FACCE ERA-GAS

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

Deliverable D7.1

Short and long-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation

Nature: Report

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Lead Beneficiary: Teagasc, Ireland and Wageningen Research, The Netherlands

1. Introduction

1.1 FACCE ERA-GAS – tackling climate change through transnational cooperation

FACCE ERA-GAS is the ERA-NET Cofund for monitoring and mitigation of greenhouse gases (GHGs) from agri- and silvi-culture. It was initiated by the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI). FACCE ERA-GAS aims to strengthen the transnational coordination of research programmes and provide added value to research and innovation on GHG mitigation. The expected impact of the ERA-NET Cofund is to provide solutions for the agricultural sector in Europe, which faces significant challenges in curbing GHG emissions while maintaining food security and sustainability in a changing climate. It also seeks to boost climate mitigation in the forestry sector. FACCE ERA-GAS receives funding from the European Union's Horizon 2020 Research & Innovation Programme under Grant Agreement No. 696356.

FACCE ERA-GAS organises funding calls for transnational research projects that aim to develop enabling technologies and innovative solutions to improve GHG inventories, increase the GHG efficiency of food, feed and fuel production, enhance carbon sinks and develop circularity in agricultural systems. This is further reinforced by additional activities that support the work of the researchers and research projects, such as training, workshops and webinars. FACCE ERA-GAS works closely with other ERA-NET Actions and reinforces existing collaborations between actors in the research area, e.g. through its close collaboration with the Global Research Alliance on Agricultural Greenhouse Gases (GRA).

The ERA-NET 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. Teagasc, the Irish Agriculture and Food Development Authority, coordinates the ERA-NET.

The activities are structured in seven work packages and the operational work is shared among partners. Teagasc leads the management of the consortium (WP1); Juelich, Project Management organisation from Germany, led the preparation and launch of the co-funded call and managed the call

office (WP2); DAFM, the Department of Agriculture, Food and the Marine from Ireland, organised the evaluation and proposal selection for the co-funded call (WP3); IFD, Innovation Fund Denmark, is conducting the monitoring, evaluation and impact assessment of the co-funded call (WP4); WR, Wageningen Research on behalf of the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), manages communication and dissemination and organises the kick-off, mid-term and final project seminars (WP5), and is leading together with Teagasc on developing a short and long-term strategy, overseeing the implementation of additional activities, interactions with other initiatives and identifying potential follow-up actions (WP7); and BLE, German Federal Agency for Agriculture and Environment, is in charge of implementing an additional joint call and further activities without EC co-funding (WP6).

In **2016**, FACCE ERA-GAS launched its co-funded joint call for transnational research projects in Europe and New Zealand. 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. In **2018**, FACCE ERA-GAS launched a second joint call for transnational research projects. This call was organised together with ERA-NET SusAn (Sustainable Animal Production Systems) and ICT-AGRI 2 ERA-NET (Information and Communication Technologies and Robotics for Sustainable Agriculture). The call theme related to novel technologies, solutions and systems to reduce greenhouse gas emissions in animal production systems. New Zealand also contributed to this joint call, as well as three further third countries: Canada, Chile and Uruguay. In **2021**, FACCE ERA-GAS launched a third call, organised together with ERA-NET SusAn, ICT-AGRI-FOOD (the follow up ERA-NET to ICT-AGRI 2) and the SusCrop ERA-NET (Sustainable Crop Production). This joint call of 4 ERA-NETs invites proposals on circularity in mixed crops and livestock farming systems with emphasis on climate change mitigation and adaptation. The call consists of 30 public Funding Parties from 16 European countries, 3 EU-associated countries and 4 from other countries, including both funders from non-European countries and international networks.

1.2 Elaborating a strategy to address climate challenges in agriculture and forestry

Work Package 7 of FACCE ERA-GAS (entitled 'Short and long-term strategy on agricultural and forestry greenhouse gas monitoring and mitigation') has as a central aim the integration of the work of the ERA-NET into the larger scope of FACCE-JPI. As a leading Member State-driven initiative, FACCE-JPI has worked since its establishment in 2010 at the intersection of challenges

linked to agriculture, food security and climate change. Its 23 European members and associated member (New Zealand) connect relevant national ministries, policymakers and funding organisations with scientific and stakeholder advisors to align research efforts in this area.

A key priority of the FACCE ERA-GAS consortium is to ensure that the ERA-NET's activities help to achieve the FACCE–JPI Strategic Research Agenda (SRA) and FACCE–JPI objectives, notably those concerning the agricultural and forestry greenhouse gas monitoring and mitigation at present and in the future. With that in mind, an analysis was conducted on the extent to which FACCE ERA-GAS co-funded and additional activities contribute to the FACCE-JPI mission. A forward-looking view was then taken on the emerging research needs in the longer term in addressing climate mitigation and monitoring in agriculture and forestry and what is needed concretely to address these needs. The results were synthesised in the present deliverable, ***D7.1 Short and long-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation***.

