DEEDS

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Research and Innovation to decarbonise the Agriculture and Land-Use sector

The European Commission's 'Farm to Fork' strategy for Sustainable food is a key component of the European Green Deal. To support this initiative, the Commission proposes that at least 40% of the overall budget of the Common Agricultural Policy (CAP) would contribute to climate action. This DEEDS Policy Brief outlines key features of EU research and innovation (R&I) needs to promote sustainable agriculture and land-use in Europe.

OVERVIEW

- Agriculture and land-use are key sectors for climate mitigation as they have the ability to both deliver substantial emission reductions and to offset emissions from other sectors through carbon sequestration.
- R&I to reduce livestock emissions, such as feed compounds and nitrification inhibitors, should be a priority as they represent most agricultural emissions in Europe. Supporting the ongoing refinement of high-performance agro-ecological and agroforestry systems should also be a key R&I priority.
- Knowledge about the benefits of plant-based diets for climate change mitigation is strong enough to warrant immediate action. The focus now needs to be on how to facilitate their adoption.
- Reducing food waste, within a circular economy framework, is a key strategy to enable a more efficient use of natural resources.
- R&I is required to better understand the environmental and sustainability impacts of dedicated energy crops and other bioenergy feedstocks such as residues and waste.
- Earth Observation data from the Sentinel missions could enhance our understanding of land use and carbon management, and R&I in this area should be pursued.

BACKGROUND

Agriculture and land use are responsible for just over 10% of overall European greenhouse gas emissions. Given this relatively minor share of European emissions, this sector has received little attention in decarbonisation strategies so far. It is, however, a key sector as it has the ability to both deliver substantial emission reductions and offset emissions from other sectors through carbon sequestration.

Greenhouse gas emissions from European agriculture come mainly from enteric fermentation (methane), synthetic fertilizers and manure use and management (nitrous oxide). European consumption of agricultural produce is characterised by a large share of animal-based proteins (60% of the total consumed), which are particularly intensive in use of land and water. This consumption pattern generates environmental degradation both in and outside Europe, since about 80% of all proteins consumed in Europe are imported from non-EU countries. Food losses and waste generation are very large in Europe, amounting to 280 kg/person/yr, the second highest rate of food losses and waste per capita in the world. On the other hand, European land-use represents a net carbon sink as forests are being replenished, but these carbon stocks remain particularly fragile and are especially threatened by the impacts of climate change.

Decarbonising European agriculture is challenging as it must be achieved in the context of rapidly growing global food demand (between +50 % and +100 % by 2050 as estimated by the latest foresights), while it must also cope with the growing impacts of climate change. More broadly, agriculture and land use – while being essential for people's livelihoods – overlap with planetary systems that are already in a critical state; namely climate, biodiversity, the biogeochemical cycle and land system change. The importance of this sector in a comprehensive R&I policy therefore goes far beyond the issue of climate change.

Components of the system

Agricultural emissions in Europe are dominated by emissions from enteric fermentation, synthetic fertilizers and manure use and management. With the exception of a rebound in 2014, these emissions have been gradually decreasing since the middle of the 1980s. This is mainly due to improvements in the efficiency of production processes (nutrient use efficiency and feed use efficiency) and the lower consumption of agricultural products in Europe.

