1. Introduction

Agriculture and land management in general, play a central role in climate change mitigation in the EU. There is an extensive list of potential measures that can be taken in agriculture for mitigating emissions and which are technically feasible. Some mitigation options, which are typically best management practices already, lower farm emissions while also contributing to cost savings and thus increasing farm profitability. Therefore, these measures are win-win measures. Many options can be carried out at farm level, although some options also require collective approaches involving multiple farmers and other stakeholders.

At EU level, the main mitigation options for the land use sector focus largely on methane (CH_4) and nitrous oxide (N_2O) reductions, the main emissions from the agricultural sector, as well as carbon dioxide (CO_2) sequestration in soils and vegetation and renewable energies. Many of these options also directly or indirectly address adaptation needs. For instance, practicing agroforestry increases above- and below-ground biomass, which may help to increase carbon sequestration and reduce CO_2 emissions. In addition, adaptation benefits of this practice include reduced soil erosion from intense rainfall events due to root systems and improved soil structure for water infiltration, contributing to flood prevention. Better water retention capacity in the soil can help with drought mitigation as well.

In general, most adaptation actions have a positive impact on mitigation, whereas some mitigation practices can also have adverse effects on adaptation objectives1. Biofuel production is one practice, which could possibly result in fewer greenhouse gas emissions; however, higher prices for maize, as one example of a crop used for biofuel production, may incentivise farmers to change their crop rotation to maize and result in increased vulnerability to climate change if maize is produced in areas prone to droughts. Production in areas requiring irrigation may be severely affected by water shortages and extreme temperatures may reduce yields. Additionally, without a cover crop to cover the soil between maize rows, heavy rainfall events may cause erosion. Therefore, the implications mitigation operations may present for adaptation need to be carefully considered1.

The potential of greenhouse gas (GHG) mitigation measures varies across space and time. The most appropriate solutions for mitigation are complex, as well as specific to the different farming systems and regions. The impact of management options also depends on the farmers' skills and choices (for example, appropriate timing in applying a practice, or the choice of the best variety of a crop for their specific farm). Socioeconomic considerations may also come into play; for instance, a biodigester may reduce emissions from manure and result in an end-product, which can be applied onto fields for fertiliser, thereby saving costs from purchase of chemical fertiliser. However, the investment costs and maintenance for biodigesters are extremely high and present a barrier to widescale uptake of this mitigation option. Depending on the social benefits derived from these mechanisms (i.e., lower impacts on climate change) and political will, subsidies may be made available to help with the investment costs.

Various policy instruments are already in place in the EU, which can provide support for the implementation of mitigation options in agriculture, most importantly the Common Agricultural Policy (CAP), the Nitrates Directive, the Water Framework Directive, and the Soil Thematic Strategy.

According to the mandates under these pieces of EU legislation, Member States implement them at the national level with varying emphases placed on mitigation options. For instance, the CAP requirements for cross-compliance include statutory management requirements (set at EU level by the various regulations mentioned above) as well as good agricultural and environmental conditions (GAECs). The GAECs vary by Member State and adherence to such practices affects whether farmers are eligible to receive payments from the CAP. Climate change mitigation measures may be included in the GAECs, but they are also more likely to be included in the Rural Development Programme under the measure for agri-environment-climate (for the 2014-2020 programming

period). Moreover, in implementing the Nitrates Directive and the Water Framework Directive, Member States can include measures which indirectly mitigate climate change since the primary focus of both is to reduce water pollution resulting from agricultural management, in particular pollution resulting from nitrogen and phosphorous application. Nitrogen use in agriculture is closely linked to N_2O emissions.

2. Key mitigation options for agriculture in the EU

Mitigation options in agriculture relate to cropland management, livestock management, management of organic soils (peatlands and wetlands), land use change, and improving energy efficiency and the use of renewable energy.

Emissions in agriculture can be reduced by:

- Reducing or avoiding N_2O emissions from soils and drainage;
- Reducing CH_4 and N_2O emissions from the storage, processing and application of manure;
- Reducing enteric CH_4 emissions from livestock management;
- Avoiding or reducing CO_2 emissions from land use and soils by sequestering carbon and preventing its release;
- Reducing CO_2 emissions from machinery use and energy use on farms;
- Reducing indirect CO_2 emissions from the production of fertilisers.

As mentioned above, the specific mix of appropriate and cost-effective options will vary according to the type of farming system. In general, however, some of the key options that can be flagged for EU agriculture include (based on summary analyses done in Frelih-Larsen et al. 2014, Underwood et al. 2013)2:

In relation to cropland management, the practices include: catch crops and green manure, crop residue management, reducing and optimising the use of fertilisers, preventing and reducing soil compaction, extending the perennial phase of crop rotations, and conservation tillage (reduced or no-tillage).

In livestock management, the main mitigation options relate to improving manure processing (including introducing anaerobic digestion for methane recovery), optimising manure application, and improving health planning and precision feeding strategies.

Management of organic soils is central to agricultural emissions since organic soils are the most carbon-dense ecosystems of the terrestrial biosphere. Drained organic soils used for agricultural production are hotspots of GHG emissions, producing the highest emissions of all types of arable land3. Among non-livestock mitigation options in agriculture, avoiding drainage of organic soils, restoration of organic soils by re-establishing a higher water table, and land use change of arable land to grassland by far have the highest potential for climate protection per hectare4.

In terms of land use change, the two key ways of reducing emissions and sequestering carbon include the conversion of arable land to grassland and afforestation of cropland.

Finally, the last set of mitigation actions relates to behavioural change for improved energy efficiency, installing more energy efficient equipment and reducing machinery fuel use, greater efficiency of farm buildings/greenhouse buildings, as well as installing small-scale renewable energy such as solar and geothermal.

Many actions, such as those focusing on improved nitrogen efficiency (e.g. more precise application of fertilisers in terms of timing and amounts), or improved energy efficiency also have substantial benefits in terms of cost-savings for farmers. Other actions, such as those related to drainage or restoration of organic soils, may require substantial investments and also affect the productivity on farms (by reducing the intensity of production on those soils or taking the soils out of production). There are also some strong barriers, which prevent some mitigation actions (e.g. those related to

soil management) from being taken up by farmers. Barriers can include lack of awareness, availability of machinery or high costs of machinery (for example, equipment for reduced tillage or precise application of N fertilisers), or higher profitability of certain crops.

Large emissions from the agricultural sector necessitate efforts to reduce its overall contribution and increase efficiency of resource use so that emissions per product unit continue to decrease. Many options are available for mitigating agricultural emissions; however, the benefits of such practices must also be evaluated in terms of their implications for adaptation in agriculture so that the resilience of farming systems is also increased.

Sources

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