1.3 Sustainable land management as a cornerstone of EU climate action

Underpinning the ERA-GAS research agenda are the challenges arising from European climate and land management policies and associated greenhouse gas emission targets. In 2015, when the proposal for ERA-GAS was written, the 2030 policy proposals required a 40% reduction in emissions, while primary production was to remain steady or even increase output. In 2019, the European Parliament declared a global "climate and environmental emergency" and the new European Commission President, Ursula von der Leyen, committed to leading the fight against the existential threat posed by climate change. The new Commission set as its headline ambition to become the world's first climate-neutral continent by 2050 and followed with a suite of proposals to meet this objective under the European Green Deal. Recently, an informal agreement has been reached by the European Parliament with the Member States to make climate neutrality a legally binding obligation. The new EU Climate Law increases the EU's 2030 emissions reductions target from 40% to at least 55% compared to 1990 levels.

Within this renewed political context, the importance of land-based primary production systems in achieving core European policy objectives has never been so high. According to a study conducted by the European Commission's Joint Research Centre, food systems are responsible for a third of global anthropogenic GHG emissions, with over 70% of these emissions

arising from agriculture and land use/land-use change activities[1]. Agriculture therefore represents a pivotal sector for implementing GHG emission reduction and carbon storage measures. Forestry remains a crucial component of EU climate, energy, bioeconomy and environmental policy and carries a weight of expectation to provide critical carbon sequestration and carbon removals (e.g. storage in long-lived wood products) in order for climate-neutrality to be achieved.

Sustainable land management can contribute to reducing the negative impacts of multiple stressors, including climate change, on ecosystems and societies (IPCC, 2019[2]). It is deeply interconnected with other major societal challenges, including food and nutrition security, ecosystem protection, land degradation and rural vitality. Achieving the required transformation of land management practices across Member States will, however, require significant investment in research to advance scientific innovations, mobilise actors and move towards realisation and implementation of solutions. This short and long-term strategy on agricultural and forestry greenhouse gas monitoring and mitigation aims to identify these research needs, framed within the key priorities outlined by FACCE-JPI in its SRA. It also serves to point towards possible future Member State priorities in responding directly to these needs.

[1] Crippa, M., Solazzo, E., Guizzardi, D. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nat Food 2, 198–209 (2021).

[2] IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

2. FACCE-JPI: advancing a sustainable future for agriculture, food security and climate

2.1 FACCE-JPI mission

The Council of the European Union launched the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) in 2010 to stimulate collaboration between Member States, and to provide coherence in research programming. Today, FACCE-JPI brings together 24 member countries (comprising EU Member States, associated countries and one Third Country, New Zealand) who are committed to building an integrated European Research Area addressing the interconnected challenges of sustainable agriculture, food security and impacts of climate change (**Figure 1**).

FACCE-JPI's vision, renewed in 2020, is for a European Research Area addressing sustainable and resilient agricultural production systems to provide adequate and nutritious food and to contribute to a climate-neutral Europe by 2050. To achieve this vision, **FACCE-JPI's mission** centres on aligning and co-designing research, and delivering knowledge for addressing the challenges of sustainable and resilient agricultural production systems integrating the climate system, the food system and the ecosystem. The scope of its work focuses on agricultural production systems but with a strong consideration of interactions with i) the food system, ii) the climate system and iii) the ecosystem and possible system shocks.

2.2 FACCE-JPI Strategic Research Agenda 2020

In November 2020, FACCE-JPI marked its ten-year anniversary with a high-level science-policy event entitled 'A world in transition: Journey towards a sustainable future'. The event served as the launch of the new FACCE-JPI SRA[3], updated from the previous 2015 document.

The FACCE-JPI SRA 2020 was the result of the collective efforts of its members, Governing Board and Scientific and Stakeholder Advisory Boards. It proposed a new vision and mission and identified four new Core Themes which would outline a path towards an agricultural sector that respects the planetary boundaries, preserves and encourages biodiversity, reduces emissions and inputs, embraces new approaches such as agroecology, and at the same time provides a sufficient and healthy diet.

