landscape level. Farming, agricultural and circular economy stakeholders (e.g. renewable energy, green fertilisers, etc.) will be employing the game to understand promises, lock-ins and ways forward. The serious game will also be adapted for use in BSc and MSc level courses in the four countries to enhance learning on circularity of future generations of scientists and stakeholders.

Coordinator

Wageningen University, The Netherlands

Prof Martin Van Ittersum

Project partners

Aarhus University Denmark

Scotland's Rural College, SRUC, United Kingdom

French National Research Institute for Agriculture, Food and Environment, INRAE, France

Ariege Chamber of Agriculture, France

Project Duration

1 March 2022– 28 February 2025

PROENV

Balancing production and environment

Challenge

Across Europe, economic factors have led to increased intensification of crop and livestock production, an increase in the specialisation of farming, a local to regional concentration of animals, increased imports of nutrients in feed and synthetic fertilisers and a simplification of crop rotations. These developments have created **barriers to achieving an optimum balance between food production and the environmental impact.** In parallel with climate change and nitrogen emissions, there is increasing political focus on the role of agriculture in compromising other ecosystem services, especially biodiversity. There are two fundamental methods of achieving a balance between agricultural production and other ecosystem services; **land spare and land share.** In land spare, the landscape is partitioned into areas with highly-productive agriculture and areas with extensive or no agriculture that provide the other ecosystem services. In land share, by limiting the farming intensity, the landscape is less partitioned and the whole area provides all ecosystem services, including agricultural production. This latter approach is the one used in organic and agroecological farming.

Approach

The PROENV (balancing PROduction and ENVironment) project will have an interdisciplinary approach, with theoretical and practical components that build on existing knowledge but contain innovative developments. The theoretical component will consider the relative merits of the land spare and land share approaches to balancing production and ecosystem services. This will provide a theoretical framework for deciding whether for a particular region, the balance between production and other ecosystem services is best achieved using a land spare, land share or a mixed approach. Such considerations are already relevant for policymakers and will become more so in the future, as they strive to maintain rural economies and employment while achieving prescribed reductions in GHG emissions and losses of N to the air and water, and increasing biodiversity.

The practical component will consist of the investigation of **specific measures to reduce nitrogen (N) losses from manure** and in the further development of an existing software tool that enables scenarios to be constructed for manure N utilization at field, farm and regional scales. This tool was developed for use in one specific region but in PROENV, its technical and modelling capacities will be extended to enable its use in other regions of Europe, using data available Europe-wide. Finally, the practical and theoretical components will come together in an **exploration of today's production and scenarios including feeding strategy for reducing GHG emissions at farm-scale** in the different partner countries, including the use of Life Cycle Assessment and evaluating the energy, nitrogen and area utilisation.

Coordinator

Aarhus University, Denmark

Dr Nick Hutchings and Jeroen Pullens

Project Duration

1 April 2022 – 31 March 2025

Project partners

Norwegian Centre for Organic Agriculture (NORSØK), Norway
Norwegian Institute of Bioeconomy Research (NIBIO), Norway
Institute of Agrifood Research and Technology (IRTA) Spain
Università Cattolica del Sacro Cuore (UCSC) Italy

ReLive

Back to the Future: reintegrating land and livestock for greenhouse gas mitigation and circularity

Challenge

The widespread reintroduction of crops and livestock could make a major contribution to the development of the wider EU circular (agricultural) economy and contribute to sustainable growth, through the more effective recycling of materials and resources, the minimization of waste, and a reduction in external supplies of feed and synthetic fertilizers. However, this comes with significant challenges, including the potential for enhanced GHG emissions, particularly methane emissions, from enteric fermentation, land degradation due to over grazing and water pollution as well as the need to effectively substitute all/most inorganic fertilizers with organic manures. Organic amendments applied to land could conversely result in enhanced GHG emissions, unless these are managed appropriately. The necessity to store large amounts of organic manures/wastes may also be problematic, given their links to environmental pollution and GHG emissions. Additional complications could arise due to associated modifications in land use, including a shift from a grass-based to a forage/alternative crop-based diet, altered grazing practices and increased competition between food and animal feed or the use of biogas or bioenergy crops. Another key issue is the economic consequences of reintroducing livestock and whether the necessary incentives are available for them to be taken up by farmers. New developments will require mixed farms to be matched with current production and market conditions and the availability of suitable value chains and business models to ensure their long-term viability.