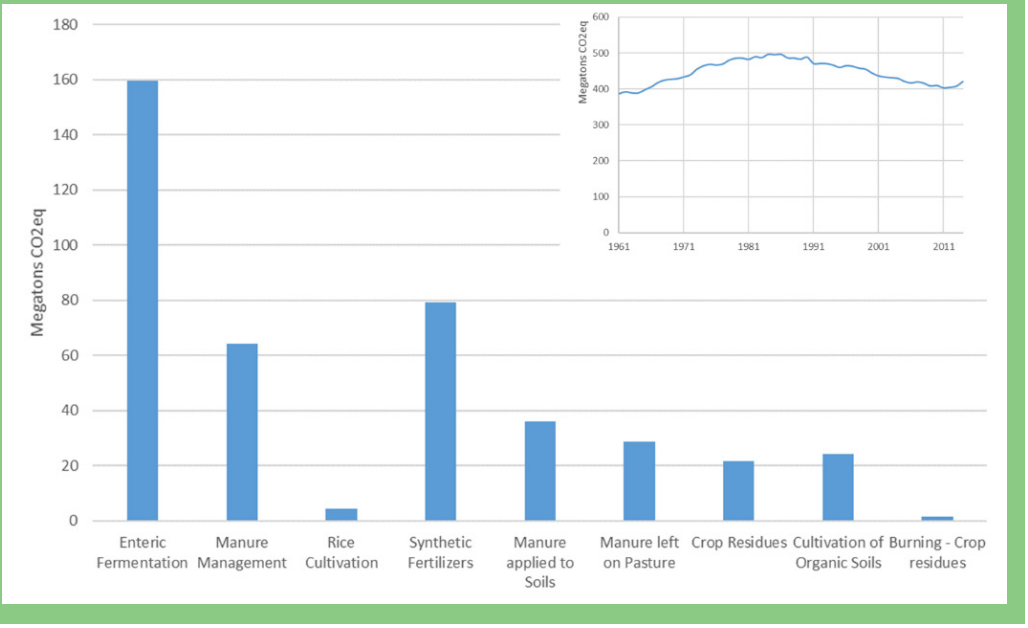


Fig. 1: Emissions from Agriculture in Europe in 2014 and evolution 1961-2014 (embedded figure). Source: FAOSTAT

PRIORITIES ON RESEARCH AND INNOVATION

Transformative technologies and practices

A large set of technical solutions exist to reduce direct emissions from agriculture (e.g., precision farming, breeding techniques enabled by digital services). Emissions from livestock represent the majority of agricultural emissions in Europe (see Box 1), and R&I in feed compounds and nitrification inhibitors (see Box 3) to reduce these and associated emissions should be a priority.

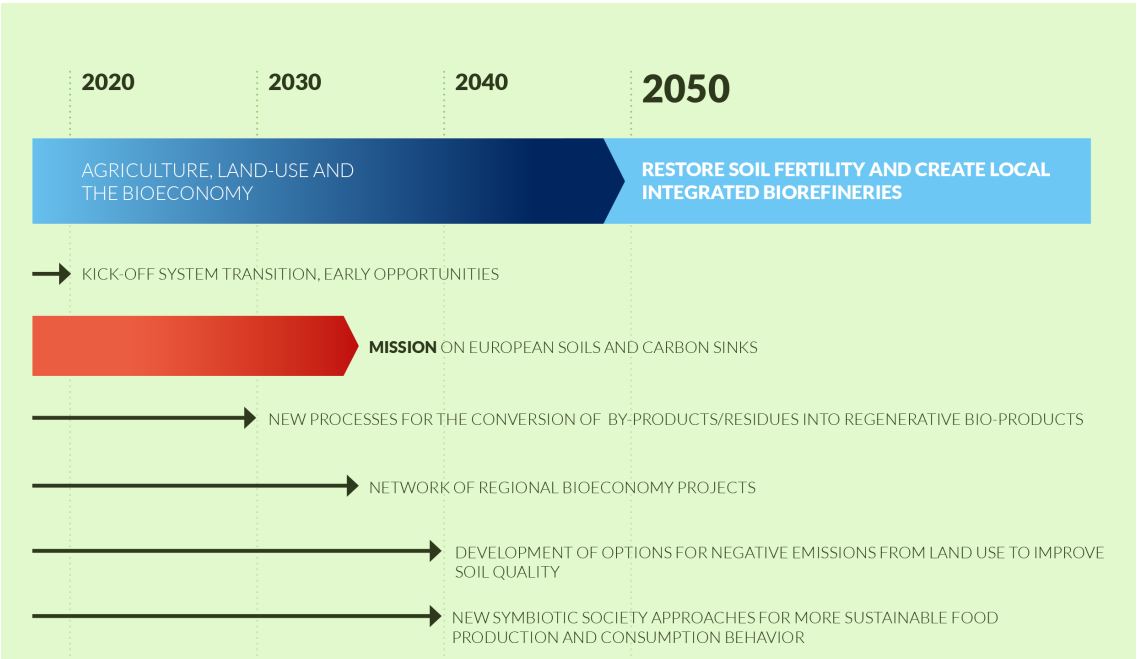
There is large heterogeneity across European farm types and locations. For this reason, the assessment of potentials for cost-effective emission reductions must be conducted at the appropriate scale and policies should be designed accordingly.