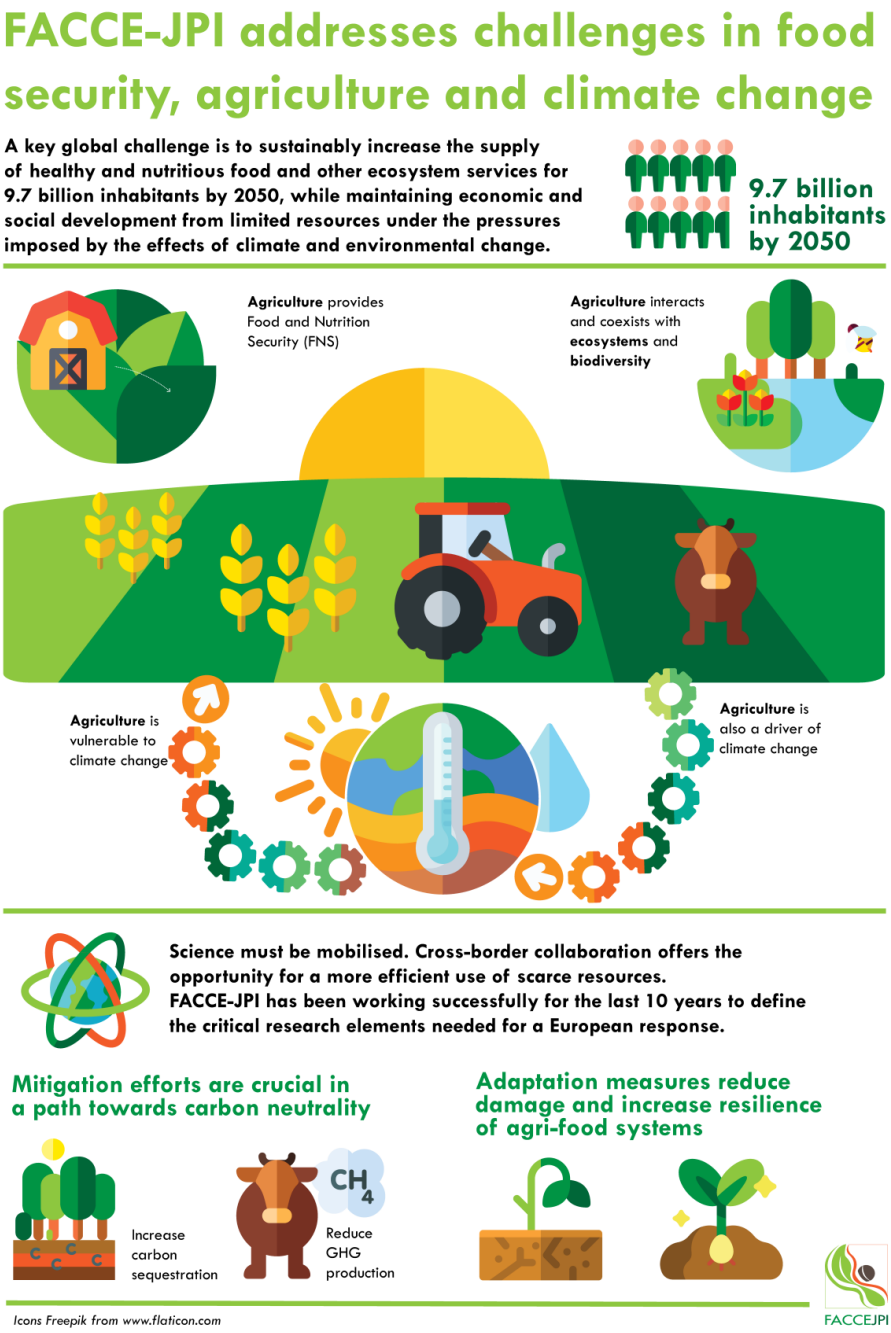

Figure 1: FACCE-JPI works at the intersection of key societal challenges in food security, agriculture and climate change[3]

The Core Themes are:

- **Core Theme 1**: An agricultural sector that contributes to climate neutrality
- **Core Theme 2**: Sustainable & resilient agriculture
- **Core Theme 3**: Nutrition-sensitive agricultural production for food security
- **Core Theme 4**: Trade-offs and synergies between food production, ecosystems and climate

[3] H. Stalb, G. Langthaler, H. McKhann, A. Berndt, P. Gomez, A. Domènech, B. Kuzniar-van der Zee (2020), FACCE-JPI Strategic Research Agenda 2020

Under each Core Theme, a description is provided outlining the background, paradigms, **key research areas**, impact, game changers and links to relevant initiatives, actions and projects.

3. Short-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation

3.1 Introduction

The FACCE-JPI SRA 2020 provides the framework for developing this strategy on agricultural and forestry GHG monitoring and mitigation. In elaborating needs in the short-term, we analyse the actions required to address the priorities outlined in **Core Theme 1 "An agricultural sector that contributes to climate neutrality"**, within the **lifetime of the FACCE ERA-GAS ERA-NET**.

