Policy
Incentives
for
Climate
Change
Mitigation
Agricultural
Techniques

PICCMAT

Policy Incentives for Climate Change Mitigation Agricultural Techniques

Project n°	044148
Project acronym:	PICCMAT
Instrument:	Specific Support Action
Thematic Priority:	8.1 Policy Oriented research / Scientific Support to Policies Call FP6-2005-SSP-5A

Deliverable D11

Climate change mitigation through agricultural techniques

Policy recommendations

Due date of deliverable: month 21
Actual submission date: 18 November 2008

Start date of project: 1 January 2007
Duration: 24 months
Organisation name of lead contractor for this deliverable: Ecologic

Authors: Ana Frelih-Larsen[1], Anna Leipprand[1], Sandra Naumann[1], Olivier Beucher[2]

Contributions: Marco Bindi[3], Daniel Blobel[1], Helen Flynn[4], Ana Iglesias[5], Zbigniew Karaczun[6], Peter Kuikman[7], Jan Peter Lesschen[7], Felipe Medina[5], Jørgen Olesen[8], John Roy Porter[9], Svetla Rousseva[10], Stephanie Schlegel[1], Pete Smith[4], Giacomo Trombi[3]

Partner institutes: Ecologic (1), Baastel (2), University of Florence (3), University of Aberdeen (4), Universidad Politecnica de Madrid (5), Warsaw Agriculture University (6), ALTERRA/University of Wageningen (7), Danish Institute of Agricultural Sciences (8), The Royal Veterinary and Agricultural University of Denmark (9), N. Poushkarov Institute of Soil Science, Bulgaria (10)

Project co-funded by the European Commission within the Sixth Framework Programme
Dissemination Level: Public

This report was prepared as part of the PICCMAT project (2007 – 2008), which was co-funded by the European Commission within the Sixth Framework Programme for Research. Further information on PICCMAT partners, results and events can be found on the project website at http://climatechangeintelligence.baastel.be/piccmat/.

Contact: ana.frelih-larsen[at]ecologic.eu

Contents

Executive summary: Policy recommendations

AGRICULTURAL TECHNIQUES FOR MITIGATION

Promoting PICCMAT practices for climate change mitigation at farm level

Policy measures for agricultural climate change mitigation need to be tailored to regional circumstances. The PICCMAT practices (see section 2) provide a menu of measures with detailed information on their mitigation potential, cost and feasibility of implementation, co-benefits and trade-offs, and their compatibility with adaptation to climate change. From this list, measures can be chosen and combined according to regional needs and opportunities.

PRIORITIES FOR POLICY ACTION

Supporting climate change mitigation as part of a strategic and integrated approach to sustainable agriculture

Climate change mitigation in agriculture should be pursued as part of an integrated approach to sustainable agriculture in order to build synergies and avoid conflicts between climate change mitigation and other policy objectives, and to avoid offsetting mitigation efforts through intensification of production or land use change. Strategic integrated rural land use programmes could be established at EU, national and/or regional level. They should overlay water, biodiversity and climate change objectives, and integrate mitigation and adaptation concerns.

As a starting point, a “climate-checking” of the Common Agricultural Policy (CAP) instruments may be carried out to assess whether they support or hamper climate change mitigation, and determine how they could be improved in this context.

Protecting existing carbon stocks

The preservation of existing carbon stocks needs to be set as a mitigation priority. The protection of soils that are rich in organic carbon, for instance wetlands, peatlands and certain grasslands, would bring great benefits for mitigation. Significant emission reduction could be obtained if drained peatlands currently used for agriculture were rewetted and restored.

A combination of regulation and financial compensation is needed to ensure effective protection of important carbon stocks in soils. Compulsory regulation can include bans on the conversion of intact peatlands or wetland areas with high soil carbon, and requirements to rewet drained peatlands and use them in a way that minimises carbon loss. Financial compensation can be offered to farmers to offset potential loss of income, and to ensure that individual farms or specific regions with a high proportion of land with such soils are not placed at a disadvantage.

Reducing peat extraction for energy use and for horticultural and agricultural purposes would also contribute to emission reductions. In order to ensure policy coherence, peat should not be allocated the status of renewable energy under the revised EU Directive on renewable energy.

EU ENVIRONMENTAL DIRECTIVES

Ensuring the implementation of existing policies and strengthening protection standards

Several policy instruments already exist at EU level that control the environmental impacts of agriculture and, usually as a side-effect, influence the emission of greenhouse gases (GHG) from agriculture. When developing strategies for agricultural mitigation, these existing policies, in particular the Habitats and the Nitrate Directives, should be taken into account in order to ensure policy coherence, avoid contradicting policy messages and doubling of efforts.

- Where there are still insufficiencies in the implementation of existing policies, the first step should be to improve implementation.
- Moreover, the mitigation objective could be a driver for stricter standards (e.g., for fertiliser use under the Nitrate Directive).

CROSS COMPLIANCE: LINKING AGRICULTURAL SUBSIDIES TO ENVIRONMENTAL SERVICES

Improving GAEC implementation, strengthening the protection of permanent grassland, and including mitigation objective in future baseline standards

Improving the implementation and enforcement of existing Good agricultural and environmental condition (GAEC) standards for soil protection would help to exploit their potential to support mitigation. More targeted provisions to maintain permanent pasture that include site-specific bans on the conversion of grassland in particular on carbon-rich soils should be considered.

In the current period (2007 – 2013), cross compliance provides limited scope to further address agricultural mitigation. However, cross compliance might develop into the environmental baseline of a future European agricultural or rural land use policy. It will then be important to include climate change mitigation as an explicit requirement of baseline standards, in order to ensure that mitigation occurs not only as a side-effect but that the measures also target emission reductions.

STRENGTHENING RURAL DEVELOPMENT POLICY

Increasing resources for rural development to support mitigation

Increased funding is needed for rural development measures that support agricultural practices with multiple environmental benefits, including GHG mitigation. Additional funding can also be targeted specifically at pilot mitigation projects that test innovative approaches to maximize GHG mitigation as part of an integrated approach to sustainable agriculture.

Integrating mitigation practices in rural development measures

A climate screening of rural development measures (in particular of agri-environment measures) can provide a first step to better integrate mitigation objectives.

Taking into account regional differences in mitigation potential and cost-effectiveness, agri-environment measures can be re-designed, or new measures can be introduced, to strengthen mitigation practices and support associated technical investments. The Commission could ask Member States to justify how the additional funding obtained from modulation is allocated, including for GHG mitigation purposes.

Organic farming should be further promoted in rural development policies, and appropriate funding should be ensured. Climate change mitigation should be set as a specific target in Art. 3 “Objectives and principles for organic production” of the Council Regulation (EC) No 834/2007. Further measures might be inserted into existing production standards (e.g. minimum tillage, improved manure storage and application techniques in organic farming) to strengthen the climate mitigation benefit of organic farming. Monitoring systems may have to be expanded.

Building knowledge and capacity for mitigation

Rural development funding can be used to increase knowledge and capacity for mitigation through agricultural techniques. Pilot mitigation projects can test different approaches (e.g. carbon offsets, results-oriented versus management prescription approaches, methods for measuring on-farm carbon balance; see below). Technical guidelines can be drafted on the basis of pilot project results.

Through rural development funds, additional support should be provided for awareness raising and capacity building related to climate change for farmers and farm advisors.

Integrated farm plans can provide an innovative delivery instrument to achieve multiple environmental objectives, including climate change mitigation.

FUTURE COMMON AGRICULTURAL POLICY (CAP)

Re-designing the CAP into an integrated land use policy

When implementing major CAP reforms, climate change mitigation needs to be a major consideration in designing the system. A system that merges the current cross compliance and rural development instruments can provide an opportunity to implement baseline measures and set more targeted incentives for more ambitious mitigation efforts.

Future CAP reforms will provide the opportunity to introduce more targeted action to support soil carbon management and maintain existing carbon sinks and carbon-rich soils. The concept of Ecological Priority Areas should be considered to protect soils with high carbon content (e.g. peatlands) or for general carbon sequestration purposes.

The economic vulnerability of small farms and farms in marginal areas should be considered, compensatory measures may be required.

ECONOMIC INSTRUMENTS

Exploring results-oriented approaches in pilot studies

Results-oriented approaches that reward farmers for achieving specific mitigation targets can be explored for their effectiveness and controllability, especially with regard to the maintenance of existing carbon stocks (peatlands and permanent grasslands). A results-oriented approach could also be used to address farm nitrogen surpluses. Pilot studies could test the feasibility of results-oriented approaches.

Results-oriented approaches could provide a methodological basis for carbon offsetting schemes.

Exploring benefits, costs and feasibility of carbon offsetting

The available evidence suggests that emission trading for the whole agricultural sector in Europe is not a feasible policy option in the near- to mid-term future.

Instead, the possibility of using voluntary project-based trading of carbon offsets in an EU context should be explored. Pilot-projects could provide a basis to assess the feasibility of such a scheme, develop accounting and monitoring methodologies, and assess the benefits (for mitigation) and costs (for farmers and administration) it would entail.

Considering taxes as an element of national integrated strategies for sustainable agriculture

Member States might consider taxes on nitrogen as an instrument to be used in national integrated strategies for sustainable agriculture and exploit their potential to reduce nitrogen loss, with benefits for water protection and N_2O emissions. Taxes are likely to be more effective if applied directly to environmental bads (e.g. nitrogen surplus) rather than on inputs (e.g. fertiliser). Careful design of taxing schemes is crucial to avoid adverse social effects. Recycling the revenues back to farmers, for instance in the form of agri-environment payments, may help to prevent income loss and reinforce environmental gains.

SUPPORTING MITIGATION THROUGH BETTER INFORMATION

Developing and promoting monitoring tools for farm sustainability

Monitoring tools for farm-level sustainability such as the Flemish MOTIFS or the French IDEA systems might be further developed, and the potential for using them across Europe could be explored. Monitoring tools should take account of the farm's greenhouse gas emissions.

Addressing consumption habits – promoting carbon labelling

Climate-friendly farming can improve the greenhouse gas balance of farming. However, to address the climate impact of food production more generally, consumption patterns have to change. In addition to information and awareness raising campaigns, product labels indicating the climate and environmental impacts of products can help to enable more climate-friendly consumer choices.

Integration of the climate mitigation aspect into existing labelling and certification systems could be a way to avoid the overburdening of products with many different labels, and to make sure that different environmental issues are taken into account. Organic farming standards and monitoring systems could provide a basis for the development of a label indicating an environmentally-friendly food-production.

Promoting exchange of experience between Member States

An exchange on national policies and programmes for climate-friendly agriculture could be organised at EU level, for instance through a pan-European survey in combination with a conference for national policy-makers. The rural development networks established under rural development programming can offer a medium for this exchange.

Developing measuring and accounting approaches for agricultural greenhouse gas emissions

Indicators or indicator systems can be developed that could be used across Europe, based on proxies for agricultural GHG emissions such as farm level nitrogen and carbon balances. These can be based on existing indicators such as those provided by the EEA.

The use of soil organic carbon maps could help to better target policies for mitigation. Remote sensing can be used for verifying the maintenance of carbon-rich ecosystems such as wetlands.

1 Introduction

This paper presents recommendations for policy-makers derived from the FP6 project PICCMAT (Policy Incentives for Climate Change Mitigation Agricultural Techniques).[1] PICCMAT was launched to identify the most cost-effective farming practices that reduce GHG emissions and to suggest policy instruments to support the necessary changes in land management. The project has been developed by an international consortium of research and consulting organisations to support policy-making in Europe in its effort to reduce the climate change impact of European agriculture.

The policy recommendations were developed based on a stakeholder consultation process. A workshop held in June 2008 in Brussels brought together stakeholders from science, EU and national administrative bodies, professional organisations and NGOs to discuss policy options presented in a background paper. In addition, stakeholders and interested parties were encouraged to send written comments on the paper. The feedback and views of the different stakeholders were collected and evaluated, and taken into account in the development of the policy recommendations set out below.

The paper first identifies the need to address the challenge of climate change mitigation in the agricultural sector (section 1.1), and defines the scope of the work (section 1.2). It then outlines the farming practices identified by the PICCMAT project as being effective for climate change mitigation, and provides information on associated costs, feasibility of implementation, and mitigation potential (section 2). Section 3 suggests key priorities for policy action. Sections 4, 5, and 6 discuss options for how climate change mitigation practices could best be promoted through EU environmental and agricultural policy measures in the 2007 – 2013 programming period. Section 7 examines ways to integrate climate change mitigation into future CAP reforms beyond 2013. The potential of economic instruments to support agricultural mitigation is reviewed in section 8, and the last section 9 presents action related to information and awareness among various stakeholders as well as methodologies that could promote agricultural mitigation efforts.

1.1 Climate change mitigation in agriculture – the challenge

The agricultural sector accounts for nine percent of greenhouse gas (GHG) emissions in European Union (EEA 2007). Depending on the relative economic importance of agriculture, environmental and climate conditions, and the dominant type of farming, agriculture's share of emissions can be considerably higher in individual Member States. For example, in Ireland agriculture accounts for 26% of emissions, and in Latvia and Lithuania 18% (EEA, 2007).
The large majority of EU agricultural GHG emissions are direct emissions of two powerful greenhouse gases – nitrous oxide (N_2O) and methane (CH_4). Agriculture emits 67% of EU's nitrous oxide emissions and 50% of EU's methane emissions. Nitrous oxide emissions derive primarily from soil management and the application of mineral, organic nitrogen fertilisers and manure, whereas methane emissions result from livestock digestion and manure management (losses during storage). During the past years, a decreasing trend has been observed in agricultural GHG emissions. Agricultural emissions of the EU-27 fell by 20% in the period 1990-2005 (European Commission 2008).[2]

1 http://climatechangeintelligence.org/piccmat/.
2 Agricultural GHG emissions were reduced by 11% in the EU-15 and by 45% in the EU-12 (New Member States, post-2004) during this period.

. This development was mainly caused by decreases in livestock numbers (in particular cattle) and in fertiliser use, and by improvements in manure management systems.

The role of agriculture in relation to climate change has been receiving growing attention from the EU public and policy makers. Given agriculture's significant contributions to GHG emissions as well as its exposure to climate change impacts, it is clear that the sector must both contribute further to emission reduction efforts and prepare adaptation strategies to cope with the risks and vulnerabilities of climate change. Current policy developments such as the legislative proposal under the "Health Check" of the CAP (COM (2008) 306/4)[3], the European Commission's efforts to step up climate protection efforts, and the EU budget review, provide an opportunity to re-orient EU agricultural policy and to strengthen climate change mitigation and adaptation measures.

At present agriculture does not have binding targets for GHG emission reductions although this could change shortly. The European Commission's climate and energy package[4] issued in January 2008 proposes a reduction target for sectors not part of the Emissions Trading Scheme (ETS). This also includes agriculture. By 2020, the Commission proposes an overall 10% reduction from 2005 levels for non-ETS sectors. It would be the responsibility of individual Member States to determine specific targets for each sector and to choose the most cost-effective combination of policies and measures. This means that there is still some uncertainty if legally binding future targets for agriculture will be set. Nonetheless, it is clear that the EU agricultural sector needs to step up its efforts for GHG mitigation.

1.2 Scope and objectives

The focus of the PICCMAT project is on agricultural land management practices that can be implemented at individual farm level to contribute to climate change mitigation. Two scientific work packages of the project identified agricultural mitigation practices and evaluated their cost effectiveness, mitigation potential, and implementation feasibility. The analysis included cropland and grassland management and focused on measures related to crop choice, tillage practice, fertiliser and manure management. Measures related to livestock keeping or to the reduction of farm energy use were not included.[5] Table 1 in the following section presents the selected PICCMAT practices and illustrates the specific focus of the project.