Alternative models to conventional agriculture, such as agro-ecology or agroforestry, offer promising prospects in terms of production per unit area while taking into account sustainability aspects. Yet their yield performance against conventional agriculture, both in levels and stability, is still heavily debated. The competitiveness for exports is a key question as un-sustainable farming practices are still largely favoured because of their ability to export at lower cost. In this regard, supporting the ongoing refinement of high-performance agro-ecological and agroforestry systems should be a key R&I priority.

A sound decarbonisation strategy must also consider adaptation to climate change and in this prospect, further research is needed in crops that can best adapt to a changing climate (such as drought-resistant crops) and hence decrease risks for farmers.

New patterns of food consumption

Efforts on both the supply and demand elements of food production is required to reduce the environmental footprint of European agricultural as a whole. Knowledge about the benefits of plant-based diets for the climate is strong enough to warrant immediate action. The challenge lies now mainly on how to facilitate their adoption. This is a question of changing behaviour on the consumer's side but also of redefining economic models on the producer's side. New patterns of food consumption can lead to profound changes in supply chains with potentially high social and economic costs, particularly in some



highly specialized regions where alternative professional options are limited. For this reason, an R&I priority should be to design new socio-economic models capable of guiding consumers and producers choices towards an approach in which the production and consumption sides are increasingly integrated.
Ultra-processed food products are a key dimension in this issue, as they generate negative impacts on both the environment and health. There is a need to reorient agricultural priorities from producing high quantities of food to producing healthy food. Urban-rural relations have an important influence on eating habits. They need to be studied to assess how they modify, and potentially lengthen, the agricultural supply chain. A superlabs-type research infrastructure could be particularly suited to pursue this objective.
Finally research for developing educational programmes focussing on the young generations (primary schools) for teaching, increasing awareness of the relation between sustainable local agriculture production and consumption would be of special interest.

Waste management

The potential for mitigation by reducing food waste is very significant given the volumes involved. The issue is also a matter of management of waste stocks, which represents a major environmental challenge because of the risk of soil contamination.
A circular economy enables a more efficient use of natural resources. This approach is of environmental interest as it envisions human activity in the form of a cycle mimicking natural ones, breaking with the dominant extractivist model. However, it will only generate environmental benefits under specific conditions that should be investigated within an R&I policy. First, reducing food losses and waste at the source should be the priority of a sustainable strategy for future agriculture. The aim should be to avoid land-use and fertiliser emissions as well as the many emission sources associated with the supply chain (e.g. refrigeration, transport). In addition, rebound effects, occurring when a more efficient use of resources leads to increased consumption, needs to be avoided as it could dramatically reduce and even reverse the benefits of a circular approach.

Preserving Carbon Stocks in Europe without deteriorating those of our main trade partners

Preserving carbon stocks in European soils and vegetation should be a focus of future R&I policies on decarbonisation. This involves dealing with two major threats: land and forest degradation, particularly due to climate change, and artificialisation of agricultural land. Decarbonisation objectives must be achieved without inducing deforestation outside European borders and should not negatively impact local initiatives.
Soil carbon sequestration represents a synergetic way to enhance crop productivity while preserving carbon stocks. However, scientific evidence of the benefits of increasing soil organic carbon across a range of different soils,