The scope of the three transnational joint calls already initiated by FACCE ERA-GAS and its partner ERA-NETs was carefully elaborated by the ERA-NET funding partners taking into account several key considerations. Firstly, alignment was ensured with the key research priorities identified by FACCE-JPI. The establishment of FACCE ERA-GAS was indeed proposed by the FACCE-JPI advisory boards (Scientific and Stakeholder) and the subsequent **2016 Joint Co-funded Call** directly contributed to Core Theme 5 (Greenhouse gas mitigation) and Core Theme 2 (Environmentally sustainable growth and intensification of agriculture) of the 2012 FACCE-JPI SRA. Secondly, the call scope and themes were informed by a strategic analysis of urgent and emerging needs and scientific developments in the area, including past work. Thirdly, common priorities across Member States were discussed and the added value of transnational research identified. Finally, the political and societal context was considered to ensure coherence with EU policy aims. Similar considerations were taken on board for the **subsequent two Joint Calls** co-organised with our partner ERA-NETs, taking into account also the key synergies between the domains and objectives of the respective ERA-NETs.

3.2 Contribution of ERA-GAS funded activities to FACCE research priorities

To elaborate the short-term needs for this strategy, an analysis was undertaken to determine the extent to which the R&I activities supported through these calls address the new FACCE-JPI SRA, in particular the Key Areas (KAs) identified under Core Theme 1:

KA1 Carbon-neutrality of sustainable food systems
KA2 Deployment of carbon farming solutions
KA3 Reducing carbon footprints through circular biomass chains
KA4 Strategies to reduce GHG emissions based on improving understanding of the microbiome of soils and animals
KA5 Optimising carbon neutrality through digital technologies
KA6 Protection and enhancement of landscape carbon stocks.

Table 1 shows the contribution of the individual projects funded under the 2016 Joint Co-funded Call (10 projects), the 2018 Joint Call (8 projects) and the 2021 Joint Call (call currently open) to each of the six KAs based on the project thematic areas and expected impacts. It provides a summary of the current state-of-play and short-term focus – the Member State actions undertaken and planned until the end of FACCE ERA-GAS.

The analysis shows that all Key Areas will be addressed through the three Joint Calls and also a good balance between the Key Areas addressed by the projects and funding calls is evident. **KA1** (Carbon-neutrality of sustainable food systems) and **KA2** (Deployment of carbon farming solutions) relate to the 'core business' of FACCE ERA-GAS of enhancing the contribution of the agriculture and forestry production sectors to climate mitigation and are therefore well addressed in the projects funded so far. No projects have yet been funded under KA3 (Reducing carbon footprints through circular biomass chains). However, enhancing circularity in primary production systems was identified as a key priority by the ERA-NET funders participating in the 2021 Joint Call and a clear gap in the scope of projects funded thus far by the respective ERA-NETs. As a result, the entire 2021 Joint Call was dedicated to the topic of circularity in mixed crops and livestock farming systems, with emphasis on climate change mitigation and adaptation. It can therefore be expected that possibly 7-10 projects will be selected for funding in this €16M Joint Call directly addressing **KA3**.

Understanding the role of the microbiome of soils and animals in regulating GHG emissions and developing GHG mitigation strategies based on this intelligence, as captured in **KA4**, is a key tool explored in several of the projects funded so far, especially in reference to the rumen microbiome. **KA5** relating to digital technologies is also well addressed as a key enabler in reducing emissions and enhancing C sinks in the 2016 Joint Call projects. The subsequent close collaboration with the ICT-AGRI 2 ERA-NET and its successor, the ICT-AGRI-FOOD ERA-NET, in the 2018 and 2021 Joint Calls, respectively, has resulted in a high number of projects harnessing the potential of data and digital technology solutions in their research methodologies. **KA6**, relating to protecting and enhancing landscape carbon stocks, was well