Approach

The ReLive project will take a holistic approach to the sustainable reintegration of livestock and cropping systems. Particular attention will be directed at livestock type and management, the appropriate use and storage of manures, crop choice, including direct grazing of crops and/or their residues, the use of afforestation/agroforestry as an alternative grazing option and to increase soil carbon, as well as and how this information can be integrated into decision support tools for identifying the best options for farmers. Importantly, ReLive will assess the use of alternative livestock dietary feed sources that have the potential to reduce enteric methane production coupled with novel investigations on a mechanistic assessment of the ability of soils to oxidise methane, and how this information can be utilized to improve whole farm methane budgets. Critical to this approach is an ability to monitor and validate any management options on the net GHG budgets and their economic consequences, as well as the effective dissemination of the results for practical implementation by policy makers, stakeholders, farmers and other end users.

Coordinator

University College Dublin, Ireland

Prof Bruce Osborne

Project Duration

1 March 2022 – 28 February 2025

Project partners

French National Research Institute for Agriculture, Food and the Environment (INRAE), France
Wageningen University, The Netherlands
Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany
Universidad de Extremadura Spain
Avoin association, Finland
Institute of Agrophysics, Polish Academy of Sciences, Poland
University of Tartu, Estonia
Teagasc, Agriculture and Food Development Authority, Ireland
AgResearch, New Zealand
University of Chile, Chile

SENSE

Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity

Challenge

Specialization, intensification and spatial separation of crop, livestock and forestry production systems have contributed to climate change and biodiversity loss. Integrated crop-livestock-forestry systems offer multiple opportunities to reduce the environmental impact of agricultural production systems. Circular systems have been proposed to increase resource use efficiency, particularly of scarce nutrients, in a more sustainable way than conventional systems. Therefore, bringing in circularity contributes to minimizing the environmental footprint of agriculture. **A clear picture of potential synergies and trade-offs is required before prioritizing solutions.**

Approach

SENSE will develop a **matrix of (existing) indicators for effective quantification** of the status of circularity within various integrated system case studies in four European countries (Italy, Germany, the Netherlands, and UK) and three South American countries (Argentina, Brazil and Uruguay). Contrasting scenarios of carbon, nutrients, water, and biomass flows will be simulated in the case studies through the application of process-based models such as manure-DNDC. This analysis will return the predictions trajectories at farm level to redesign systems towards more complete local circularity within crop-livestock-forestry integrated systems. We will **compare the circularity scenarios** according to their potential for mitigating greenhouse gases (GHG) emissions. Further, the resilience of farm systems under climate change will be compared for the scenarios using a probabilistic risk analysis approach. At farm level, we will evaluate their side effects on other societal goals based on multidimensional sustainability assessment tools. SENSE will demonstrate a novel solution for improved land management systems, building knowledge through the linkage between sensors and High-Performance Computing (HPC)-based data analysis, supported by modelling and visualization to meet farmer's information needs to attain net zero GHG emissions. We will **test a novel digital Monitoring, Reporting and Verification (MRV) system** developed by James Hutton Institute and its application in quantifying and mitigating GHG emissions. We will compare and discuss our cases including with the participating farmers at different levels of detail, through both circularity and ecological functioning indicators to discover general lessons for enhancing circularity at the farm level.