Main challenges

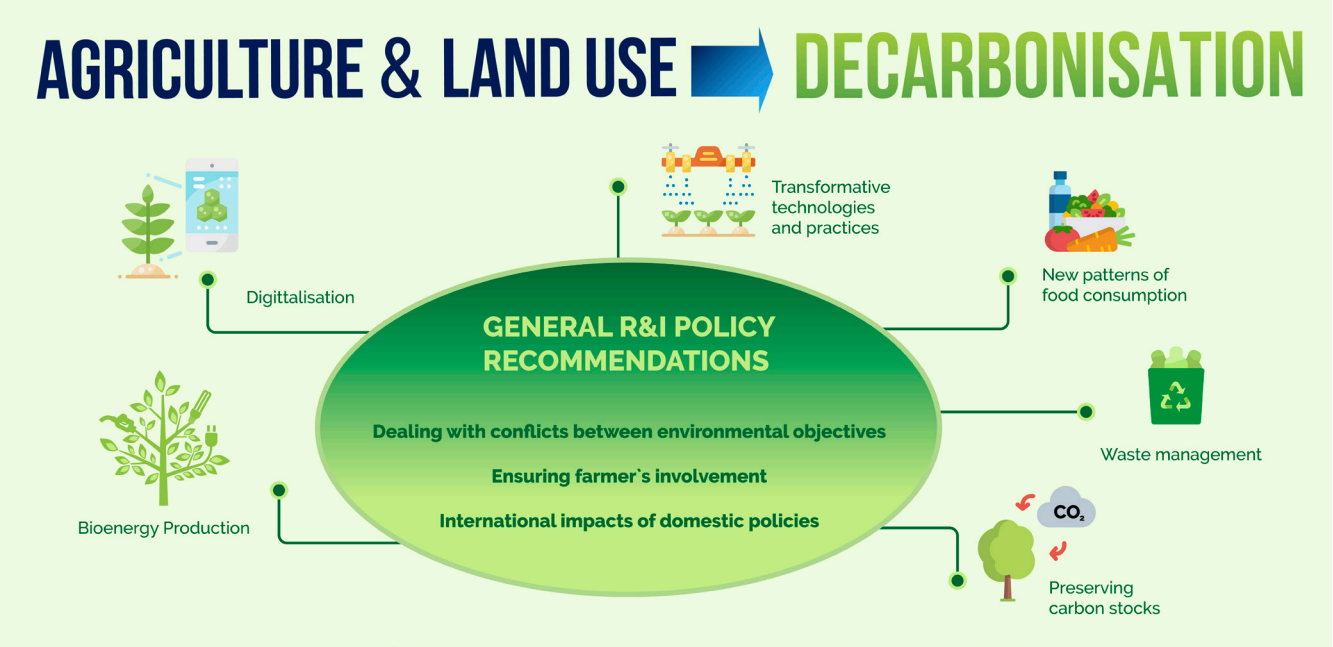
The importance of European agriculture and land use in decarbonisation strategies is threefold. It is first a matter of reducing greenhouse gas emissions emitted through the agricultural production process (methane from livestock production and nitrous oxide from fertilizer use). It is also a matter of reducing the environmental footprint of European food consumption, which is characterised by a large share of animal-based proteins and a high proportion of food wastage. Finally, European agriculture must promote the sequestration of carbon in soils and vegetation to meet the target of negative emissions, i.e. the geological or biological sequestration of carbon, associated to the decarbonisation pathways limiting the global warming to 1.5°C or 2°C.

agro-ecosystems and climatic zones is still insufficient. It is especially important to increase knowledge about the role of grasslands and on the best ways to include cover crops in rotation. Storage permanence is also a key issue that needs to be addressed from a multidisciplinary perspective. Compensation schemes, such as carbon rights and trading platforms, to ensure a certain income for farmers for the sustainable use of their lands should be further investigated.