The PICCMAT project does not address all agricultural emissions, omitting in particular methane emissions from enteric fermentation from cattle and sheep.[6] PICCMAT also does not include emissions related to land use change and forestry, nor does it consider biomass production for renewable energy and its contribution to emission reductions.

3 Proposals for: 1) Council Regulation establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers; 2) Council Regulation on modifications to the common agricultural policy by amending Regulations (EC) No 320/2006, (EC) No 1234/2007, (EC) No 3/2008 and (EC) No (...)/2008; 3) Council Regulation amending Regulation (EC) No 1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD); 4) Council Decision amending Decision 2006/144/EC on the Community strategic guidelines for rural development (programming period 2007 to 2013).

4 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: 20 20 by 2020 – Europe's climate change opportunity. COM (2008) 30. 23.1.2008.

5 According to the methodology for accounting of GHG under the UNFCCC as developed by the IPCC, emissions from farm energy use are not accounted as agricultural emissions, but are allocated to the "energy" or "transport" sectors.

6 These emissions accounted for 30% of EU-15 agricultural GHG emissions in 2005 (EEA 2007).

That said, it is clear that the development of a climate-friendly European agricultural policy can only be based on a comprehensive account of all emission sources and potential mitigation options. Also, given that agriculture and land use policies are closely linked, and that the long-term objective should be to develop integrated strategies for sustainable land use and spatial planning, the broader perspective should not be left aside. Finally, the PICCMAT consultation process made it clear that policy areas with a more indirect link to agricultural practices and agricultural GHG emissions, such as those addressing consumer behaviour, are an important concern for stakeholders.

For these reasons, the present paper focuses on the development of policy recommendations which can directly affect farmers' use of PICCMAT practices, but also broadens the perspective to point to issues and policy instruments that are relevant in the context of a coherent and integrated agricultural mitigation policy.

2 The PICCMAT practices: mitigation potential, co-benefits, and feasibility of implementation

Based on an extensive review of international literature, the PICCMAT project created a database of agricultural techniques for climate change mitigation at farm-level. A selection of the most relevant agricultural practices was made using the following criteria: mitigation potential, geographical cover, cost effectiveness, technical feasibility, drawbacks, political incentives, measurability for Kyoto accounting, and expert judgement.

The mitigation potential of individual measures across Europe was calculated with the MITERRA-Europe simulation model (Lesschen et al. 2008). A case study approach was used to analyse the costs associated with the implementation of these practices in European regions in more detail, and to explore the feasibility and probability of implementation (see Karaczun 2008).

Table 1 provides a list of PICCMAT practices with the summary of the PICCMAT research results, including the mitigation potential of individual practices, their potential implementation costs and the main sources of these costs, the probability of implementation,[7] and the key co-benefits and trade-offs of implementation with regard to other environmental policy objectives. A brief description of the individual measures can be found in Annex 1 (page 52). More details can be found in the project reports available on the PICCMAT website.[8]

Following Table 1, a brief discussion of the mitigation potential of individual practices is made in order to point to the practices with the greatest mitigation potential. This is followed by a review of the contribution that PICCMAT practices can make to climate change adaptation in agriculture, and a discussion of main findings affecting the feasibility of implementation.

[7] This is based on an assessment of potential barriers to implementation; see the Synthesis report on case studies (Karaczun 2008).

[8] See http://climatechangeintelligence.org/piccmat/. An online database of climate change mitigation techniques is available, as well as a report on practice description and analysis (Flynn et al. 2007).

Table 1 Summary of PICCMAT mitigation practices

Management practices	Potential implement-tation cost[9]	Probability of implementation[10]	Global mitigation potential[11] (Smith et al., 2008)			EU27 mitigation potential (MITERRA-Europe results)				Description of costs	Co-benefits and trade-offs
			CO_2	N_2O	CH_4	CO_2	N_2O	CO_2	N_2O		
			(tCO_2 eq./ha/yr)			($MtCO_2$ eq./ year)		(tCO_2 eq./ ha/yr)			
Catch crops	Low	High	0.29 - 0.88	0.10	0.00	9.7	--3.8	0.31	-0.12	Cost of legume seed only	Benefits water quality, soil erosion, pest control, soil productivity
Reduced tillage	Low	Medium (low in some areas)	0.15 - 0.70	0.02	0.00					Capital cost of buying or hiring new equipment. Costs decrease as more people do it. Potential for opportunity cost of lost production in areas less suited to reduced tillage via yield penalty	Benefits water conservation, soil quality, biodiversity, energy conservation. May increase fungal problems (and reduce yield) and increase need for herbicides due to reduced mechanical weeding
a. reduced tillage						9.6	0.0	0.25	0.00		
b. zero tillage						19.9	-0.5	0.96	-0.02		
Residue management	Low	High	0.15 - 0.70	0.02	0.00					No cost unless residues can be sold for other use (but usually low value)	Benefits water conservation, soil quality, biodiversity, energy conservation. May conflict with efforts to use residues as biomass for energy production
a. no removal						8.5	-1.3	0.35	-0.04		
b. composting and returning						1.8	0.64	0.38	0.12		
Extensification	Medium	Low	1.69 - 3.04	2.30	0.02					Opportunity costs of lost production	Benefits: soil quality, biodiversity, water quality
Fertiliser application	No	Medium (already done in some areas)	0.26 - 0.55	0.07	0.00	0.0	4.2	0.00	0.21	Should lower costs	Benefits water quality, biodiversity

9 Source: PICCMAT Deliverable 6 (Karaczun 2008).

10 Source: PICCMAT Deliverable 6 (Karaczun 2008).

11 Smith et al. (2008) include mean estimates of mitigation potential for four climate zones (cool-dry, cool-moist, warm-dry, and warm-moist). The lower mean estimate for CO_2 normally refers to cool and warm dry zones and the higher estimate to cool and warm moist climate zones. In the case of N_2O, mitigation estimates are the same for all four climate zones. For CH_4 estimates, the only difference among climate zones relevant to PICCMAT practices occurs in relation to grazing and grassland renovation (0.02 t CO_2 eq./ha/yr for cool-dry climate and 0.00 tCO_2 eq./ha/yr for others). For details, please see Table 2 in Smith et al (2008) p. 795 – 796.

Management practices	Potential implement-tation cost[9]	Probability of implementation[10]	Global mitigation potential[11] (Smith et al., 2008)			EU27 mitigation potential (MITERRA-Europe results)				Description of costs	Co-benefits and trade-offs
			CO_2	N_2O	CH_4	CO_2	N_2O	CO_2	N_2O		
			(tCO_2 eq./ha/yr)			($MtCO_2$ eq./ year)		(tCO_2 eq./ ha/yr)			
Fertiliser type	Low	Medium (already done in some areas)	0.26 - 0.55	0.07	0.00	0.0	2.3	0.00	0.06	Should lower costs unless fertilizer replacement type is more expensive	
Rotation species	No	Medium	0.29 - 0.88	0.10	0.00	7.7	0.27	0.35	0.01	Low cost unless lower production or low market value	Benefits in terms of reduced runoff and erosion, improved soil quality, higher yields, wildlife habitat
Adding legumes	Low	High	0.26 - 0.55	0.07	0.00	10.6	0.2	0.31	-0.00	Cost of legume seed only	Improves soil fertility, reduces fertiliser needs, helps to protect biodiversity and water
Permanent crops	Variable	Low (reduces flexibility)	1.69 - 3.04	2.30	0.02					Depends on the crops used. Can be no cost through to high depending on market value of the crop	Improves soil quality and water balance, could also improve biodiversity depending on crop used
Agroforestry	Medium	Low (reduces flexibility)	0.15 - 0.70	0.02	0.00	0.63	0.02	0.20	0.01	Opportunity cost of lost production; cost of trees	Could improve biodiversity, depending on the permanent crop used
Grass in orchards & vineyards	Medium/high	Low	1.69 - 3.04	2.30	0.02	1.8	0.3	0.48	0.01	No information on this	
Optimising grazing intensity	Low / medium	Medium (already done in some areas)	0.11 - 0.81	0.00	0.02 - 0.00					Low unless opportunity cost of less production per hectare of grass	Benefits for biodiversity, reduced soil erosion
Length and timing of grazing	Medium	Medium	0.11 - 0.81	0.00	0.02 - 0.00					Low unless opportunity cost of less production per hectare of grass	Benefits for biodiversity, reduced soil erosion
Grassland renovation	Low	High	0.11 - 0.81	0.00	0.02 - 0.00					Part of the normal cycle on many grasslands	Benefits for biodiversity, reduced soil erosion
Optimising manure storage	Medium / high	Medium								New storage equipment can have a large capital cost	Benefits for soil quality, air quality
Manure application techniques	Medium	Medium	1.54 - 2.79	0.00	0.00					New equipment for some techniques, e.g. direct injection	Possible trade offs with ammonia volatilisation (trans-boundary air pollution issues)
Application of manure to cropland versus grassland	Low	Medium	1.54 - 2.79	0.00	0.00					Only costs are need for additional transport from livestock to cropland on or off farm	
Organic soil restoration	Medium / high	Medium	36.67 – 73.33	0.16	-3.32					Opportunity cost of abandoning the land; small cost of drain blocking	Benefits for soil quality and erosion protection, biodiversity, air quality, aesthetic value

2.1 Mitigation potential of PICCMAT practices

The quantification of mitigation potential of PICCMAT practices is based on two different sources. The MITERRA-Europe modelling results were created as part of the PICCMAT project and specifically refer to the potential for mitigation in Europe (Lesschen et al. 2008).[12] Not all PICCMAT practices were included in the MITERRA model.[13] For comparison, data on global mitigation potential of agricultural mitigation practices are taken from Smith et al. (2008).[14]

The mitigation potentials of CO_2 and non-CO_2 gases (N_2O and CH_4) are presented separately in Table 1 because they are qualitatively different. The CO_2 emissions are reduced primarily through soil carbon sinks and are reversible. Also, soil organic carbon stocks will reach a maximum, so reductions can only be achieved temporarily, i.e. they are saturating. By contrast, reductions in N_2O and CH_4 are permanent and non-saturating since they represent avoided emissions. Due to the fact that livestock management is largely excluded from the PICCMAT analyses (except for manure storage and application), the effects of most measures on CH_4 emissions are marginal.

Figure 1 shows the mitigation potential for PICCMAT measures calculated with the MITERRA model as a percentage of total agricultural GHG emissions in Europe (EU-25) in 2004.[15]

MITERRA results illustrate that **zero tillage** has the highest mitigation potential, followed by **adding legumes**, **reduced tillage**, **residue management (no removal of residues)**, **rotation species**, and **catch crops**.[16] **Fertiliser application and fertiliser type** are the measures with the largest positive effect on N_2O emissions. For the **optimisation of manure storage**, a pilot modelling exercise based on MITERRA-Europe suggests that the measure could contribute CH_4 emission reductions in the order to 2% of total EU agricultural emissions (unpublished data). However, this would require the application of advanced and expensive techniques.

12 Data on CH_4 emissions are not reported because the measures that were included in the MITERRA-Europe study do not affect CH_4 emissions.

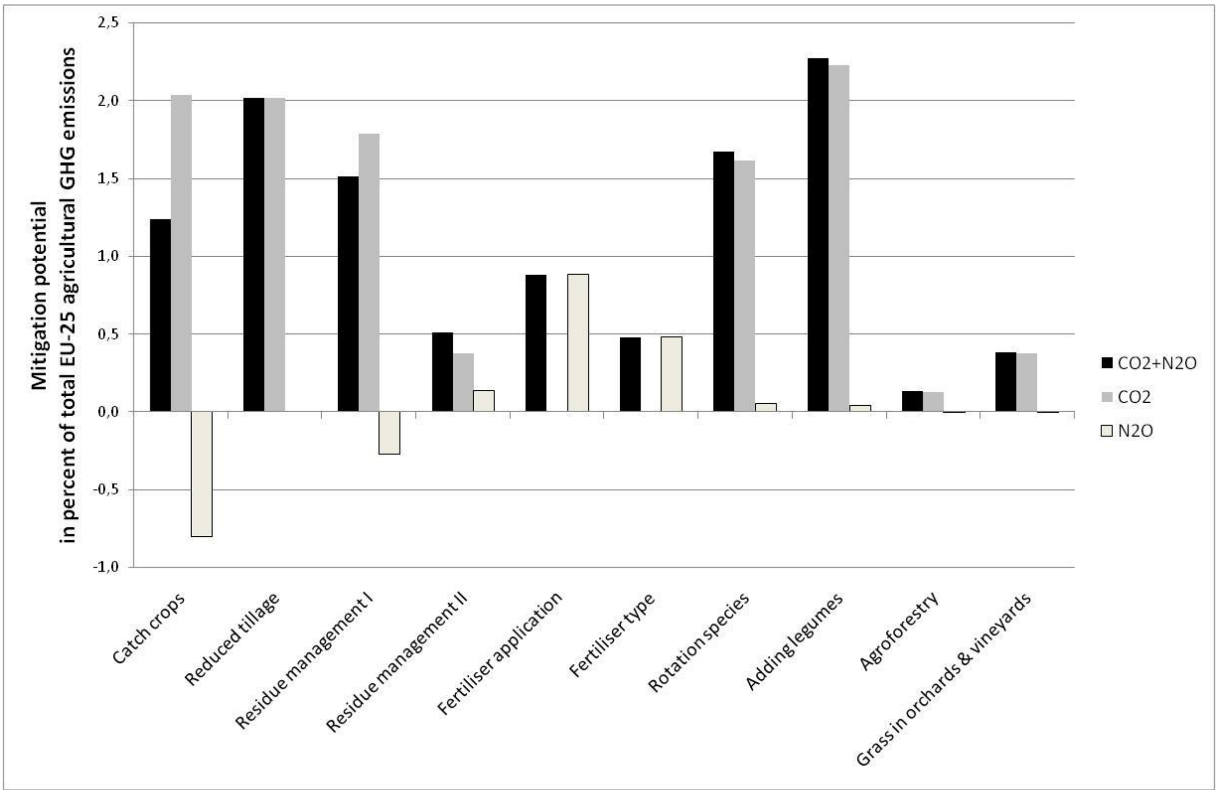
13 See Table 1. The MITERRA-Europe study was restricted to those measures for which sufficient data could be provided from the case study analysis (see Lesschen et al. 2008).

14 For a comparison of MITERRA-Europe and the method used by Smith et al. (2008), see Lesschen et al. 2008.

15 In 2005, the agricultural sector of the EU-25 produced almost 475 million tonnes of CO_2 equivalent of greenhouse gases (European Commission 2008). Note that MITERRA modelling covers the EU-27, and that therefore the figures are only indicative of the magnitude of the mitigation potentials.

16 Figure 1 shows that the MITERRA-Europe model calculates a negative effect of catch crops on N_2O emissions. This is explained by the incorporation of extra crop residues (30 kg N/ha of crop residues is assumed), which leads to an additional emission of N_2O. This is not outweighed by the positive effect on N_2O emissions of the reduction of fertilizer consumption, since this reduction is only assumed for areas with an N-surplus.

Figure 1 Mitigation potential of selected PICCMAT practices (MITERRA)



Mitigation potentials calculated by MITERRA-Europe for CO_2 (grey) and N_2O (white), both in Mt CO_2-equivalents per year (for EU-27), are divided by the total agricultural emissions of the EU-25 in 2005 (475 million tonnes of CO_2 equivalent, European Commission 2008). The black columns represent the sum of CO_2 and N_2O mitigation potentials in relation to total emissions.