	FACCE-JPI Strategic Research Area 2020 – CORE THEME 1 – Key Areas					
FACCE ERA-GAS MONITORING & MITIGATION OF GREENHOUSE GASES FROM AGRI- AND SILVI-CULTURE	**KA1. Carbon-neutrality of sustainable food systems**	**KA2. Deployment of carbon farming solutions**	**KA3. Reducing carbon footprints through circular biomass chains**	**KA4. Strategies to reduce GHG emissions based on improving understanding of the microbiome of soils and animals**	**KA5. Optimising carbon neutrality through digital technologies**	**KA6. Protection and enhancement of landscape carbon stocks**
2016 Joint Call on "monitoring & mitigation of greenhouse gases from agri- and silvi-culture"						
3DForMod		■			■	■
CEDERS	■			■		
FORCLIMIT		■			■	■
GHG-Manage	■	■			■	■
INVENT		■			■	■
MAGGE-pH	■			■		
METHLAB	■			■		
PEATWISE	■	■				■
ResidueGas	■	■				■
RumenPredict	■			■		
2018 Joint Call on "novel technologies, solutions and systems to reduce greenhouse gas emissions in animal production systems"						
CCCfarming	■				■	
FarmSustainaBl	■				■	
GrassToGas	■			■		
GrASTech	■				■	
M4Models	■	■			■	
MELS	■				■	
MilKey	■				■	
SEASOLUTIONS	■			■		
2021 Joint Call on "circularity in mixed crops and livestock farming systems with emphasis on climate change mitigation and adaptation"						
€16M funding call currently open for proposals	■		■		■	

Table 1: Contribution of FACCE ERA-GAS funded projects and the 2021 Joint Call to the Key Areas of Core Theme 1 of the FACCE-JPI Strategic Research Agenda 2020

addressed by the projects funded under the 2016 Joint Call, including one project (PEATWISE) which explores the wise use of drained peatlands, a particular focus of this KA.

3.3 Short-term priority areas of action

The conclusion we can draw from this analysis is that the strategic alignment and research prioritisation conducted by Member States when designing and implementing joint calls has been successful in addressing the top priority research areas that can help us to achieve climate-neutrality in agriculture, as identified in 2020 by FACCE-JPI. The short-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation will therefore focus on the following **three key areas of action**.

Firstly, between now and the end of FACCE ERA-GAS, the consortium will continue to provide **on-going support to the funded projects** to ensure that research results are captured, valorised and disseminated. This will help to enhance adoption of GHG innovations (technologies, inventory improvements, etc.) along the innovation chain. It will include presentations to key stakeholders, including policymakers, towards the end of the project lifetimes (e.g. Final Research Programme Meeting of the 2016 Joint Call funded projects). Targeted monitoring and evaluation activities at mid- and end-term will also assess progress against key indicators relating to project outputs (e.g. publications, patents or pilots), outcomes (e.g. new partnerships or knowledge on technologies) and impacts (e.g. for the research community, policy or regulation, see PEATWISE Policy Brief[4] as an example). This work will culminate in an Impact Assessment Report in Month 70 (D4.2) which will evaluate impact at both project and aggregated project level within the lifetime of FACCE ERA-GAS.

Secondly, FACCE ERA-GAS will put a strong focus on **developing human capital**, with particular attention given to early career researchers. This entails exploring ways to support these GHG researchers in acquiring new competencies and skills, learning about and applying innovative ideas and managing their career. Already a FACCE ERA-GAS Early Career Researcher Summer School on GHG monitoring and mitigation in agriculture and forestry was held in June 2019 in the Netherlands and a FACCE ERA-GAS GHG Research Breakfast Club has been established.

[4] https://www.eragas.eu/en/show/ERA-GAS-PEATWISE-policy-brief.htm

The Breakfast Club is an initiative targeted at post-doctoral researchers and PhD students which includes presentations from eminent scientists on cutting edge research topics related to GHG monitoring and mitigation from agriculture and forestry, and career development presentations. It has been hugely successful so far, attracting on average 260 registrations per online event from 37 countries in the EU and around the world and will continue to be a priority action in ERA-GAS.

Finally, the FACCE ERA-GAS consortium will **explore and open up new areas of focus**. Table 1 shows that although there is a strong and balanced representation of the Key Areas in the funded projects and funding calls, some Key Areas have not been comprehensively addressed since the 2016 Joint Call and these projects will end in the coming 12 months. Therefore, a particular focus will be to identify priorities in addressing these areas, as elaborated in the long-term strategy in the next section.

4. Long-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation

4.1 Introduction

On 2 February 2021, the European Commission announced the formal launch of the new EU Framework Programme for Research and Innovation, Horizon Europe under the Portuguese Presidency. With a budget of €95.5 billion, this ambitious R&I programme will run from 2021 to 2027. It includes many novelties in terms of its instruments, approach and infrastructure to maximise the impact of the projects funded. Chief among these new elements are the five new **Missions**, which are sets of measures to achieve bold, inspirational and measurable goals within a set timeframe. There is also a new objective-driven and more ambitious approach to **Partnerships**, involving the European Commission, public and private partners in concerted R&I initiatives.