Bioenergy production

Bioenergy production is seen as a major option to produce energy while storing carbon in vegetation (mainly short rotation grassy or woody energy crops such as poplar or miscanthus). This option, however, is particularly debated within the academic community. The scientific literature is divided between two positions. On the one hand, replacing fossil fuels and possibly generating negative emissions through carbon capture and storage offers the outlook of a better management of natural resources. On the other hand, the development of large-scale bioenergy production may alter the terrestrial carbon stock and result in net increases in greenhouse gases emissions.
The research priorities in this field should focus on

Mitigation objective	Innovation	Example of policies support
Reducing emissions from manure left on pasture	Chemical or biological nitrification inhibitors to prevent microorganisms to turn nitrogen into nitrate	Funding into methods for reducing nitrification of manure
Reducing emissions from enteric fermentation	Feed compounds such as 3-nitrooxypropran that lower methane emissions	Funding large-scale 3-nitrooxypropran (3-NOP) or related demonstration projects
Reducing emissions from fertilizer use	Producing nitrogen from renewable electricity	Funding research and support design of demonstration nitrogen fertilizer plants using renewable electricity
Increasing storage capacity in soils and vegetation	Increase use of agroforestry, which builds above-ground carbon and practices to increase productivity of grasslands and croplands, which adds carbon in roots and residues and	Supporting ongoing research initiatives (4 per 1000, Montpellier declaration on Agroforestry)
Changing land use pattern	Carbon market platforms and emission trading systems could help compensate for the loss of income due to less or no land-production, but maintaining a particular balance in carbon storage at a certain time and geographical demarcation.	Support the design of tools and scheme's to reward farmers for not utilizing their land, for reasons to use as carbon sink.



improving the environmental assessment of dedicated energy crops and on better evaluating the sustainability impacts in different regions of using other bioenergy feedstock than biomass from dedicated plantations (e.g., organic waste and/or agricultural/forestry residues). Research should also investigate all possible energy carriers for biomass, including bio-hydrogen and the conditions for efficient methanisation (e.g., size of installation, risk of leakage).

Digitalisation

Digital technologies have the potential to increase farm efficiency while improving economic and environmental sustainability. This potential could be further enhanced by a wealth of data provided by Sentinel missions from the European Space Agency. These missions provide an unprecedented amount of data to monitor a large variety of land- and carbon-related parameters at a fine time and spatial resolution. This effort should be pursued and intensified, as it can be the start of a revolution in land and carbon management. To realize the full potential of this breakthrough, it is important that the data collection effort be accompanied by appropriate support for data analysis and application.

POLICY RECOMMENDATIONS

R&I policy should aim to better deal with conflicts and synergies across all environmental domains from biodiversity to land use to food waste. From this point of view, agro-ecology or agroforestry offer promising prospects. For effective action, it is also important to target emissions that are especially important in Europe such as emissions from livestock activities and synthetic fertilizers.

R&I in agriculture could also contribute to the success of the Green Deal by conducting an in-depth reflection on European agricultural demography. Farmers' involvement is a necessary condition for the sustainability of the sector as well as to enhance innovation. Shifting from resource intensive to labour intensive production models will not be possible without an increase in agricultural employment. Research is needed to understand how decent incomes for farmers can be guaranteed and how to increase the number of young persons who want to work in the agriculture sector.

Funding will be key to implementing the Green Deal. Mobilising the private sector and using the CAP as a financing tool are appropriate solutions. Research could contribute here by proposing cost efficient financing schemes taking into account the heterogeneity in mitigation potentials across European regions and farm types.

Because of Europe's position in world agricultural trade, it is important to stress that the policy choices will concern not only the European territory, but also the trading partners via international exchanges. Public policies in this area will have to be based on appropriate sustainability criteria and indicators reporting on direct and indirect effects of public policies in a reliable and transparent manner.

The Green Deal is an ambition commensurate with the environmental challenges, but trade-offs may emerge between climate, biodiversity and social objectives. Within the European democratic regimes, it is essential to facilitate a wider discussion on the priorities to be given to European environmental action and the ways of implementing them. This should be the true founding basis of the European Green Deal that would give it its full meaning.

Risks & Mitigation

- Impacts of climate change on forest's capacity to sequester carbon
- Social and economic costs induced on supply chains by changing food pattern
- Conflicting objectives between different environmental and social dimensions
- Rebound effects that could dramatically reduce and even reverse the benefits of a circular approach
- Exporting emissions to our trading partners without reducing the environmental footprint of European consumption

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