PICCMAT measures not included in the MITERRA-Europe model calculations may also offer a significant mitigation potential (Smith et al. 2008), in particular **permanent crops**, **optimising grazing**, **grassland renovation** and **manure application**. For **management and restoration of peatlands**, the data from Smith et al. (2008) indicate clearly that on a per-area basis, the mitigation potential of this measure is at least one order of magnitude higher than that of all other measures.[17] Further work done for the EU level confirms that protection of peatlands and other organic soils is key in a mitigation context: the conservation of soils with high organic matter such as peatlands not only enables carbon uptake of between 0.4 – 1.2t CO_2/ha/year but also prevents potential emissions from drained lowland peatlands of between 0.4 and 27 t CO_2/ha/year (ECCP, 2003; 14, Kuikman et al., 2002). The combined loss of not protecting peatlands could thus be between 0.8 – 28.2t of CO_2 equivalent/ha/year. Of PICCMAT agricultural mitigation practices, only set-aside, or restoration of organic soils compare to the carbon savings from protecting peatlands (maximum 5.36 and 70.18 t/ha/year of CO_2 equivalent) (Smith et al. 2008).

The MITERRA-Europe data show the additional mitigation potential that could be realised if these practices were applied *beyond* the current level of implementation. The methodology considered both the extent of agricultural area across Europe on which a measure could realistically be applied (potential level of implementation), and the current level of

17 Please note that these figures refer to the per-area potential, i.e. the potential on each hectare of land. The absolute potential for a certain region, e.g. Europe, depends on the total size of the area with organic soils. This area is relatively small in Europe compared to developing countries.

implementation that has already been achieved.[18] This means, for instance, that the additional mitigation potential for zero tillage as presented in Table 1 is larger than that of other measures partly because the current level of implementation is low.

On the one hand, this implies that important contributions to mitigation could be achieved by enhancing the implementation of measures with a high additional mitigation potential, such as zero tillage. On the other hand, it is important to ensure the continuation of those practices and standards that contribute to mitigation already today, such as optimised fertiliser application, and to maintain the current level of implementation where it is already high.

The MITERRA-Europe results also show that although CH_4 and N_2O are the most important GHG *emitted* from agricultural activities, it is more difficult to mitigate these emissions than increasing soil organic carbon (SOC) stocks and thus compensate them through carbon sequestration (Lesschen et al. 2008). However, although the mitigation potential for carbon is larger than for N_2O, it needs to be kept in mind that the effect on carbon is only temporary, while for N_2O the emission reduction is permanent and non-saturating. Besides, the sequestered SOC stocks can easily be lost again when the climate-friendly management is abandoned.

Overall the MITERRA-Europe data show that the additional mitigation potential of individual PICCMAT measures is limited, but that the combined sum effect of individual practices nonetheless makes a significant contribution to mitigation. Also, the measures with high mitigation potential (zero tillage, adding legumes, reduced tillage, residue management - no removal of residues, rotation species, catch crops, fertiliser application/type) are all associated with no or low implementation costs. Moreover, most of these practices have multiple environmental benefits and contribute to improved longer-term productivity of soils, and should thus be considered as part of improving environmental performance of agriculture.

Another important implication that follows from the MITERRA-Europe report is that there are large regional differences with regard to mitigation potential, which illustrates the need to tailor policy measures to regional conditions.

2.2 PICCMAT practices and climate change adaptation

Because agriculture is one of the sectors that are most vulnerable to climate change *impacts* it is also important to consider the side-effects of agricultural mitigation practices on the adaptive capacity of farmers and farming systems. This following paragraphs summarize the results of a short study on adaptation and mitigation linkages prepared as part of the PICCMAT project (Olesen and Porter 2008).

The main adaptation challenges for agriculture under climate change relate to the predicted intensification of the hydrological cycles leading to more intensive rainfall and longer dry periods, as well as an increase in the occurrence of extreme high temperature events and inter-seasonal variability in temperature and rainfall. In summary, the main adaptation options for agriculture that are also relevant for mitigation are the following:

- Measures that reduce soil erosion,
- Measures that reduce leaching of nitrogen and phosphorus,
- Measures for conserving soil moisture,

[18] The data for current and potential implementation levels were derived from work done in the PICCMAT case studies and based on expert judgement. For more details on the methodology see Lesschen et al. 2008.

- Increasing diversity of crop rotations by choices of species or varieties,
- Modification of microclimate to reduce temperature extremes and provide shelter,
- Land use change, involving abandonment or extensification of existing agricultural land or cultivation of new land.

Table 2 illustrates the side-effects of PICCMAT mitigation practices on these six categories of adaptation issues. The effects are denoted by “+” (the measure may assist adaptation) or “-“ (the measure is likely to hamper adaptation).

Table 2 Effects of PICCMAT mitigation measures on adaptation

Mitigation measure	Soil erosion control	Nutrient loss reduction	Soil water conser-vation	Genetic diversity	Micro-climate modify-cation	Land use change
Catch crops etc	+	+	−			
Reduced tillage	+		+			
Residue management	+		+		−	
Extensification						+
Fertiliser application		+				
Fertiliser type		+				
Rotation species	+	+		+		
Adding legumes	+	+		+		
Permanent crops	+	+	−	+		
Agroforestry	+	+			+	
Grass in orchards & vineyards	+	+	−		−	
Optimising grazing intensity			+			
Length and timing of grazing	+					
Grassland renovation				+		
Optimising storage manure						
Application techniques						
Application to cropland vs grassland			+			
Peatland management						+

Most of the PICCMAT mitigation options are estimated to have positive effects also on adaptation to climate change, because they increase the resilience of the agroecosystems to perturbation by climatic variation through increasing the nutrient and water retention in the systems and through prevention of soil erosion and degradation (see also Lal 2008).

Some mitigation measures may also have negative effects in relation to adaptation. Examples could be catch crops that while reducing nutrient leakages and adding carbon to soils, also consume water. In situations of water scarcity this water consumption of the catch crop may reduce available soil water for the cash crops and thus negatively affect yields. Other examples of negative effects are establishment of soil covers from crop residues or permanent understories in orchards that act as insulating materials for heat transfer to and from the soil. This insulation will increase the risk of low temperatures (frost) for the crops during night and of extremely high temperatures during daytime.

2.3 Feasibility of implementation

One of the key objectives of the PICCMAT project was to examine possibilities for the practical implementation of PICCMAT techniques. This section briefly outlines the findings of this research (see Karaczun 2008 for a synthesis report of the results). Through eight case studies, the research evaluated current policies relevant for climate change mitigation in agriculture, the technical advantages and drawbacks of PICCMAT practices, as well as the main socio-economic and policy barriers to implementation. The case study methodology reflected the need to address the regional diversity of European agriculture in terms of environmental (climate) conditions and types of production.[19] Each case study focused on PICCMAT practices that were relevant to the region and production system.

The research illustrates that most countries (except for Denmark, see Karaczun 2008) have not yet set climate change mitigation as an explicit objective for agriculture. Nonetheless, mitigation practices are supported indirectly either through the maintenance of traditional management regimes or through addressing other environmental policy objectives (in particular the Nitrates directive). In terms of the feasibility of implementation of various practices, the findings show that economic barriers to implementation can be significant for options that require high investments in equipment (related to manure management, for example) and for practices which reduce yields and profitability of production. Moreover, technical barriers related to local climate and soil characteristics were identified (for example, in the case of crop rotations certain crops cannot be introduced under all conditions). Finally, institutional barriers were shown to affect potential implementation. These specifically included low awareness in relevant institutions of the need and possibilities for climate change mitigation in agriculture, as well as concern for further bureaucratic restrictions arising from mitigation requirements.

The research reveals considerable regional variation in barriers, confirming the need for regional flexibility in designing policy options for climate change mitigation in agriculture. To achieve this flexibility, regionally specific packages of best mitigation practices and methods to overcome barriers should be identified.

[19] Case studies were conducted in Denmark, UK, Spain, Italy, Poland, and Bulgaria.

3 Priorities for policy action

Two policy priorities emerge most clearly from the results of the PICCMAT project as outlined in the previous section and the discussion of policy options during the stakeholder consultation process.

3.1 Mitigation as part of an integrated approach to sustainable agriculture

POLICY RECOMMENDATIONS

Supporting climate change mitigation as part of a strategic and integrated approach to sustainable agriculture

Climate change mitigation in agriculture should be pursued as part of an integrated approach to sustainable agriculture in order to build synergies and avoid conflicts between climate change mitigation and other policy objectives, and to avoid offsetting mitigation efforts through intensification of production or land use change. Strategic integrated rural land use programmes could be established at EU, national and/or regional level. They should overlay water, biodiversity and climate change objectives, and integrate mitigation and adaptation concerns.

As a starting point, a “climate-checking” of CAP instruments may be carried out to assess whether they support or hamper climate change mitigation, and determine how they could be improved in this context.

Policy options for climate change mitigation need to be developed as part of a broader approach to sustainable agriculture. This is important for at least two reasons. First, mitigation practices in agriculture can have complex and manifold effects on agro-ecosystems. As illustrated in the previous section, they can generate multiple environmental benefits by also contributing, for example, to biodiversity conservation, soil protection, water conservation, or improved soil fertility. Moreover, they can improve agriculture’s ability to adapt to the impacts of climate change by increasing the resilience of farming ecosystems. On the other hand, mitigation practices also involve trade-offs or they may conflict with other objectives. For example, increasing soil carbon by incorporating residues may conflict with efforts to use all available biomass for energy production.

Secondly, if mitigation practices are implemented in isolation rather than as part of integrated land use policies, there is a real danger that the overall net mitigation effects can be undermined because of the so-called ‘leakage problem’ (Smith et al, 2007b). Carbon savings in one area can be quickly offset by the intensification of arable production (increased use of fertilisers, simplified rotation practices) and land use changes (conversion from grassland to arable) elsewhere.[20] This leakage can occur between regions within the EU, as well as with regions outside the EU and especially the developing countries.[21]

[20] The recent growth in cereal prices and concerns over food security will most likely further increase pressure to intensify production especially in the arable sector (as already signalled in the Commission’s Health Check proposal to fully abolish the arable set-aside obligation as a supply control instrument). This can lead to pressures to bring marginal (including rich organic soils) land into arable production and would result in significant GHG emissions, undermining the overall mitigation results in agriculture in addition to resulting in other negative

Because of the possible co-benefits and trade-offs, as well as the variability in mitigation (biophysical and socio-economic) potential and feasibility of implementation across different regions, it is important that mitigation practices be promoted as part of 'mitigation and adaptation' plans for agriculture at EU, national and/or regional level. These in turn would be most effective as part of broader strategic/integrated rural land use programmes which would overlay water, bio-diversity, and climate change objectives, set shorter- and longer-term priorities and goals, and maintain a degree of flexibility to respond to change. Such rural land use strategic programmes could, for example, build on an extended version of the 'analysis and evaluation of current situation' of existing rural development programmes, and replace the National strategy plans for rural development.

A key benefit of such a strategic and integrated approach would be to provide a consistent and reliable long-term framework that would enable the sector to respond well to GHG mitigation. A potential starting point for this strategic approach would be to conduct a 'climate checking' of the CAP, by reviewing all existing instruments against certain "climate change criteria" (to be defined). Even if not measurable in terms of quantifiable mitigation effects, climate checking policy reviews should be conducted. Climate checking could, for example, be conducted as part of the revision of rural development plans following the adoption of Health Check modifications.

---

environmental impacts. As outlined below, for GHG mitigation purposes, it is especially important that rich organic soils are protected from intensification.

[21] An important aspect of this leakage effect, which illustrates the need for linking agricultural and food/health policy when addressing climate change mitigation, relates to per capita meat consumption in the EU. Most agricultural policy modelling exercises assume that an increase in per capita meat consumption is an inevitable trend and an external driver to agricultural policy development. This assumption, however, needs to be looked at more closely both for health and environmental reasons. Simply reducing livestock numbers in the EU without reducing meat consumption leads to the export of emissions by shifting livestock production to the other production regions and in particular to the developing world. Consumer awareness and total carbon footprinting of food are important in this context.

3.2 Preservation of existing carbon stocks as a mitigation priority

POLICY RECOMMENDATIONS

Protecting existing carbon stocks

The preservation of existing carbon stocks needs to be set as a mitigation priority. The protection of soils that are rich in organic carbon, for instance wetlands, peatlands and certain grasslands, would bring great benefits for mitigation. Significant emission reduction could be obtained if drained peatlands currently used for agriculture were rewetted and restored.

A combination of regulation and financial compensation is needed to ensure effective protection of important carbon stocks in soils. Compulsory regulation can include bans on the conversion of intact peatlands or wetland areas with high soil carbon, and requirements to rewet drained peatlands and use them in a way that minimises carbon loss. Financial compensation can be offered to farmers to offset potential loss of income, and to ensure that individual farms or specific regions with a high proportion of land with such soils are not placed at a disadvantage.

Reducing peat extraction for energy use and for horticultural and agricultural purposes would also contribute to emission reductions. In order to ensure policy coherence, peat should not be allocated the status of renewable energy under the revised EU Directive on renewable energy.

The PICCMAT results indicate that the conservation of soils with high carbon stocks should be given priority in policy action on mitigation in agriculture and land use in order to guarantee the best possible mitigation results. In addition to the results on mitigation potential, a number of other factors argue in favour of setting conservation of existing carbon stocks as a priority rather than carbon sequestration:

- Protecting soils with high carbon content is more efficient than attempting to try to increase carbon in soils with low carbon content as carbon losses from organic soils are far higher that gains in mineral soils under improved management (Smith et al., 2008). It is thus also a very cost-efficient measure (UNEP 2008).
- More carbon can potentially be lost through the destruction of current stores than can be sequestered anew. If the destruction of carbon stocks is not prohibited and not accounted for, policies that only target sequestration may provide the perverse incentive to first destroy carbon stocks and then claim support for re-sequestration.
- Sequestration occurs more slowly than carbon loss.
- Carbon sequestration is difficult to monitor reliably and over short time periods. Measuring the maintenance of soil carbon levels is easier and more robust than monitoring small increases in carbon content derived from sequestration.
- Sequestration options have a saturation limit – once the maximum capacity for an ecosystem is reached, further carbon sequestration is not possible. Furthermore, carbon gains can actually be reversed with a change in management (so-called 'permanence' problem) (Smith et al., 2007b).
- The requirement of 'additionality' means that the net reductions of GHG emissions must be additional to what would happen under a 'no action' scenario (or the absence of a market). This additionality may be difficult to identify and/or quantify.
- Protecting peatlands and other high carbon stocks creates several synergies with biodiversity, water, soil protection and other policy objectives.

Currently, drained peatlands contribute significantly to GHG emissions. Only a relatively small percentage of peatlands in European countries are under conservation.[22]

The most important mitigation practice is avoiding the drainage of these soils in the first place, or re-establishing a high water table where GHG emissions are still high, for instance through blocking of drainage pipes (Smith et al. 2007a). While this means that arable cropping on such lands needs to be abandoned, alternative uses are possible, for instance the cultivation of plants for biomass harvest.[23] Section 2 shows that the restoration of organic soils is the PICCMAT measure with the highest mitigation potential on a per-area basis.

The carbon stock conservation approach would focus on regions or areas (parts of landscape or individual farms) that have high existing carbon content, thus differing from soil protection strategies which target more vulnerable soils with lower organic matter content. Areas or landscapes that deserve specific attention for carbon stock conservation are permanent grasslands, forests, and soils with high organic matter content (peatlands, bogs, and wetlands).

Because soils with high carbon content tend to be among the most productive ones, efforts for their conservation may conflict with other objectives such as the expansion / intensification of production due to market incentives. The potential conflicts further suggest the need for an approach which weighs different objectives and the impacts of their implementation. A possible solution to addressing conflicts can be to define priority areas for different objectives, and high carbon content soils would qualify as achieving multiple objectives.