The development of the Horizon Europe programme has heralded a new level of ambition for how R&I can support a green, healthy, digital and inclusive Europe. It also inspires Member States to adopt new approaches and priorities in their national and regional R&I funding programmes. This long-term strategy for agricultural and forestry greenhouse gas monitoring and mitigation needs to be cognisant of the priority actions of Horizon Europe, to ensure that coordinated Member State activities in this area can leverage opportunities for synergy and alignment with Horizon Europe and avoid duplication of efforts. It will also be important to identify and work to address important gaps in European R&I, in particular where coordination of programmes across Europe is needed. As in the short-term strategy, the FACCE-JPI SRA 2020 provides the basis for identifying long-term priorities, thus ensuring that FACCE ERA-GAS advances FACCE-JPI core objectives agreed by its Members, Governing Board and Advisory Boards. The timeframe considered will be the same as that of the FACCE-JPI SRA, **2020 – 2027**, which also aligns with the Horizon Europe funding programme. For ease of reference, a summary of the main gaps and long-term priorities identified in the following sections of this long-term strategy is provided in **Table 2.**

	FACCE-JPI Strategic Research Area 2020 – CORE THEME 1 – Key Areas					
FACCE ERA-GAS MONITORING & MITIGATION OF GREENHOUSE GASES FROM AGRI- AND SILVI-CULTURE	**KA1. Carbon-neutrality of sustainable food systems**	**KA2. Deployment of carbon farming solutions**	**KA3. Reducing carbon footprints through circular biomass chains**	**KA4. Strategies to reduce GHG emissions based on improving understanding of the microbiome of soils and animals**	**KA5. Optimising carbon neutrality through digital technologies**	**KA6. Protection and enhancement of landscape carbon stocks**
Addressed to Date?	Addressed comprehensively	Addressed in depth in 2016 call – less so since then	Will be addressed through 2021 call	Addressed comprehensively	Addressed comprehensively	Addressed in depth in 2016 call – less so since then
Long-term Priorities	Ensure proposed European Partnership on Agroecology takes climate mitigation objectives into consideration Feed into work and priorities of SCAR CWG on Sustainable Animal Production	Soil aspects can be comprehensively addressed by EJP Soil and the Soil Health and Food Mission Instigate a dialogue to identify research needs in the area of forestry	Support, valorise and assess impact of projects funded under the 2021 Joint Call Support work of European Partnership for Circular Bio-based Europe	Soil Microbiome to be addressed as part of EJP Soil Work of IBF Working Group on Food System Microbiome Unlocking potential through piloting and demonstrating microbiome innovations	Support, valorise and assess impact of projects funded under the 2021 Joint Call Align and feed into the work of the ICT-AGRI-FOOD ERA-NET Align and inform the development of the European Partnership on Agriculture of data	Soil aspects can be comprehensively addressed by EJP Soil and the Soil Health and Food Mission Instigate a dialogue to identify research needs in the area of forestry Promote holistic view of sustainable land management amongst early career researchers and assess research needs
Long-term Priorities – Cross Cutting	Role of citizens/consumers and social innovation Trade-offs and co-benefits Global cooperation and leadership					

Table 2: Summary of main gaps and long-term priorities identified in addressing Key Areas of Core Theme 1 of the FACCE-JPI Strategic Research Agenda 2020

4.2 Gaps to be addressed

Table 1 highlights the contribution of FACCE ERA-GAS funded projects and funding calls to the Key Areas of Core Theme 1 of the FACCE-JPI SRA 2020, but it also points towards areas that received less attention overall. These areas could be the focus of future Member State joint actions and initiatives to address important gaps and strengthen the European Research Area. Actions could include joint programming and alignment activities, funding calls, networking structures, common strategic research agendas, workshops, seminars or training events.

In developing the 2018 and 2021 Joint Calls, a strong collaboration was built with other ERA-NETs, in particular ERA-NET SusAn, in the area of sustainable animal production. As a result, **KA2** (Deployment of carbon farming solutions) and **KA6** (Protection and enhancement of landscape carbon stocks) have not been comprehensively addressed since the 2016 Joint Call. Nonetheless, carbon farming solutions and protection and enhancement of landscape carbon stocks are crucial elements of any long-term roadmap for decarbonisation and climate-neutrality. Practices that promote carbon sequestration in managed land represent biological negative emission technologies which can support domestic climate change policies and boost soil health[5].

Two key areas for consideration are climate mitigation and monitoring in soils and forests. In terms of **soils**, there are major initiatives underway or planned that aim to address this topic directly. The European Joint Programme Cofund on Agricultural Soil Management (**EJP Soil**), comprising 26 partner organisations from 24 countries, is tackling key societal challenges including climate change and soil carbon sequestration. It will include activities addressing peatland, which was identified as a focus of KA6 by FACCE-JPI. Furthermore, one of the proposed **Mission areas** under Horizon Europe is on **Soil Health & Food**. It will develop a portfolio of actions to ensure "75% of soils are healthy by 2030", including agricultural and forest soils. Therefore, concerted action by Member States on soils & climate change is already underway or planned and no obvious additional actions can be identified at this time.