Coordinator

The James Hutton Institute, UK

Dr Jagadeesh Yeluripati

Project Duration

1 March 2022- 28 February 2025

Project partners

Stichting Wageningen Research, The Netherlands
University of Hohenheim, Germany
Demeter e.V., Germany
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agrarian, Italy
Brazilian Agricultural Research Corporation, Brazil
National Institute of Agropecuarian Technology, Argentina
Instituto Nacional de Investigación Agropecuaria, Uruguay
Centre for Ecology and Hydrology - University of Bristol, UK

Solution4Farming

Solutions for GHGs emissions mitigation for the mixed farming systems across different European climates

Challenge

Solution4Farming (S4F) project aim to provide solutions for GHG emissions mitigation for the mixed farming systems across different European climate while increasing circularity. Its objectives are to:

(i) systemically identify synergies and complementarities with other sectors for mixed crop livestock production;
(ii) identify the most suitable solutions for each climate area to increase circularity in mixed farms;
(iii) develop ICT tools to mitigate GHG emissions,
(iv) test and validate the project solutions,
(v) assess the effectiveness of the project solutions based on an LCA approach and
(vi) provide the dissemination, communication, and channel to results exploitation.

Approach

The project solutions will be demonstrated in three pilots. Pilot #1 will explore the management options to mitigate GHG emissions in a mixed crop-livestock production, Pilot #2 will evaluate regional synergies between livestock and crop production for enhancing agro-systems circularity in south-eastern-Spain, while Pilot #3 will test new solutions to increase circularity and mitigate GHG emissions. The solutions will be tested in a pilot plant in Poland.

Expected Results are to:
(i) develop new technologies to increase circularity and reduce GHG emissions: new liquid and solid fertilizers, new adsorbents for use in ammonium nitrogen removal;
(ii) create a Decision Support System for management of the mixed crop-livestock farms activities to mitigate GHG emissions;
(iii) elaborate management options to enhance agro-systems circularity based on the regional synergies between livestock and crop production and
(iv) create new controlled growth module to be used for the cultivation tests related to high-value crops

Coordinator

Beia Consult International, Romania

Dr Mihaela Balanescu

Project Duration

1 December 2021 - 30 November 2024

Project partners

University of Agricultural Sciences and Veterinary Medicine of Bucharest, Romania
Wroclaw University of Science and Technology, Poland
Universidad Politécnica de Cartagena, Spain
Kajaani University of Applied Sciences, Finland

Consortium

The FACCE ERA-GAS consortium consists of 19 partner organisations from 13 countries.
The consortium is led by Teagasc, Ireland.

	Organisation
DK	INNOVATIONSFONDEN (IFD)
FI	MINISTRY OF AGRICULTURE AND FORESTRY (MMM)
FR	AGENCE NATIONALE DE LA RECHERCHE (ANR)
DE	FORSCHUNGSZENTRUM JÜLICH
DE	FEDERAL OFFICE OF AGRICULTURE AND FOOD (BLE)
DE	FEDERAL MINISTRY OF FOOD AND AGRICULTURE (BMEL)
DE	FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V. (FNR)
IE	TEAGASC - AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY
IE	DEPARTMENT OF AGRICULTURE, FOOD AND THE MARINE (DAFM)
LV	STATE EDUCATION DEVELOPMENT AGENCY (VIAA)
NL	MINISTRY FOR AGRICULTURE, NATURE AND FOOD QUALITY (LNV)
NL	NETHERLANDS ORGANISATION FOR SCIENTIFIC RESEARCH (NWO)
NL	WAGENINGEN UNIVERSITY & RESEARCH (WUR)
NO	RESEARCH COUNCIL OF NORWAY
PL	NATIONAL CENTRE FOR RESEARCH AND DEVELOPMENT (NCBR)
RO	EXECUTIVE AGENCY FOR HIGHER EDUCATION, RESEARCH, DEVELOPMENT AND INNOVATION FUNDING (UEFISCDI)
SE	THE SWEDISH RESEARCH COUNCIL FORMAS
TR	MINISTRY OF FOOD, AGRICULTURE AND LIVESTOCK (GDAR)
UK	DEPARTMENT FOR ENVIRONMENT, FOOD & RURAL AFFAIRS (DEFRA)

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