A prerequisite for setting up an effective protection scheme for high-carbon soils is mapping these areas across Europe. This could be done based on remote sensing and soil organic carbon databases (see also section 9.4).

Policy action to protect existing carbon stocks

Protection of grassland, wetlands and peatlands: In the first instance, conservation of existing carbon stocks should be targeted through the conservation of protected peatland habitats (including the maintenance of their good hydrological conditions) as required by the Habitats Directive (92/42/EEC). In addition, the restoration of a certain amount of drained wetlands/peatlands could be made compulsory.

Similarly, better protection needs to be afforded to other rich organic soils, in particular permanent pastures under agricultural use. Better targeting the protection of high-value grassland beyond the current cross compliance standards, for instance through a ban on the conversion of grasslands on carbon-rich soils could be an effective mitigation measure (Osterburg et al. 2008; for a more detailed discussion see section 5).

Given the urgency of the mitigation agenda and the large potential to avoid emissions and increase sequestration through the protection of existing carbon stocks, action should be taken as soon as possible, i.e. within the current financial period.

Compensation: Financial compensation needs to be given to farmers to offset their potential loss of income, and to ensure that individual farms or specific regions with a high proportion of land with such soils are not placed at a disadvantage. This compensation for income foregone could be provided under rural development funding. Similarly, investments necessary for restoration of organic soils could be funded under agri-environment schemes or through the Life funding instrument. In some catchments used for drinking water supplies, concerned bodies such as water supply companies may also be interested in contributing funding (Flynn et al. 2007).

[22] See http://www.ipcc.ie/wpeurope.html.
[23] See for instance http://paludiculture.botanik.uni-greifswald.de/start_eng.html.

Policy coherence: Conflicts of interest and conflicting policy objectives present an important challenge to the effective protection of existing carbon stocks. For instance, peat extraction for energy use and for horticultural and agricultural purposes is an important source of income in some areas of Europe. From a climate mitigation point of view, however, peat extraction and use would need to be minimised. Also, given that carbon-rich soils (peat soils, riversides) also are very productive land, there may often be a strong demand for these areas for agricultural production and thus significant conflicts of interest.

An important question in this context is whether peat should receive the status of a renewable energy source. The current draft EU Directive[24] on renewable energy does not exclude peat as a renewable energy source. The only restriction is that biofuels may not be produced from raw material obtained from *pristine* peatland, which implies that peat from areas that are already drained can be used. However, the slow rate of renewal of peat implies that it should be treated as a non-renewable resource. This is reflected by the fact that the IPCC 2006 Guidelines for National Greenhouse Gas Inventories treat peat as fossil carbon (Josten 2007).

24 Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM(2008) 19 final.

4 EU environmental policies and agricultural mitigation

POLICY RECOMMENDATIONS

Ensuring the implementation of existing policies and strengthening protection standards

Several policy instruments already exist at EU level that control the environmental impacts of agriculture and, usually as a side-effect, influence the emission of greenhouse gases from agriculture. When developing strategies for agricultural mitigation, these existing policies, in particular the Habitats and the Nitrate Directives, should be taken into account in order to ensure policy coherence, avoid contradicting policy messages and doubling of efforts.

- Where there are still insufficiencies in the implementation of existing policies, the first step should be to improve implementation.
- Moreover, the mitigation objective could be a driver for stricter standards (e.g., for fertiliser use under the Nitrate Directive).

Several policy instruments already exist at EU level that control the environmental impacts of agriculture and, usually as a side-effect, influence the emission of greenhouse gases from agriculture. The most important Directives are briefly presented below. For a more detailed account see PICCMAT policy review.[25]

When developing strategies for agricultural mitigation, these existing policies need to be taken into account in order to ensure policy coherence, avoid contradicting policy messages and doubling of efforts. It may be more efficient to revise existing policy instruments and set stricter standards (e.g. for fertiliser use under the Nitrate Directive), than to develop new mitigation policies. However, the mitigation objective needs to be emphasised at least in strategy documents (or for instance in the recitals of the revised Directives) in order to make the policy objectives transparent.

Habitats Directive (92/43/EEC) and Wild Birds Directive (79/409/EEC)

The Habitats and Wild Birds Directives form the cornerstone of EU's nature conservation policy. They provide the legal basis for the EU-wide Natura 2000 network of protected areas which consists of Special Areas of Conservation established under the Habitats Directive and Special Protection Areas designated under the Birds Directive. In order to guarantee the protection of the most valuable and threatened European species and habitats, Natura 2000 sites are subject to various management restrictions. Much of the surface area under Natura 2000 sites includes high nature value farmland and/or habitats such as wetlands and peatlands.

The effective enforcement of restrictions for Natura 2000 sites can contribute to the protection of rich organic soils that contain extensive carbon stocks. Some of the restrictions that can be incorporated into Natura 2000 management plans to support mitigation are: the prohibition of ploughing of grassland and pastures; restrictions on the alteration of the current use of wetlands and coastal areas; ban on applying slash and burn methods as well as the burning of the plant cover of meadows, fallow lands, field margins, meadow margins or wood margins.

25 http://climatechangeintelligence.baastel.be/piccmat/spaw/uploads/files/PICCMAT_WP3_policy_review_02April07.pdf.

Nitrates Directive (91/676/EEC)

The Nitrates Directive was introduced with the objective to mitigate the negative effects of fertilisation on drinking water sources and ecosystems by limiting the input of inorganic fertilisers and manure on farmland. It currently limits the total organic manure loading averaged over the whole farmed area per hectare and year to 170 kg total N per ha. Derogation is possible and has been granted to several Member States for certain crop or soil types. In addition, the Directive requires Member States to establish standards and codes regulating a number of issues, among others i) periods during which the application of fertiliser is limited/prohibited, ii) consideration of crop N requirements, iii) manure storage facilities, iv) farm and field records on cropping, livestock numbers, N fertiliser usage and manure usage.

Thus, with the Nitrates Directive the European Union has a policy instrument to control the nitrogen balance of European agriculture. Although climate change mitigation is not an explicit objective of the policy, the implementation of the Nitrate Directive is likely to have contributed to the decreasing trend in agricultural GHG emissions (European Commission 2008). Improving the implementation of the Nitrate Directive, for instance with regard to manure storage and management, across Europe will thus also contribute to mitigation efforts.

The Nitrate Directive provisions belong to the Statutory Management Requirements under the Cross Compliance Regulation (see section 5) and thus are linked to CAP subsidies in pillar I.

Water Framework Directive (2000/60/EC)

The Water Framework Directive establishes a framework for the protection of European water bodies. The environmental objective of the WFD is to achieve ‘good status’ for all ground waters and surface waters by 2015 at the latest. The WFD introduced the principle of river basin management, i.e. water resources have to be managed at river basin level, rather than according to administrative, geographical or political boundaries. River basin management plans (RBMPs) are required to be drawn up for each river basin.

A central element of the RBMPs are the Programmes of Measures (PoMs) to ensure that all waters achieve good water status. This will require, at least, the full implementation of all national and Community legislation on water and related issues. If this basic set of measures is not sufficient to reach the goal of good water status, then the programmes must be supplemented by additional measures, such as stricter controls on pollution from agriculture or industry or from urban waste sources. PoMs may thus indirectly also affect agricultural greenhouse gas emissions. Furthermore, the Water Framework Directive may influence the relationship between water managers and agriculture: in France, for instance, water management agencies are becoming increasingly active in the agricultural field, providing financing to farmers for implementing measures such as intercropping and reduced fertilisation, and even buying arable land and converting it back to permanent grassland.

National Emissions Ceiling Directive (2001/81/EC)

The National Emission Ceiling Directive (NECD) sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (which includes ammonia), but leaves it largely to the Member States to decide which measures to take in their national programmes. This Directive is not directly related to climate change. However, the measures used to reduce ammonia have an impact on animal density, manure management and fertiliser use, which also positively affects the emissions of methane and nitrous oxide.

Member States have reported a relatively wide range of policies and measures aimed at reducing ammonia (NH_3) emissions from agriculture (Entec 2005). The most commonly reported policies and measures are those aimed at i) reducing livestock density and numbers, and changes in their feed; ii) improving the management of manure and slurry; and iii) improving, and ultimately reducing, the use of fertilisers.

Integrated Pollution Prevention and Control Directive (96/61/EC)

The Integrated Pollution Prevention and Control (IPPC) Directive aims at minimizing environmental pollution and nuisance from large operations/installations in the European Union. In the agricultural sector, the IPPC Directive covers large pig and poultry farms with more than 2000 fattening pigs and/or more than 750 sows and/or more than 40,000 chickens. Measures that must be applied on IPPC farms are mainly NH_3 emission abatement measures (e.g. covered storage of animal manure, improved housing systems, air purification, manure handling and treatment, low-emission manure application). As in the case of the NEC Directive, greenhouse gas emissions are not directly targeted, but positively influenced by the Directive, since measures concerning manure treatment also influence methane and nitrous oxide emissions.

The proposed Soil Framework Directive

The EU's **Thematic Strategy on Soil Protection** (COM(2006)231 final), which includes a proposal for a Soil Framework Directive (COM(2006)232 final), was adopted by the Commission on 22 September 2006. It identifies a number of pressures on soil that need to be addressed: erosion, decline in organic matter, local and diffuse contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides, and desertification. It also recognises that soil degradation affects other environmental areas, and that soil protection among other things can contribute to climate change mitigation.

The obligations of the Member States introduced by the proposed **Soil Framework Directive** are to identify areas at risk of soil degradation within 5 years after entry into force of the Directive, and to specify risk reduction targets for these areas (within 7 years) and establish programmes of measures, which have to be put in place (within 8 years).

The Directive lets Member States choose their own level of ambition (e.g. acceptable levels of soil erosion), as well as measures for their programmes to achieve the targets. The programmes could for instance build on measures already implemented under cross compliance and rural development, codes of good agricultural practice and action programmes under the Nitrate Directive, future measures under the river basin management plans for the Water Framework Directive, and others.

An **impact assessment** (SEC(2006)620) was carried out for the proposed Soil Framework Directive. The assessment lists several beneficial effects for climate to be expected from anti-erosion practices, practices to avoid loss of organic matter, and practices to avoid compaction: a reduction in carbon dioxide and other greenhouse gases emissions due to less machinery use (reduced tillage) and reduced stocking rates, and contributions to carbon sequestration.

The future of the Soil Framework Directive is currently uncertain. In December 2007, EU environment ministers failed to reach an agreement on the proposed legislation. However, the French government may re-open council negotiations on the Directive during its current EU presidency.[26]

[26] ENDS Europe DAILY 2563, 13/06/08.

5 Cross compliance

POLICY RECOMMENDATIONS

Improving GAEC implementation, strengthening the protection of permanent grassland, and including mitigation objective in future baseline standards

Improving the implementation and enforcement of existing GAEC standards for soil protection would help to exploit their potential to support mitigation. More targeted provisions to maintain permanent pasture that include site-specific bans on the conversion of grassland in particular on carbon-rich soils should be considered.

In the current period (2007 – 2013), cross compliance provides limited scope to further address agricultural mitigation. However, cross compliance might develop into the environmental baseline of a future European agricultural or rural land use policy. It will then be important to include climate change mitigation as an explicit requirement of baseline standards, in order to ensure that mitigation occurs not only as a side-effect but that the measures also target emission reductions.

Cross compliance, which became mandatory for all Member States with the 2003 reform of CAP (Council Regulation 1782/2003 and Commission Regulation 796/20042), links the CAP subsidies to environmental policies. Starting from 2005, farmers' receipt of direct payments is made dependent upon their compliance with rules concerning the environment, animal identification and registration, public, animal and plant health, and animal welfare.[27]

The cross compliance standards consist of two strands:

SMRs: Statutory Management Requirements ("Annex III"): Farmers must respect standards called statutory management requirements (SMRs) which correspond to 19 EU Directives and Regulations (listed in Annex III of Regulation 1782/2003) including the Nitrate Directive. SMR standards are mandatory in legal terms; cross compliance adds a sanctioning element through the link to the direct payments under the CAP.

GAEC standards: Good agricultural and environmental condition ("Annex IV"): All farmers claiming direct payments must abide by standards to be established by the Member States, which constitute minimum requirements for the maintenance of land and soil conditions and must cover the aspects set out in Annex IV of Regulation 1782/2003. These requirements include protection of soil from erosion, maintenance of soil organic matter and soil structure, and a minimum level of maintenance and protection of habitats (see Table 2). GAEC standards are specified by the Member States. By contrast to SMRs, they offer the possibility to Member States to introduce new requirements. GAEC standards differ significantly regarding the type and the level of implementation among Member States (Hudec et al., 2007).

[27] For those new Member States that opted for the Single Area Payment Scheme, only the GAEC standards are mandatory now; SMRs will become mandatory in 2009.

Table 3 Standards on good agricultural and environmental conditions (Annex IV of Regulation 1782/2003)

Issue	Standards
Soil erosion: Protect soil through appropriate measures	- Minimum soil cover - Minimum land management reflecting site-specific conditions - Retain terraces
Soil organic matter: Maintain soil organic matter levels through appropriate practices	- Standards for crop rotations, where applicable - Arable stubble management
Soil structure: Maintain soil structure through appropriate measures	- Appropriate machinery use
Minimum level of maintenance: Ensure a minimum level of maintenance and avoid the deterioration of habitats	- Minimum livestock stocking rates or/and appropriate regimes - Protection of permanent pasture - Retention of landscape features - Avoiding the encroachment of unwanted vegetation on agricultural land

Climate change mitigation is not an explicit objective of the GAEC standards, but many of them may bring side-benefits for mitigation. GAEC standards implemented by Member States may enhance the sink function of agricultural soils (measures against soil erosion, maintenance of ratio of permanent pasture to arable land; conservation of soil organic matter). However, as Osterburg et al. (2008) point out, it is unclear whether the benefits of current GAEC standards for climate protection are significant.

For instance, cross compliance includes a specific requirement to maintain the ratio of permanent pasture to arable land (Regulation 796/2004 and 239/2005). However, this provision relates to the ratio at national or regional level and there is no site-specific limitation on the conversion of permanent pasture. Thus, the rules are not targeted at maintaining environmentally important permanent pasture land that has a high biodiversity value and/or represents a large carbon store (see also Farmer et al. 2007). Cross compliance rules therefore miss the opportunity to effectively limit emissions from soils – the net balance may still be negative, and newly created grasslands may not be able to counterbalance the effects from land-use change elsewhere.

The rules on permanent pasture should therefore be reviewed and updated to ensure that the environmentally valuable permanent grasslands can be effectively protected (Farmer et al. 2008) Osterburg et al. (2008) recommend site-specific restrictions, especially of the conversion of grassland on soils with high C content.

Strengthening requirements to conserve grasslands becomes even more important given the increased pressure on land use resulting from incentives to grow energy crops. There may also be conflicts between mitigation objectives and current cross compliance standards or biodiversity objectives – for instance with respect to the standards to avoid the encroachment of unwanted vegetation on agricultural land. Allowing natural succession may be desirable from a climate protection point of view, since it would lead to biomass creation and carbon sequestration (Osterburg et al., 2008).[28] Different objectives (keeping landscapes open, maintaining extensive grazing systems and climate change mitigation) may have to be weighed against each other, or priority areas for each could be defined.

28 However, note that in Mediterranean countries the allowance for natural succession must be extremely carefully managed as it might increase the risk of wildfires.