[5] Keith Paustian, Sarah Collier, Jeff Baldock, Rachel Burgess, Jeff Creque, Marcia DeLonge, Jennifer Dungait, Ben Ellert, Stefan Frank, Tom Goddard, Bram Govaerts, Mike Grundy, Mark Henning, R. César Izaurralde, Mikuláš Madaras, Brian McConkey, Elizabeth Porzig, Charles Rice, Ross Searle, Nathaniel Seavy, Rastislav Skalsky, William Mulhern & Molly Jahn (2019) Quantifying carbon for agricultural soil management: from the current status toward a global soil information system, Carbon Management, 10:6, 567-587, DOI: 10.1080/17583004.2019.1633231

In the area of **forestry**, the 2021 Joint Call includes agroforestry within its scope, however projects dedicated specifically to forestry have not been funded since the 2016 Joint Call, when three projects were selected (3DForMod, FORCLIMIT and INVENT). There have been several ERA-NETs funded on forestry (ForestValue, SUMFOREST, WoodWisdom-Net+, FORESTERRA and WoodWisdom-Net 2), however only ForestValue is still running (expected to end in September 2022). A proposed topic in the draft Horizon Europe 2021-2022 Work Programme has been included to fund a Coordination and Support Action on "Strengthening the European forest-based research and innovation ecosystem". However, forestry would seem to represent a gap in the longer-term plans for coordinated Member State actions. To address this gap in the shorter term, there is a need to **instigate a dialogue** with forestry researchers, stakeholders and Member State representatives to identify research needs in this area and inform potential future action. This will provide a key building block for future pan-European actions in this area.

Discussing climate mitigation and monitoring in agricultural soils and forestry within European landscapes raises the topic of the **multi-functionality of land-based systems**. Landscapes have been described as multi-functional through their simultaneous support of habitat, productivity, regulatory, social, and economic functions[6]. A holistic view is needed to see the linkages between climate regulation and other land functions, as well as across land uses. Such a bird's eye could bring together perspectives relating to **planning** how we can sustainably manage our land to meet multiple policy objectives and **solving ingrained issues**. To promote a **more holistic view of sustainable land management**, the concept could be presented and promoted among **early career researchers** as the future scientific leaders in the area, prompting them to bring new perspectives into their research and enhance interdisciplinarity. In the longer term, efforts would be required to identify on-going efforts and promising approaches in this field and **potential research needs**.

4.3 Alignment with existing and planned actions

For the Key Areas targeted recently by FACCE ERA-GAS funding calls, the focus should be on continuing critical work in these areas and aligning with and informing other relevant on-going or planned initiatives.

[6] Mander Ü, Helming K, Wiggering H. 2007. Multifunctional land use: meeting future demands for landscape goods and services. In: Mander Ü, Wiggering H, Helming K (eds). Multifunctional Land Use. Springer. Berlin, Heidelberg. P 1–13.

Long-term priorities under **KA1, Carbon-neutrality of sustainable food systems**, are:

- Ensuring the proposed **European Partnership on Agroecology** (accelerating farming systems transition: agroecology living labs and research infrastructures) takes climate mitigation objectives into consideration to ensure co-benefits. The SCAR Strategic Working Group on Agroecology is already working towards this Partnership and has overlaps with ERA-GAS in terms of membership. Therefore, synergies can be readily highlighted.
- Feeding into the work and priorities of the **SCAR Collaborative Working Group on Sustainable Animal Production**.

Long-term priorities under **KA3, Reducing carbon footprints through circular biomass chains**, are:

- Supporting, valorising and assessing the impact of the projects funded under the **2021 Joint Call**
- Supporting the work of the **European Partnership for a Circular Bio-based Europe**, in particular in relation to enhancing the circularity of feedstock production systems.

Under **KA4, Strategies to reduce GHG emissions based on improving understanding of the microbiome of soils and animals**, there are on-going or planned actions involving Member States of key relevance to the topic:

- The soil microbiome constitutes an important aspect of the key targets of **EJP Soil**, in particular the target relating to 'soils, environment and ecosystems services'
- The International Bioeconomy Forum, **IBF**, has a Working Group on the "Food System Microbiome" aimed at understanding the complexity and benefits of microbiome in the context of food systems.

The Horizon Europe Work Programme will also fund projects in the area of the microbiome. Therefore, it would appear that the microbiome is mainstreamed in both EU and Member State R&I actions. Future priorities could include unlocking its potential in agriculture and forestry, in particular through **piloting and demonstrating** microbiome innovations.