Cross compliance is an instrument that can ensure a wide implementation of minimum standards for land management and agricultural production, since a large majority of farmers in the EU receive direct payments, and it contributes to the enforcement of existing standards. However, cross compliance standards only represent a baseline and are not targeted or specific. Cross compliance also faces much opposition from farmers, in part because of the costs of compliance and in part because of additional administrative burden and bureaucracy that is involved.

The PICCMAT workshop indicated that cross compliance is not seen as an appropriate instrument to implement mitigation measures, and that adding further measures to cross compliance does not seem politically feasible. However, cross compliance has an important role in ensuring the implementation of existing regulation, and improved implementation of GAEC may bring co-benefits for mitigation. In the longer term, baseline standards under a reformed CAP need to take climate change mitigation into account.

6 Rural Development

POLICY RECOMMENDATIONS

Increasing resources for rural development to support mitigation

Increased funding is needed for rural development measures that support agricultural practices with multiple environmental benefits, including GHG mitigation. Additional funding can also be targeted specifically at pilot mitigation projects that test innovative approaches to maximize GHG mitigation as part of an integrated approach to sustainable agriculture.

Integrating mitigation practices in rural development measures

A climate screening of rural development measures (in particular of agri-environment measures) can provide a first step to better integrate mitigation objectives.

Taking into account regional differences in mitigation potential and cost-effectiveness, agri-environment measures can be re-designed, or new measures can be introduced, to strengthen mitigation practices and support associated technical investments. The Commission could ask Member States to justify how the additional funding obtained from modulation is allocated, including for GHG mitigation purposes.

Organic farming should be further promoted in rural development policies, and appropriate funding should be ensured. Climate change mitigation should be set as a specific target in Art. 3 “Objectives and principles for organic production” of the Council Regulation (EC) No 834/2007. Further measures might be inserted into existing production standards (e.g. minimum tillage, improved manure storage and application techniques in organic farming) to strengthen the climate mitigation benefit of organic farming. Monitoring systems may have to be expanded.

Building knowledge and capacity for mitigation

Rural development funding can be used to increase knowledge and capacity for mitigation through agricultural techniques. Pilot mitigation projects can test different approaches (e.g. carbon offsets, results-oriented versus management prescription approaches, methods for measuring on-farm carbon balance; see below). Technical guidelines can be drafted on the basis of pilot project results.

Through rural development funds, additional support should be provided for awareness raising and capacity building related to climate change for farmers and farm advisors.

Integrated farm plans can provide an innovative delivery instrument to achieve multiple environmental objectives, including climate change mitigation.

The EAFRD comprises the most important EU funding instrument for sustainable land management; it is the obvious first choice mechanism for promoting farming practices that contribute to GHG mitigation. In addition, complementary funding opportunities can be explored through the LIFE+, regional development funding, as well as through the Community research funding (FP7).

Three instruments provide the legal basis for the rural development policy in the 2007 – 2013 programming period: Community strategic guidelines for rural development (Council decision 2006/144/EC), the Council Regulation (EC) No 1698/2005 on support for rural development by the European Agricultural Fund for Rural development (EAFRD) and the Commission

Regulation (EC) No 1975/2006 laying down the implementation rules. Based on these instruments, each Member State has had to prepare national strategy plans and national (or regional) rural development programmes (RDPs).

Rural development measures fall under three thematic axes covering 1) improving competitiveness for farming and forestry, 2) environment and countryside, and 3) improving quality of life and diversification of the rural economy. The fourth axis, also called the Leader axis, enables the implementation of measures from axis 1 – 3 through participatory, bottom-up approaches (particularly through so-called local action groups).

Using rural development funding for addressing climate change mitigation in agriculture provides a range of options. The set-up of RD funding allows the development of more specific regional measures and the adaptation of programmes and measures to specific local or regional conditions – something that is not possible for instance with cross compliance. Moreover, using subsidies and incentives rather than fines has an advantage in terms of acceptance by farmers.

On the other hand, the overall impact that can be achieved through rural development funding, and in particular agri-environment measures, may be limited. In 2002 for instance, only 24% of the total utilised agricultural area in the EU 15 was under agri-environment schemes (EEA, 2005a). Since measures are not compulsory, the impact depends on the degree to which farmers make use of the programmes. Increasing commodity prices (especially high cereal prices), in combination with the administrative and control costs of participation in AEM, may make AEMs even less attractive for farmers in the future. Thus, in order to make AEM an effective policy option, the measure premiums must be maintained at sufficiently attractive levels and the delivery of measures must minimize administrative costs for farmers.

Several partly overlapping steps can be recommended to better incorporate GHG mitigation practices in rural development programmes in the current programming period (until 2013). These are examined in the following sections.

6.1 Climate screening of rural development measures

The strategic community guidelines for rural development programmes identify climate change as a priority; however, it is not possible to say to what extent climate change mitigation measures have received explicit attention in current programmes.

Rural development programmes for each Member State and (where applicable) their regions can be reviewed to identify opportunities for making them more climate friendly and provide a baseline for evaluation later on. This applies in particular to agri-environment measures, but can also include, for example, non-productive investments or farm modernisation measures.

This screening could be conducted as part of the modification of rural development programmes following the agreement on the Health Check proposals. The screening could provide the basis (along with more detailed analysis of the environmental situation in terms of GHG emissions) against which Member States would justify the allocation/targeting of additional funding resources to address the ‘new challenges’.

6.2 Improved funding for rural development

Greater funding is required in order to strengthen rural development instruments to cover the additional objective of GHG mitigation. The legislative proposal for the Health Check issued by the Commission on May 20, 2008 (COM (2008) 306/4), includes a proposal for progressive modulation of direct farm payments under Pillar 1. This modulation would yield additional funds to be earmarked for addressing the challenges of climate change, biodiversity, and water conservation. Member States would have the freedom to decide how they would allocate additional funding among the new challenges. Furthermore, the Health Check legislative proposal sets out the possibility of revising Article 69 of Regulation (EC) No. 1782/2003[29] to secure further funding also for environmental services. The question remains if the Commission should set a minimum percentage to be allocated to each of the challenges (similar to the minimum funding requirement for individual axes). Member States could be asked to justify their selection / approach in addressing the 'new challenges' against the background of an analysis of environmental needs/priorities which would also include GHG mitigation needs. At the very least, targeted funding should be made available for pilot GHG mitigation projects, which can serve as the basis for measures for the period beyond 2013.

Improved funding for rural development might be particularly important in Member States that tend to have weaker institutional (advisory) capacities and lower awareness of climate change.

6.3 Agri-environment measures and technical investment options

Recent evaluation studies have shown that a number of agri-environment measures (practices) which have already been implemented in Member States have GHG mitigation as a side-effect (GFA 2006). Increased funding for and improved implementation of measures with multiple benefits can provide a cost-effective element in a mitigation and adaptation strategy in agriculture. While the Commission cannot require that Member States harmonize agri-environment measures with the most effective PICCMAT practices, a requirement can be set to ensure that the additional funding is appropriately targeted and that well-designed measures which yield multiple environmental benefits are supported. In promoting the protection or restoration of carbon rich soils (wetlands, peatlands), for example, targeting could be guided by the need to enhance ecological connectivity in European landscapes.

Table 4 show the opportunities for incorporating PICCMAT practices in RD measures in the current financing period. As outlined in section 2, measures with high mitigation potential at EU level which are also associated with no or low implementation costs include: catch crops, adding legumes, reduced tillage, residue management (no removal of residues), selection of rotation species, and fertiliser application/type.

[29] Council Regulation (EC) No 1782/2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers. O.J. No. L 141, 30.4.2004. Article 69 enables Member States applying the Single Farm Payment to retain up to 10% of national ceilings for direct payments in the sector concerned for environmental protection or support of quality and marketing of agricultural products.

Table 4: Opportunities for incorporating PICCMAT practices in RD measures 2007 - 2013

Farm level mitigation practices	RD measures
Catch crops Reduced tillage Residue management Extensification Fertiliser application timing Fertiliser type Rotation species Adding legumes, N-fixing crops to rotation or Under-sowing Planting grass in orchards and vineyards Grassland renovation Manure application techniques Manure application to cropland vs grassland Optimizing grazing intensity, length and timing	Agri-environment
Investments in farm equipment for better application of farm manure (spreaders, precision farming)	Farm modernisation
Agroforestry	First establishment of agroforestry systems on agricultural land
Restoration of organic soils	Agri-environment, Non-productive investments
Pilot projects to further develop integrated AEM measures providing multiple benefits	Agri-environment
Pilot projects to test results-oriented measures as opposed to prescribed measures for carbon storage in soils and wood	Agri-environment

6.4 Organic farming policy

Organic agriculture aims to reduce negative environmental impacts of farming. It promotes recycling techniques and low external input strategies, bans pesticides and mineral fertilisers, and aims to enhance soil fertility and reduce erosion. Organic farming may also have side-benefits for climate change mitigation. Recent studies suggest that GHG emissions per agricultural area from organic farming systems tend to be lower than those from conventional farming, and that they may also be lower per unit output product in some cases (for a discussion of potentials and limitations see Box 1).

Box 1: Potentials and limitations of organic farming for mitigation

According to ITC and FIBL (2007), organic farming nitrous oxide emissions tend to be lower than in conventional farming. The obligatory ban on mineral nitrogen, the reduced livestock units per hectare and the diversified crop rotation with green manure lead to reduced emissions of nitrous oxide. In addition, the integration of livestock and crop rotation promotes the on-farm use of farmyard manure and slurry and avoids long-distance transports and consumption of energy for synthetic fertilizer production.

The role of organic farming with respect to **methane emissions** is controversial. On the one hand, life longevity of animals on organic farms determined by a favourable ratio between unproductive phase of young cattle and the productive phase of dairy cows in organic systems results in lower methane emissions. On the other hand, milk yields are lower due to a higher proportion of roughage in the diet, which might increase the methane emissions per yield unit. Furthermore, the practice of composting and biogas production by using aerobic fermentation of manure leads to decreased methane emissions, but also to increasing emissions of N_2O. This problem could be solved by applying controlled anaerobic digestion of manure and waste combined with biogas production. Further improvements are required in organic rice production by using low methane-emitting varieties and avoiding continuous flooding (ITC and FIBL 2007).

With regards to **CO_2-sequestration in soils**, organic agriculture may achieve carbon gains through the use of green and animal manure, soil fertility-conserving crop rotations with intercropping and cover cropping, as well as by using composting techniques. In particular, in Northern European countries, conversion from conventional to organic farming would result in an increase of soil organic matter (from 100 to 400 kg/ha annually during the first 50 years). Nevertheless, there is a need to promote minimum tillage techniques in organic farming systems particularly in very fragile soils (ITC and FIBL 2007).

For German farming systems, a recent modelling study quantifies and compares the climate effect of four key products (wheat, pig, milk and cattle) in conventional and organic farming (Hirschfeld and Weiß 2008). The study finds that in organic farming, GHG emissions per kg product are significantly lower (more than 50%) for wheat than in conventional farming; emissions are 40% lower for pork production, and 9% lower for milk. For beef production, results are ambiguous due to the variety of processes and procedures.

To support agricultural mitigation, organic farming as an overall environmentally-friendly agricultural production system could be promoted and its mitigation aspects could be strengthened. Climate change mitigation could be set as a specific target in the current regulation on organic farming,[30] and further measures to mitigate climate change could be inserted into existing production standards (e.g. minimum tillage, improved manure storage and application techniques in organic farming). Moreover, it is important to expand monitoring and labelling systems. Thereby, consumers that are already paying for higher standards would be provided with products that address all environmental impacts.

Moreover, organic farming should play a role in the development of agroforestry systems (that themselves offer a high mitigation potential). Combining these two systems could reduce GHG emissions, sequester carbon dioxide and increase the productivity of agro-ecosystems. In general, investment for research on organic farming must be increased to enhance the production efficiency of organic farming systems as well as to improve farming practices and their environmental benefits, including their mitigation effects. Such research should for example focus on better exploitation of leguminous plants in improved crop sequences or on improved soil fertility management.

6.5 Pilot projects to test results-oriented agri-environment measures

Pilot projects to test results-oriented agri-environment measures for carbon storage in soils and wood or for improving nitrogen management could be an innovative approach which can tie in with a future emissions trading scheme for agriculture (see section 8). Results-oriented measures can be tested side by side with management prescription measures. Moreover, these projects can also be an opportunity to test existing or new methods for measuring on-

[30] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91

farm carbon balance. The data and experience obtained from pilot projects can be assembled in technical guides and demonstration projects for training purposes.

The possibilities for introducing a results-oriented approach are discussed in more detail in section 8.1. In the current phase of rural development funding, pilot projects could be carried out to test the feasibility of the approach and to develop methodologies. The Commission should strongly encourage that such projects are funded, and, if possible, also provide additional funding, for example, from the LIFE funds.

6.6 Provide additional support for awareness raising and capacity building

Farm training

Farmers' understanding of farm GHG balance, mitigation techniques, as well as mitigation costs and benefits is vital for successful implementation of mitigation practices (Smith et al, 2008). Thus there is a need for a strong element of awareness-raising and training. This is also needed to address technical and social barriers to implementation of mitigation measures as identified in PICCMAT case studies as well as to promote small on-farm changes that can make a big difference in terms of GHG emissions or C-storage. Additionally, the PICCMAT stakeholder consultation process identified awareness raising as a crucial element of promoting mitigation in agriculture.

Targeted farm training on climate change mitigation can be introduced as a separate programme or incorporated into existing training schemes. The Commission could set a requirement for a minimum number of hours to be dedicated to the topic or minimum content of the training programme. Training can incorporate, for example, visits to demonstration farms, one-day educational courses, on-line information materials and other methods of providing advice and information.

Institutional capacity building

Farm advisory services provide a key information and delivery channel for agricultural policy measures. In order for farmers to receive appropriate technical advice for mitigation (and adaptation) strategies, it is essential that policy also supports the development of advisory services and, more broadly, institutional capacity building for climate change mitigation in agriculture. The current rural development regulation enables Member States to use the measure of 'setting up advisory services' for this purpose. Within this measure support can also be provided for the training of farm advisors on climate change, and specifically on the technical and economic aspects of mitigation practices. Support can also be given for the development of co-operative advisory approaches with environmental partners such as statutory and non-governmental conservation bodies. Moreover, government institutions involved in agricultural policies can provide training for their staff in relation to climate change mitigation and adaptation to improve awareness of the challenges and opportunities, and facilitate the integration of climate change with other farm and environmental objectives.

In the Health Check proposal for amending Regulation (EC) 1698/2005, awareness raising and capacity building are not included in the list of indicative types of operations that Member States can support in relation to the 'new challenges'. This does not preclude Member States from addressing mitigation needs also through training and capacity building, yet it also does not highlight the importance of the issue.

Possibilities should also be explored to make available additional funding for capacity building in relation to climate change mitigation in agriculture through regional development funding. Interreg III funding schemes, for example, have offered support for networking and capacity building in the area of renewable energies, bringing together various stakeholders, including farmers.

6.7 Use of innovative delivery instruments: pilot integrated farm plans

At farm level, integrated voluntary nature conservation and GHG mitigation (adaptation, resilience) farm plans can provide a tool to improve the effectiveness of AEM implementation, raise farmers' awareness and act as a basis for 'results-oriented' agri-environment measures as well as for the tracking of carbon credits for potential future ETS. Funding could, for example, be provided through 'non-productive investments'. As part of these plans, farm-level GHG evaluations (for which methodologies already exist) could be set up with specific objectives and indicators to monitor mitigation achievement. Integrated farm plans could build on existing sustainable farm management tools (see section 9.1).

Integrated farm-level plans could in particular sensitize and inform farmers about practices with synergistic effects that would work best in the context of their own farms. Being prepared in collaboration between an authorized advisory body (including a conservation/environmental NGO) and individual farmers, these plans would build on farmers' detailed knowledge of the economic and environmental situation of their farms. They could be developed on the basis of best-practice 'nature protection plans' such as those implemented within the Austrian agri-environment programme (WWF, 2005). A guidance handbook on the content of these plans could be prepared at Community level and could benefit the implementation of nationally/regionally tailored plans.

In the longer-run, the experience with such voluntary plans could inform the development of compulsory environmental management plans for farms, which have been identified as a possible policy instrument to improve environmental integration in agriculture (see, for example, Kristensen and Primdahl 2006). These plans could also form a minimum requirement to receive support for insurance premiums as a proof of 'due diligence'.

7 A future CAP: Options for the post-2013 period

POLICY RECOMMENDATIONS

Re-designing the CAP into an integrated land use policy

When implementing major CAP reforms, climate change mitigation needs to be a major consideration in designing the system. A system that merges the current cross compliance and rural development instruments can provide an opportunity to implement baseline measures and set more targeted incentives for more ambitious mitigation efforts.

Future CAP reforms will provide the opportunity to introduce more targeted action to support soil carbon management and maintain existing carbon sinks and carbon-rich soils. The concept of Ecological Priority Areas should be considered to protect soils with high carbon content (e.g. peatlands) or for general carbon sequestration purposes.

The economic vulnerability of small farms and farms in marginal areas should be considered, compensatory measures may be required.

The future of CAP after 2013 is highly uncertain. The key drivers for policy change have come from global trade negotiations, budgetary constraints, the EU enlargement and growing criticism from environmental and civil society stakeholders about the negative environmental and social impacts of the current CAP. The Health Check proposal published by the

Commission on May 20, 2008, makes certain steps to more explicitly address environmental and rural development concerns through, for example, progressive modulation of farm payments and explicit calls to address new and ongoing environmental challenges (climate change, biodiversity loss, sustainable water management etc.). However, some environmentally beneficial measures with mitigation potential - such as set aside – are proposed to be scrapped without introducing alternative measures. Increasing pressure, however, is being raised for a fundamental re-orientation of the policy, which would go well beyond the Health Check proposals.

To better address environmental needs in agriculture, one proposed approach has been to replace CAP with a sustainable land management and rural development policy, building on the current Rural Development Regulation. Under this proposal, Pillar 1 (market price support and direct payments) would be closed and its funds merged with Pillar 2 funds (rural development) into a single "Fund for sustainable development in rural areas".[31] This fund could be put online after 2013 and the reformed CAP would be based on 'public money for public goods' principle (BirdLife, 2007).

Assuming there will be a radical change of the current CAP and the existing two pillar system, the following approach (as proposed by BirdLife, 2007) could be applied:

- Funding would be provided to farmers for meeting a minimum legislative baseline based on the principle of 'do no harm'
- Cross compliance would be linked to agri-environmental measures to offer either basic AEMs (designed to enhance the farmed environment and encourage more sustainable farming practices), or advanced AEMs

Such a system would provide scope to include mitigation measures, and it might be further developed to differentiate between more than two different levels of environmental benefits or services. For instance the baseline level (A) could ensure the preservation of soil organic matter content, erosion protection, and include measures to limit N_2O -release from fertiliser use and on manure management (for N_2O and NH_4 release). These measures could be more or less equivalent to those currently set by cross-compliance, but would have to be more targeted towards climate protection. In other words, this would correspond to a kind of reinforced cross-compliance supported by a minimum funding level.

The following level(s) (B, C, etc.) would be defined by additional requirements and supported by additional funding.

The new CAP would then have to:

- Set up the requirements for each level (types of measures included and maximum GHG emission levels)
- Fund on-farm audits on emission levels or carbon balance (possibly included in an overall environmental audit) to produce base-line data for each farm, with recommendations on necessary improvements to attain level A, B, etc. Indicators need to be defined for this type of audit, like C-content of soil, type of equipment used, manure quantities and management, etc.
- Provide a time-schedule to farmers to reach level A first, and then level B, C, etc.

This would apply to all EC farms (possibly above a certain size threshold) and would include a strong education component. For smaller farms, compulsory measures should be set-up with an appropriate compensation scheme.

[31] At present, Pillar 1 is funded with 79 % of the CAP-budget, while the Pillar 2 receives only 21 % of the budget. When measured against the challenges identified for the agricultural sector in the budget review and the Health Check process, a clear misbalance between the CAP budget and EU environmental objectives is evident.

Priority areas: The concept of Ecological Priority Areas (as proposed by Farmer et al. 2007, NABU 2008, Osterburg et al. 2008) could be considered to better target mitigation action for future CAP reforms. This concept foresees to declare a proportion of the most valuable farmland (for example, 5%) on the farm as "ecological priority area". The management of these areas would have to be targeted to specific local objectives such as biodiversity and wildlife protection. The concept of priority areas could be used also to support the protection of sites of high importance for mitigation. "Carbon priority areas" could receive a special protection status with management prescriptions targeted to maintenance of carbon stocks.

8 Economic instruments

The following sections discuss the use of economic instruments to support climate change mitigation in European agriculture, in particular options related to carbon trading (section 8.2) and environmental taxes (section 8.3). The first section (8.1) presents results-oriented approaches for carbon and nitrogen management as a methodological basis for innovative incentive schemes.

8.1 Results-oriented approaches: carbon storage and nitrogen surplus

POLICY RECOMMENDATIONS

Exploring results-oriented approaches in pilot studies

Results-oriented approaches that reward farmers for achieving specific mitigation targets can be explored for their effectiveness and controllability, especially with regard to the maintenance of existing carbon stocks (peatlands and permanent grasslands). A results-oriented approach could also be used to address farm nitrogen surpluses. Pilot studies could test the feasibility of results-oriented approaches.

Results-oriented approaches could provide a methodological basis for carbon offsetting schemes.

Currently, funding and other policy measures to promote environmental services in agriculture are based on *action* taken by farmers. An alternative approach could be to remunerate the *results* of farmers' actions, by making payments conditional on the achievement of environmental benefits rather than on taking a certain action. Results-oriented approaches could provide a basis for the application of economic instruments such as project-based emission credit schemes (section 8.2) or taxes that are targeted to environmental impacts (section 8.3)

The AEM evaluation in 2005 (Oreade-Breche, 2005) states that "development of monitoring and evaluation procedures and tools that are less oriented towards implementation and more oriented towards impact, and adapted to the variety of issues concerned" is a possible improvement of the current AEM mechanism.

Under a result-oriented approach, the farmer himself is responsible for the selection of suitable measures, their realisation and the result-check. That gives him much more flexibility and ability to implement the measures most adapted to his particular environment, but at the same time participation is more risky: he is only rewarded if the desired environmental effect is achieved. Another difficulty for the farmers is to estimate the real adaptation cost due to uncertainty, for example about yield performance.

Table 5 Action-oriented vs. result-oriented measures: Role of farmers and administration

	Action-oriented	Result-oriented
Target definition	Administration	Administration
Choice of measures	Administration	Farmer
Realisation	Farmer	Farmer
Check of results	Administration	Farmer
On-the-spot-control	Administration	Administration
Farmer's behaviour	Executing	Entrepreneurial

Source: Runge and Osterburg 2007.

A results-oriented approach might be applied to carbon storage measures. This would mean that carbon storage on agricultural land would be remunerated – either by subsidies (equivalent to current agri-environment funding measures) or in the context of project-based carbon offset schemes or cap-and-trade system. Tons of carbon would thus become a product to sell by farmers to society.[32]

The PICCMAT list of climate-change mitigation measures contains a number of measures aiming to increase the carbon storage in soils (catch crops, reduced tillage, residue management, extensification, rotation species, adding legumes, permanent crops, grass in orchards & vineyards, optimising C storage in grazing land management, rewetting and peatland management, optimising grazing intensity, grassland renovation) or in wood (agroforestry). In a results-oriented approach, this list could represent recommendations to farmers, in effect a "menu" to choose from.

Remunerate the carbon stock in soils

Carbon sequestration: One idea would be to measure every year the soil carbon content in the different pieces of land of a farm and remunerate the annual increase through AEM or trading carbon credits. However, the analysis of the soil carbon content does not provide very precise results on a short term basis, depending significantly on the sampling homogeneity. As a consequence, remunerating low increases of carbon (usually around 0.1-0.2% a year) makes it very uncertain and hard to implement, whatever the funding strategy adopted (AEM, emission trading scheme, etc), and will include increases that would have occurred without any financial incentives as well. It would also generate inequality between land managers since the soil capacity to store carbon is very different from one type of soil to the other (IPCC, 2007). Also, such a system might create the perverse incentive for farmers to reduce carbon content first and then claim remuneration for the re-sequestration.

Conservation of carbon stores. While increasing soil organic matter content must remain an important goal, maintaining the current C-content of particularly rich soils would already constitute a major asset, considering the considerable loss trend going on in many such European soils (see also section 3.2). The results-oriented approach could here remunerate the carbon stocks as long as they are kept in place, thanks to adapted management practices, controllable through regular analyses. This could apply to:

- Peatlands: maintain the water table in order to avoid carbon losses;
- Permanent grasslands: effectively maintain existing permanent grasslands (and not only the 'permanent' grassland rate within a region, which allows a rotation of this grasslands, with considerable carbon losses when ploughed);

[32] As with project-based credit schemes, the definition of baselines and the problem of additionality would represent considerable challenges.

- Other C-rich soils identified.

Remunerate the carbon stock in wood

A results-oriented approach on wood could be designed as well. While hedgerows have been strongly encouraged, difficulties have occurred in the countryside on the definition of a hedgerow, its widths and density, etc. As far as climate change mitigation is concerned, planting and maintenance of trees should be encouraged whatever their position/density in the field. A new approach could be the funding of the wood stock in place at a precise date, evaluated by professionals regularly (with different ratings according to the species in place).

This would allow:

- Remuneration of maintained trees;
- Remuneration of new plantations, including isolated trees, agroforestry practices, and even complete afforestation;
- Freedom for farmers in their management: they are allowed to cut down trees if needed, but will simply loose the related funds;
- Numerous synergies with other environmental policy objectives.

More globally, this type of measure could also apply to non-farm trees, e.g, cities, gardens, road-sides, etc., as long as controlling can be effectively managed.

Remunerate reductions in nitrogen surplus

A results-oriented approach may also be applied to address N_2O emissions if an appropriate indicator can be identified. For instance, a reduction of the farm-level nitrogen surplus could be identified as the result that is to be achieved and remunerated, while it is left to the farmers to choose the appropriate measures. In the context of water protection efforts under the Water Framework Directive in Germany, Runge and Osterburg (2007) tested a results-oriented approach to reward the improvement of nutrient management at farm level. The indicator “N-efficiency improvement” was rewarded. The calculation of N-efficiency improvement was based on a farm-gate balance, with additional information about on-farm use of fodder and organic fertiliser. Coefficients for N-efficiency were calculated separately for mineral and organic nitrogen in order to identify efficiency improvements independent from structural changes.

8.2 Emissions trading and carbon offsetting

POLICY RECOMMENDATIONS

Exploring benefits, costs and feasibility of carbon offsetting

The available evidence suggests that emission trading for the whole agricultural sector in Europe is not a feasible policy option in the near- to mid-term future.

Instead, the possibility of using voluntary project-based trading of carbon offsets in an EU context should be explored. Pilot-projects could provide a basis to assess the feasibility of such a scheme, develop accounting and monitoring methodologies, and assess the benefits (for mitigation) and costs (for farmers and administration) it would entail.

Cap and trade systems

Emissions trading, in theory, is regarded as a cost-effective policy solution, since it leads to emission cuts being achieved by those participants in the scheme who face the lowest emission abatement costs. Possibilities to set up emissions trading schemes for the agricultural sector are being analysed and debated (e.g. Radov et al., 2007, van Witzke and Noleppa, 2007). New Zealand is currently setting up an emissions trading scheme that will include agriculture from 2013 onwards (see Box 2).

If there is a large potential for mitigation in agriculture that could be tapped at relatively low cost, it could be attractive for farmers to participate in a trading system with other sectors and to sell their emission credits to participants with higher abatement costs. Credits could also be generated and traded in the context of project-based schemes (see next section).

However, there are a number of very significant challenges that would have to be solved if emissions trading for agriculture were to be introduced.

- Firstly, emissions trading for agriculture would involve a high administrative burden in terms of monitoring, reporting and verification requirements. Given the low concentration in the sector, a large number of small emitters would have to be covered by the scheme, which would result in high costs both for farmers and authorities. Schemes could be limited to a part of agricultural holdings only (e.g. size threshold), but then a substantial share of emissions would not be covered and environmental effectiveness reduced. For the UK, a recent study carried out for Defra (Radov et al., 2007) finds that the administrative and abatement costs would outweigh the benefits from emissions in both cases, and that a cap-and-trade system cannot currently be considered a cost-effective policy solution.
- A monitoring and accounting system would need to be developed, taking into account both emissions and carbon removals (sinks). In this context, problems related to additionality and permanence would have to be solved.
- The problem of carbon leakage would have to be addressed: Trading agricultural emissions in the EU would not guarantee that emissions worldwide decrease, if the reductions in emissions within Europe are compensated by increases in food imports and corresponding emissions from agricultural production and land use changes abroad.
- Introducing emissions trading would require substantial investments in information campaigns and education. Farmers would need to understand and learn how to manage an entirely new system.

Summary

The available analyses suggest that emission trading for the agricultural sector in Europe is not a feasible policy option in the near- to mid-term future.

Box 2: Agriculture in the New Zealand Emissions Trading Scheme

In September 2007 the New Zealand government proposed an emissions trading scheme (NZETS) as part of its response to the climate change mitigation challenge. The scheme will also cover agriculture, this sector being responsible for 49% of the country's total GHG emissions. The scheme will cover the three sources of emissions which the country is accountable for under its Kyoto obligations, namely synthetic fertilizer use, livestock management (enteric fermentation) and manure management. Some sources that are not reported in the national inventory (e.g. soil carbon) are excluded.

The agriculture sector will be included in the scheme from January 2013, while the forestry sector will already be included in 2008. The design of the scheme for the agricultural sector has not yet been decided. The government outlines different options which are to be discussed with the relevant stakeholders. The main issue is the point of obligation: should farmers be responsible to hold and trade emission credits, or should trading take place at a higher level? Given the administrative inefficiencies that would result if trading was applied at the level of individual farmers, the following options for the point of obligation are proposed:

- Synthetic fertilizer: importers and producers
- Livestock and manure management: processing companies such as meat processing companies and dairy factories.

Alternatively, the participants with obligations could be the farmers themselves or sector bodies managing the units on behalf of the farmers. This will be subject to consultation with agricultural stakeholders.

While obliging fertiliser producers and processing companies to hold credits may reduce administrative costs, it would also reduce the ability of the scheme to provide incentives to farmers to cut their emissions. It would encourage broader structural changes rather than changes in individual farming practices.

At the beginning, the emission units will be freely allocated to the agricultural sector, to the extent of 90% of 2005 emission levels. However, a decline on a linear scale through to zero free allocations in 2025 is envisioned.

Source: New Zealand Government 2007.

Project-based credits and offsets

In project-based emissions trading, enterprises that (voluntarily) implement emission-reducing projects receive credits which can then be sold to other participants in the scheme who want to offset their own emissions. Project-based emission reduction credits are for instance generated in the context of Kyoto Protocol trading through Joint Implementation and Clean Development Mechanism projects. Land-use based credits from CDM projects (mostly based on CO_2 sequestration in forests) are accepted under the Kyoto protocol. Voluntary offset schemes are being explored in the US, but also in some European countries (see Box 3).