Long-term priorities under **KA5, Optimising carbon neutrality through digital technologies**, are:

- Supporting, valorising and assessing the impact of the projects funded under the **2021 Joint Call**
- Aligning and feeding into the work of the ICT-AGRI-FOOD ERA-NET, which has overlaps in terms of membership with FACCE ERA-GAS

- Aligning and informing the development of the **European Partnership on Agriculture of data** to ensure the potential of digital and data technologies in environmental observation to enhance climate mitigation can be explored in depth.

4.4 Other priority areas and cross-cutting issues

The FACCE-JPI SRA 2020 also identifies some important '**game changers**' (actors, technologies, trends, events) that may significantly alter the organisation and outcomes of primary systems. For Core Theme 1, these include some areas, listed below, that are related to topics already discussed:

- **functional biodiversity** to sustain high productivity, low external inputs and carbon neutrality
- manipulation of **microbial functions** to reduce the level of GHG emissions
- **digital technologies** that substantially improve the capacity of monitoring and predicting the behaviour of agricultural systems and provide a foundation for financially rewarding net emission reductions.

The other game changers identified are:

- **societal push** for less livestock products;
- **bio-refining technologies** that reduce waste, save energy and enhance carbon retention of soils
- **co-development and demonstration** of technologies and production systems to enhance implementation of **carbon-neutral practices** by farmers.

Future work could assess the existing research efforts in these areas (in particular, future Horizon Europe Partnerships) and identify needs for coordinated Member State actions. While bio-refining technologies and co-development and demonstration of carbon-neutral practices can be considered enablers or pathways for achieving impact, the **human dimension** of the climate challenge emerges as a strong cross-cutting issue requiring attention. Several analyses have highlighted the role of **consumers/citizens** and **social innovation** in achieving the necessary transition in our economy and environment, including the SCAR 5th Foresight Report[7] and the report on Foresight Scenarios for the EU bioeconomy in 2050[8] prepared by experts for the European Commission.

[7] https://scar-europe.org/images/FORESIGHT/FINAL-REPORT-5th-SCAR-Foresight-Exercise.pdf
[8] https://publications.jrc.ec.europa.eu/repository/handle/JRC123532

Another critical cross-cutting issue is addressing **trade-offs and co-benefits**, as highlighted by the FACCE-JPI SRA 2020 under **Core Theme 4, Trade-offs and synergies between food production, ecosystems and climate**. Achieving climate objectives should not have major detrimental impacts for food and nutrition security or for ecosystems, the latter enshrined under the 'Do no significant harm' principle. Therefore, solutions for agriculture and forestry production systems that maximise their contribution to multiple policy objectives, such as creating **co-benefits for both climate and biodiversity**, could be supported through Member State actions. This could be achieved by aligning and informing the development of the European Partnership on Agroecology and the European Partnership for rescuing biodiversity to safeguard life on Earth. However, **additional funding efforts** may be needed to provide the evidence base for policy on particular aspects of agriculture and forestry systems. The importance of considering trade-offs and co-benefits in a holistic approach should also be **communicated and promoted** among FACCE ERA-GAS funded projects and early career researchers.

Finally, **global cooperation and leadership** in the area of GHG mitigation is of paramount importance in addressing such an immense shared challenge. FACCE ERA-GAS has already established very close links with the Global Research Alliance on Agricultural Greenhouse Gases (GRA), comprising more than 60 countries from all regions of the world. This cooperation has culminated in the participation of funders from several Third Countries in the FACCE ERA-GAS joint calls. Future efforts should continue this close alignment to achieve optimal networking and global added value from EU R&I.

5. Conclusion

The higher ambition of EU policy on climate demands that Member States and the scientific community raise their efforts and respond with resources, resolution and transformative ideas to enact change. Agriculture and forestry are two sectors where significant efforts will be needed to reduce GHG emissions and enhance carbon sinks, taking into account the biological complexity of these systems.

The analysis conducted in this strategy demonstrated that the joint Member State actions supported by FACCE ERA-GAS and its partner ERA-NETs since 2016 have contributed to many of the key research areas identified by FACCE-JPI in the area of climate-neutrality in agriculture. In the short-term future, this strategy recommends concentrating on three key areas of action, relating to on-going support to projects, developing human capital and exploring and opening up new areas of focus. The long-term strategy emphasises addressing key gaps in Member States' on-going and planned activities, aligning with existing and future activities, in particular under Horizon Europe, and key cross-cutting issues that warrant careful consideration.

This short and long-term strategy will inform the planning of potential follow-up activities to perpetuate the actions carried out under this ERA-NET. It can also serve as input to the next FACCE-JPI Implementation Plan arising from the 2020 SRA.