Radov et al. (2007) conclude from a comparison of different approaches that a voluntary project-based scheme would be easier to implement than a cap-and-trade scheme, and that it could provide a starting point based on which mandatory schemes could later be introduced. The authors also suggest that in the UK, a project-based approach could lead to some emissions reductions and that farmers could benefit from selling credits. However, the total emissions reductions are assumed to represent less than one percent of the sector's total GHG emissions.

One of the greatest challenges in relation to project-based schemes would be to determine whether emission reductions are "additional", i.e. to ensure that no credits are awarded to actions that would have occurred anyway. For this, baseline emission levels would have to be defined that describe emissions for a "business-as-usual" scenario. Given that emission trends in agriculture are decreasing in many regions, and given that there may be other incentives for farmers to reduce their emissions, establishing baselines would be difficult. Moreover, the eligibility of different land management change options would have to be defined, taking into account factors such as GHG savings and monitoring possibilities.

Offset projects in the European Emissions Trading Scheme (EU ETS). The ETS currently recognises credits from emission reduction projects implemented in third countries or bilaterally by EU countries (Joint Implementation and Clean Development Mechanism). The current review of the ETS proposes an amendment to the Emissions Trading Directive that would also allow domestic offset projects in sectors not covered by the ETS under harmonised rules and standards.[33] This could create further scope for agricultural emission reduction projects in Europe. However, it has to be noted that credits from carbon sink projects from land use, land use change and forestry (LULUCF) can currently not be traded within the EU ETS.[34]

Summary

It is unclear whether voluntary project-based credit schemes can bring significant benefits for mitigation in quantitative terms in the near future. However, they may hold a potential if carbon prices increase, and they may bring economic benefits to farmers. Research is needed in order to analyse the feasibility of implementing carbon offsetting projects in agriculture, assess potential benefits and costs, and to solve methodological problems and develop monitoring and measuring frameworks. The relationship to rural development funding would need to be clarified.

Box 3: Approaches to trading greenhouse gas offsets from agriculture

The United States

Although the United States has not adopted a national cap on greenhouse gas emissions, voluntary initiatives including trading systems are in place, and carbon offsets generated in the agricultural sector are already being sold and traded. For instance the Chicago Climate Exchange[35] accepts agricultural methane emission offsets and agricultural soil carbon offsets. In 2007, the Nicholas Institute for Environmental Solutions of Duke University together with the non-profit advocacy group Environmental Defense published a manual for farmers and investors on how to reduce GHG through changes in land use and farming practices, and turning those reductions into verifiable credits for trading in carbon markets (Willey and Chameides 2007).

---

[33] Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading system of the Community. COM(2008) 16 final. Article 24a.

[34] Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms.

[35] http://www.chicagoclimateexchange.com/content.jsf?id=821.

Europe

In the EU, some pilot initiatives and scoping studies on domestic carbon offsetting have been carried out. The French government defined a legal framework for domestic offset projects in March 2007, and launched a first pilot call for projects in 2007. Among the project proposals that were received so far, there is one that addresses methane in animal waste.[36] A feasibility study on domestic carbon offsets has been carried out in Germany (Betz et al. 2007), and the UK Department for Environment, Food and Rural Affairs (Defra) commissioned a study on emissions trading and project-based carbon offsets in the UK (Radov et al. 2007).

8.3 Taxes

POLICY RECOMMENDATIONS

Considering taxes as an element of national integrated strategies for sustainable agriculture

Member States might consider taxes on nitrogen as an instrument to be used in national integrated strategies for sustainable agriculture and exploit their potential to reduce nitrogen loss, with benefits for water protection and N_2O emissions. Taxes are likely to be more effective if applied directly to environmental bads (e.g. nitrogen surplus) rather than on inputs (e.g. fertiliser). Careful design of taxing schemes is crucial to avoid adverse social effects. Recycling the revenues back to farmers, for instance in the form of agri-environment payments, may help to prevent income loss and reinforce environmental gains.

Taxes can be used as an economic instrument to internalize the external costs of environmental pollution and thus influence the behaviour of producers and consumers. In some countries (e.g. Austria, Sweden), taxes have already been applied to tackle diffuse pollution from agriculture (see Box 4), and they could also be used to address agricultural GHG emissions. Taxes might be levied on different products and at different levels (van Witzke and Noleppa, 2007, Berntsen et al., 2003):

- **Tax on mineral fertilizers**: Such a tax could be applied at the level of retailers. Price increases will pass the incentive to reduce fertiliser use on to the farmers, or they could encourage fertiliser producers to create more climate-friendly products.

- **Tax on nitrogen surplus or farm-level nitrogen balance**: A tax could be levied on farm nitrogen surplus calculated as the difference between inputs (e.g. imports in manure, feed, seed, fertiliser) and outputs (exports in plant and animal products). This approach was used in the Dutch MINAS system (see Box 4).

Advantages

There are several arguments in favour of taxes. Taxes are easier to implement and cause less administrative effort and costs than, for instance, emissions trading schemes. When compared to direct regulation, taxes are usually considered to be more efficient, because the decision on abatement measures is left to the individual actors, so there is more flexibility to achieve emissions where costs are lowest.

Experiences with taxes on fertiliser and nitrogen in the EU show that they may be an effective instrument to control nitrogen loss and can lead to a drop in fertilizer use (see Box

36 http://www.caissedesdepots.fr/spip.php?article663.

4). Taxes achieve a broad coverage and could thus have a wider impact, while other instruments, such as voluntary offset schemes or subsidies such as agri-environmental programme, may only reach a relatively small part of farmers.

Disadvantages

On the other hand, there are also drawbacks to taxing. An argument that is often brought forward against fertilizer taxes is that price elasticity for nitrogen fertilizers is low (i.e. that farmers will rather pay higher prices than reduce fertilizer use), and that therefore taxes could cause negative economic effects but no significant environmental benefits. Empirical evidence on price elasticities for fertiliser seems to be scarce. Generally, different taxing schemes may affect farm types in different ways (Berntsen et al. 2003), so it is a challenge to ensure that the system is fair and equitable.

Also, taxes cannot incentivize all measures that would be desirable. For instance, a tax on fertilizer may lead to the use of leguminous crops to save mineral fertilizer, but would not represent an incentive for other forms of abatement, such as optimal timing of fertilizer application.

In terms of policy development, an important drawback is that the public acceptance of taxes is often low. The PICCMAT stakeholder workshop outcomes confirm that there is currently very little political support for taxes on nitrogen.

Design criteria

The effectiveness of a tax, but also potential negative effects on distribution, depends very much on the design of the scheme, for instance on the tax base, the rate of the tax and the use of revenues. It has been shown that taxing the environmental bads directly (e.g. emissions) could be more cost-effective than taxing inputs or products (e.g. fertilisers) – although such a system is likely to require larger administrative and monitoring efforts.

Several scientific analyses suggest that earmarking the revenues from fertiliser taxes contributes to avoiding adverse social effects (e.g., income loss among certain groups of farmers, concentration of agricultural activity on a smaller area, higher nitrate and ammonia emissions in productive regions and land abandonment in others), to increasing the legitimacy of taxing policies, and to gaining the support of stakeholders (Rougoor and van der Weijden 2001, Söderholm and Christiernsson 2008).

Summary

In summary, the empirical evidence on the cost-effectiveness of taxes on fertilisers and nutrients is limited, although it is clear that they have the potential to contribute to controlling nitrogen loss. The data presented in section 2 show that the potential for significant mitigation achievements through fertiliser management is limited. However, national integrated strategies for sustainable agriculture may under certain circumstances make use of taxation.

Box 4: Taxes on fertilisers in Europe

There are currently few taxes on fertilizers or nutrients in the EU. Austria and Finland repealed their fertilizer taxes when they joined the EU in 1994. While the taxes were in place, consumption of fertilizers dropped in both countries. Norway abolished its fertilizer tax in 2000 and introduced other political measures to control nutrient emissions. In Denmark and Sweden taxes are currently in place (EEA 2005).

In Austria, the tax appears to have raised awareness that fertilizers are environmentally damaging, and led to a significant reduction of synthetic fertilizer use. In Sweden, it is estimated that the tax reduced demand for fertilizers in 1991-2 by 15-20% and also reduced optimal dosages by about 10 percent. The Danish experience also suggests that the nitrogen tax (which covers fertilizers and manure) can help to solve regional nitrate problems (Pearce and Koundouri 2003).

The German Advisory Council on the Environment (SRU) in its 2008 report recommends introducing a fee to reduce nitrogen surpluses in agriculture. The SRU considers this fee necessary to ensure water and climate protection, given that existing instruments so far have not delivered the desired results. The administration could be based on the existing documentation and monitoring systems introduced under the Nitrate Directive (SRU 2008).

The Dutch MINAS system (1998 – 2006)

The MINAS system was introduced in the Netherlands in 1998 in order to reduce nitrate and phosphate leaching from agricultural soils. It was based on a farm gate nutrient balance. Farmers were obliged to keep up-to-date accounts of nutrient flows entering the farm in animals, feeds, mineral fertilisers and manures, and nutrients leaving the farm in animals or their products, crops and manures. If the nutrient losses exceeded a certain standard (“levy-free surplus” or “loss standard”), the farmer had to pay a charge. The levy-free surplus was defined according to soil type and was successively tightened. MINAS thus combined elements of a tax system (charge on surplus) and a cap system (levy-free loss standards).

In the Netherlands, MINAS proved to be an effective way to control nutrient losses in agriculture. It resulted in a reduction of the N surplus on dairy farms of approximately 50 kg per hectare, at limited or no costs to the farmers involved. MINAS resulted in higher costs for manure removal for intensive livestock farmers (Aarts 2005, Westhoek et al. 2004).

The scheme was abandoned after the European Court of Justice ruled that the Nitrate Directive required application standards instead of loss standards. Under Dutch conditions environmental benefits of the mineral accounting systems are thought to be at least equal to fertilizer application standards, but superior in terms of economic effects, since MINAS left it to the farmers to choose the most cost-effective method to reduce nutrient losses. However, the system was considered costly for the government (RIVM 2004).

9 Supporting mitigation through better information

The following section presents possible action related to information and awareness among various stakeholders as well as methodologies that could promote agricultural mitigation efforts.

9.1 Information tools for sustainable farming

POLICY RECOMMENDATIONS

Developing and promoting monitoring tools for farm sustainability

Monitoring tools for farm-level sustainability such as the Flemish MOTIFS or the French IDEA systems might be further developed, and the potential for using them across Europe could be explored. Monitoring tools should take account of the farm’s greenhouse gas emissions.

As already stressed in section 6.6, farm training on climate change mitigation (and adaptation) and the development and strengthening of farm advisory services are crucial to enable farmers to take action related to mitigation and adaptation, and they could be financed under the rural development policy.

Specific management tools, such as those developed in France and Belgium, can help farmers to optimise their environmental performance and minimise greenhouse gas emissions. The French IDEA method and the Flemish MOTIFS system (see Box 5) are tools to assess the evaluation of overall sustainability at farm level. The climate change mitigation aspect is currently not explicitly addressed, but some of the indicators used are relevant in a mitigation context (e.g. fertilisation, soil protection, organic matter management), and there might be scope to strengthen it by including additional indicators. The CALM (Carbon Accounting for Land Managers) Calculator developed by the UK Country Land and Business Association is an online tool for farmers to assess the GHG balance of their business.

Box 5: Tools for evaluation of sustainability and GHG balance at farm level

IDEA (France)

The IDEA method (*Indicateurs de durabilité des Exploitations Agricoles*, *Farm Sustainability Indicators*) is a self-assessment tool for farmers and aims to provide operational content for agricultural sustainability. The method is based on objectives which are grouped together to form three sustainability scales (agro-ecological, socio-territorial, and economic). Each of these three scales is subdivided into three or four components which in turn are made up of a total of 41 indicators. Scores are assigned to each indicator and aggregated for each scale.

The agro-ecological scale does not explicitly address reduction of greenhouse gases, but includes relevant indicators such as cropping patterns, organic matter management, fertilisation and soil protection.

The method is implemented by farmers and farm advisors in co-operation. Test case studies in France have confirmed that IDEA is capable of detecting differences in sustainability both between production systems and within a certain production system, and that it is an easy-to-use tool. The tool can also be used for group trainings (Zahm et al. 2006).

MOTIFS (Belgium/Flanders)

The MOTIFS Monitoring Tool for Integrated Farm Sustainability (Meul et al. 2008) was developed with the aim to translate the vision for sustainable Flemish agriculture into an operational assessment framework. Similarly to the French IDEA method, it covers not only ecological but also economic and social aspects, and it is based on a number of indicators. Climate change mitigation and GHG emission reductions are not explicitly mentioned, but some of the ecological indicators are relevant in a mitigation context, such as energy use efficiency, nitrogen surplus, and soil organic matter content.

The method was tested through a case study on Flemish dairy farms.

The CALM-calculator (UK)

The UK Country Land and Business Association provide an online tool for farmers to assess the balance of greenhouse gases emitted by their farming business, and carbon stored in their trees and soil. It includes GHG emissions from livestock and their waste, from cultivations and from the application of inorganic and organic nitrogen fertilisers. It also allows farmers and land managers to calculate the emissions associated with the production of nitrogen fertilisers, and future versions are expected to include other indirect emissions such as from animal feed.[37]

[37] http://www.cla.org.uk/Policy_Work/CALM_Calculator/.

9.2 Addressing consumer behaviour: carbon labelling

POLICY RECOMMENDATIONS

Addressing consumption habits – promoting carbon labelling

Climate-friendly farming can improve the greenhouse gas balance of farming. However, to address the climate impact of food production more generally, consumption patterns have to change. In addition to information and awareness raising campaigns, product labels indicating the climate and environmental impacts of products can help to enable more climate-friendly consumer choices.

Integration of the climate mitigation aspect into existing labelling and certification systems could be a way to avoid the overburdening of products with many different labels, and to make sure that different environmental issues are taken into account. Organic farming standards and monitoring systems could provide a basis for the development of a label indicating an environmentally-friendly food-production.

While the choice of farm-level practices influences the amount of greenhouse gases associated with agricultural production, it is important to keep in mind that the climate impact of different food products can vary substantially. For instance, calories from animal products generally are associated with higher emissions than calories derived from plant products, but the transport distances also play an important role ("food miles"). Consumers can reduce their personal carbon footprint from food production through their choice of products.

The PICCMAT stakeholder workshop highlighted the awareness among *consumers* as a key issue that should be considered alongside action taken by farmers. Product labeling is an important instrument to raise consumer awareness and support climate sensitive choices. While carbon labelling is unlikely to promote specific climate change mitigation measures in farming such as minimum tillage or the use of catch crops, it could help to make overall consumption patterns more climate-friendly. Labelling could for instance raise awareness of the large climate change impact of meat production. The introduction of new climate or carbon labels may be more effective if accompanied by information campaigns.

There is some debate as to whether separate labels indicating climate impact will be helpful, or whether all environmental issues should be integrated into a single labelling system.[38] Integration of the climate mitigation aspect into existing labelling and certification systems could avoid the overburdening of products with many different labels, and ensure that different environmental issues are taken into account. Existing standards and monitoring systems, e.g. for organic farming, could be used as a basis to develop a certification scheme for environmentally friendly food production.

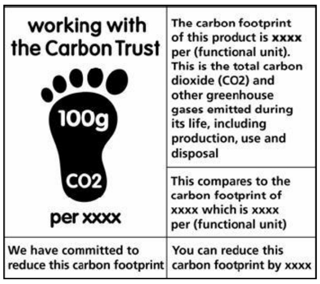
At national levels, some labelling schemes that provide information about carbon balances or climate impacts already exist or are in development. These are briefly presented in the box below. Further discussions about assessment and labelling of the climate impact of consumer goods are going on, for example, in France, Switzerland and Austria.

[38] See for instance http://www.euractiv.com/en/sustainability/food-industry-rejects-carbon-label-idea/article-167926 (accessed 23 April 2008), ENDS Europe DAILY 2474, 31/01/08.

Box 6: Carbon labelling

UK Carbon Trust - Carbon Label Company (http://www.carbon-label.co.uk/)

The UK Carbon Trust developed a Carbon Reduction Label to reveal the carbon footprint of products and services.



The calculation of the carbon footprint is based on a life cycle assessment, accounting for GHG emissions from production, distribution, use and disposal. Companies using label for products and services commit to reducing their carbon footprints within two years.

A number of products already carry the label, including food products such as orange juice or potatoes.

German pilot project "Product Carbon Footprint" (http://pcf.thema1.de/)

Following the Carbon Trust initiative, the WWF, in cooperation with the German research institutes PIK (Potsdam-Institute for Climate Impact Research) and Öko-Institut, launched the pilot project "Product Carbon Footprint" in 2008. The project seeks to develop and introduce a harmonised method to measure the GHG-balance of consumer goods in coordination with other European and international initiatives. So far, nine business companies have joined the initiative, analysing at least one of their products (e.g. coffee, washing powder, or organic strawberries). The project will increase transparency for consumers to influence their purchase decision towards a more sustainable consumption, identify potentials on how to reduce GHG emissions along the value chain and thus, promote competitive advantages and innovations. The methodology is based on a life-cycle approach and takes into account agricultural practices such as the application of fertilisers or soil management (for example, type of ploughing).

German initiative "Stop Climate Change" (http://www.stop-climate-change.de).

"Stop Climate Change" provides an "emissions-neutral" certificate for products (e.g. fruits and meat-based products), services or entire companies. The system comprises five elements: collection, balancing and documentation of GHG emissions (along the entire value chain[39]), as well as their mitigation and neutralisation.

Once the GHG emissions have been identified, the company is required to propose mitigation measures in order to reduce GHG emissions, which are validated by an independent auditor. Moreover, the company commits itself to offset unavoidable emissions by buying carbon credits that are administrated by an independent trust account.

Swedish system of climate labelling for foods

From 1 July 2008 domestic fruit and vegetable growers will be able to apply for certification that production and transportation of their crops have caused minimal climate impact at national level. Similar arrangements for dairy and meat products shall follow later in 2008.

[39] Taking into account production, storage, packaging, transport etc.

There will also be a label for fish, probably organised across the whole Nordic region. Initially only organic and quality-assured products will be eligible.[40]

Danish initiative for climate labelling

The Danish cooperative association FDB, which owns a leading consumer goods retailer, proposes developing a climate label that can show the CO_2 impact of an item to inform producers and thereby enable them to reduce CO_2 emissions through their consumption. The FDB will aim for a scheme that is logically understandable and practical to handle for producers.[41]

9.3 Exchanging knowledge and experience on national and regional approaches

POLICY RECOMMENDATIONS

Promoting exchange of experience between Member States

An exchange on national policies and programmes for climate-friendly agriculture could be organised at EU level, for instance through a pan-European survey in combination with a conference for national policy-makers. The rural development networks established under rural development programming can offer a medium for this exchange.

The PICCMAT stakeholder consultation workshop revealed that there are different approaches to encourage and promote climate-friendly and environment-friendly farming in the Member States, and that there is a demand for an exchange of experience.

Some interesting national programmes were brought forward at the workshop.

- **The Netherlands**. The Dutch Non-CO_2 Greenhouse Gas Reduction, ROB international,[42] is a long-term interdepartmental programme that aims to facilitate sectoral partnerships between government and stakeholders from industry and agriculture, and to stimulate the innovation of new reduction measures. SenterNovem implements the programme, which is financed by the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) and supported by two other ministries - the Ministry of Agriculture, Nature and Food Quality and the Ministry of Economic Affairs. Participants at the PICCMAT workshop reported on pilot projects related to manure fermentation, cattle feed, and precision farming. In addition, a research project is being launched to explore ways to influence consumer behaviour and change eating habits.
- **Flanders**. The Belgian region of Flanders adopted a Climate Action Plan in 2002.[43] Flanders aims to reduce its agricultural emissions by 1 Mton CO_2-eq. by 2012 compared to 2006. The main concerns are CH_4 emissions from cattle, direct and indirect N_2O emissions, and CO_2 emissions from energy use in greenhouses. The plan comprises a

[40] ENDS Europe Daily 2523, 15/4/08.
[41] http://www.denmark.dk/en/servicemenu/news/environment-energy-climate-news/cooperativeassociationtablesideatodevelopclimatelabel.htm.
[42] http://www.senternovem.nl/Robinternational/Index.asp.
[43] See https://portal.health.fgov.be/portal/page?_pageid=56,512629&_dad=portal&_schema=PORTAL and http://www.lne.be/themas/klimaatverandering/klimaatconferentie/vlaams-klimaatbeleidsplan-2006-2012/flemish-climate-policy-plan-2006-2012.

variety of action, such as renewable energy for greenhouses, investments in energy reduction and renewable energy installations, evaluating the effect of manure policy on GHG emissions (e.g. tradable nutrient emission rights), stimulating reforestation, and building awareness among farmers through advising on environmental bookkeeping and MOTIFS, the Monitoring Tool for Integrated Farm Sustainability (Meul et al. 2008; see also section 9.1).

- **The UK**. The UK is also exploring the relationship between agriculture and climate change. For instance, the **Rural Climate Change Forum**[44] provides a high level forum for dialogue with Government, and authoritative advice and leadership for rural stakeholders, on climate change and rural land management. Its current activities focus on reducing greenhouse gas emissions from agriculture, communications, emissions trading, anaerobic digestion and adaptation to climate change. **Farming Futures**[45] is a communications collaboration between the National Farmers' Union, the Country Land and Business Association, the Agricultural and Horticultural Research Forum, the Agricultural Industries Confederation, Forum for the Future and Defra (UK Department for Environment, Food and Rural Affairs). Defra recently commissioned a study on options to include agriculture in emissions trading (Radov et al. 2007).

The examples presented above are indicative only and represent a sample of initiatives that were brought forward by the workshop participants. In some countries, for example in the new Member States or Spain, agricultural mitigation is likely to be lower on the political agenda and approaches may not be as far developed (see also Karaczun 2008). Country approaches targeting specific national problems may provide models for other Member States with similar conditions, and there is a large potential for mutual learning and transfer of experience.

9.4 Measuring, accounting and monitoring of agricultural greenhouse gases

POLICY RECOMMENDATIONS

Developing measuring and accounting approaches for agricultural greenhouse gas emissions

Indicators or indicator systems can be developed that could be used across Europe, based on proxies for agricultural GHG emissions such as farm level nitrogen and carbon balances. These can be based on existing indicators such as those provided by the EEA.

The use of soil organic carbon maps could help to better target policies for mitigation. Remote sensing can be used for verifying the maintenance of carbon-rich ecosystems such as wetlands.

Whichever policy instruments are used to encourage more climate-friendly land management by European farmers, measuring, monitoring and verification will play an important role. Depending on whether an activity-based or a results-oriented approach is chosen, verification and measurement either have to target farmers' activities or the effects of management practices in terms of greenhouse gas emission reductions.

If measuring and monitoring tools are not available, are subject to very high uncertainties, or are disproportionately expensive, the implementation of certain schemes may not be

44 http://www.defra.gov.uk/environment/climatechange/uk/agriculture/rccf/index.htm.
45 http://www.farmingfutures.org/.

feasible. It is therefore a particular challenge to identify appropriate indicators that can be monitored easily and with reasonable accuracy.

The traditional policy instruments (legislator standards, agri-environment funding) usually require or encourage certain activities, and verification is based on documentation, monitoring or controls of these activities. This approach is feasible and efficient from a mitigation point of view if the activity is easy to monitor and the beneficial effects on GHG emissions are relatively certain. For instance, the planting of catch crops can be easily verified, and there is little doubt on the measure's beneficial effect on greenhouse gas emissions and carbon balance. In other cases, it is more difficult to prove or verify that a certain activity takes place, for instance with regard to fertiliser and manure application practices.

A different approach is to quantify and monitor the effects of activities rather than the activities themselves. This is necessary for instance if a policy instrument is meant to encourage certain outcomes (e.g. reducing emissions) but leaves the choice of measures to the farmers (see section 8.1).

Measuring and accounting methods should provide reliable estimates, yet remain as simple as possible to reduce costs and facilitate their application. Rather than actually measuring the emissions, proxy indicators can be used. For instance, nitrogen balance or nitrogen surplus may be a useful indicator for nitrogen-related emissions. Modelling studies have shown that GHG emissions at farm level are closely related to farm nitrogen surplus (Schils et al. 2007, Olesen et al. 2008), and the Dutch MINAS system (see Box 4) has successfully used farm level nitrogen balance as a basis for controlling nitrogen loss. Nitrogen surplus can be relatively easily determined based on farm records of imports and exports and the composition of the crop rotation. Similarly, farm carbon balance could be an indicator to account for CO_2 and CH_4 emissions.

Indicator development in this context may build on work done by the European Environment Agency (EEA). Relevant indicators already developed by the EEA, for instance, include "area under nature protection", "area under organic farming", and "nutrient surpluses".[46]

Measuring and verifying carbon sequestration in soils and ecosystems is generally associated with major methodological challenges. It is difficult and expensive to measure changes of the carbon content in agricultural soils, and gains and losses are small relative to uncertainty ranges. However, it is relatively straightforward to identify which soils and ecosystems constitute large carbon stores. Protecting carbon-rich systems should be a priority for policy action (see section 3.2). To ensure compliance it would then have to be verified that these carbon-rich parts of farmlands (e.g. grassland areas, peatlands, wetlands) are being maintained. Remote sensing could be used as a tool for monitoring in this context.

Soil organic carbon mapping in general can help to better target mitigation policies. Montanarella et al. (2006) derive the distribution of peatland in Europe as the extent of peat and peat-topped soils based on soil databases. The data show that the distribution of carbon-rich soils is highly uneven across European countries and regions. This needs to be taken in to account in the design of policies for their protection.

Generally, monitoring and accounting systems to support the implementation of agricultural mitigation practices in many cases have to go beyond the scope of the international accounting system for GHG emissions under the UN Framework Convention for Climate Change (UNFCCC) and the Kyoto Protocol. Many mitigation efforts in the agricultural sector, in particular those based on the PICCMAT practices, will not have an effect on the Member States' national GHG inventories reported to the UNFCCC (see Box 7).

[46] http://www.eea.europa.eu/themes/agriculture/indicators.

Box 7: Agricultural mitigation practices and international GHG accounting

The international accounting methodology for reporting GHG emissions to the UNFCCC is elaborated by the Intergovernmental Panel on Climate Change (IPCC). It includes the category "agriculture", which accounts for methane and nitrous oxide emissions (in CO_2 equivalents). The IPCC methodology is based on country-specific data (such as animal numbers, crop area, fertiliser use, manure) and default emission factors. These standard emission factors are subject to high uncertainty and do not reflect regional differences.

Carbon sequestration in agricultural soils and crops is not accounted under the "agriculture" category but reported under the “Land Use, Land Use Changes and Forestry“ (LULUCF) category. The Kyoto Protocol provides the option to include cropland and grazing land management in accountable activities. However, cropland management options for carbon sequestration (Kyoto Protocol Art. 3.4) have not been selected by Member States so far and will not be accounted for in the first commitment period of the Kyoto Protocol (ECCP 2006).

10 References

Aarts, F. (2005). Nutrient balances as implementation of the EU Nitrates Directive; experiences from the Netherlands. http://www.lr.dk/planteavl/diverse/PLK05_11_1_1_F_Aarts.pdf.

Andersen, H.E., Kronvang, B., Larsen, S.E., Hoffmann, C.C., Jensen, T.S., Rasmussen, E.K., 2006. Climate-change impacts on hydrology and nutrients in a Danish lowland river basin. Sci. Total Env. 365, 223-237.

Berntsen, J., B.M. Petersen, B.H. Jacobsen, J.E. Olesen, and N.J. Hutchings (2003). Evaluating nitrogen taxation scenarios using the dynamic whole farm simulation model FASSET. Agricultural Systems 76 (2003) 817–839.

Betz, R., K. Rogge, M. Schön 2007: Domestic offset projects: Limited opportunities in germany but potential for others? Energy & environment 2006, vol. 17, no 4, pp. 569-582.

BirdLife (2007). New challenges, new CAP - BirdLife International's vision for the future of the EU Common Agricultural Policy.

Cannell, M.G.R, van Noordwijk, M., Ong, C.K., 1996. The central agroforestry hypothesis: the trees must acquire resources that the crop would not otherwise acquire. Agroforestry Syst. 34, 27-31.

Christensen, J.H., Hewitson, B., Busuloc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., Laprise, R., Rueda Magana, V., Mearns, L., Menendez, C.G., Raisenen, J., Rinke, A., Sarr, A., Whetton, P., 2007. In: Solomon, S., Qin, D.,Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M.,Miller, H.L. (Eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA.

CIAA (2007). Managing Environmental Sustainability in the European Food & Drink Industries. Confederation of the Food and Drink Industries in the EU (CIAA). http://www.ciaa.eu/documents/brochures/brochure_CIAA_envi.pdf

Cooper, T., D. Baldock, and M. Farmer (2007). Toward the CAP Health Check and the European Budget Review. GMF.

Dumanski, J., Peiretti, R., Benites, J.R., McGarry, D., Pieri, C., 2006. The paradigm of conservation agriculture. Proc. World Assoc. Soil Water Conserv. P1, 58–64.

ECCP (2006). Final Report, Working Group ECCP I review - Topic Group Agriculture and Forestry.

EEA (2005a) Agriculture and environment in EU-15: the IRENA indicator report. Technical report 6/2005, Luxembourg: Office for Official Publications of the European Communities.

EEA (2005b): Market-based instruments for environmental policy in Europe. Technical report 8/2005, Luxembourg: Office for Official Publications of the European Communities.

EEA (2006): GHG emission trends and projections in Europe 2006. EEA report 9/2006.

EEA (2007). Technical report No 7/2007 – Annual European Community greenhouse gas inventory 1990 – 2005. Available at: http://reports.eea.europa.eu/technical_report_2007_7/en

ENTEC UK Limited (2005): National Emissions Ceiling Directive Review. Task 1 – In depth analysis of the NEC national programmes. Final Report for the European Commission, DG Environment. http://ec.europa.eu/environment/air/necr.htm.

European Commission (2008): Fact Sheet: Climate Change – The Challenges for Agriculture. http://ec.europa.eu/agriculture/publi/fact/climate_change/2008_en.pdf.

Farmer, Martin, Vicki Swales, Lone Kristensen, Heike Nitsch, Bernhard Osterburg, Xavier Poux (2007): Cross Compliance: Practice, Lessons and Recommendations. http://www.ieep.eu/publications/pdfs/crosscompliance/cc_network_D24.pdf.

Freibauer, A., Rounsevell, M., Smith, P. & Verhagen, A. (2004) Carbon sequestration in the agricultural soils of Europe. Geoderma 122, 1–23.

GFA Consulting Group (GFA) (2006). Analysis of the requirements for soil and biodiversity protection as well as for greenhouse gas mitigation within the rural development programmes. Available at: http://ec.europa.eu/agriculture/analysis/external/index_de.htm.

Hudec. B., Kaufmann, C., Landgrebe-Trinkunaite, R. & Naumann, S. (2007). Evaluation of soil protection aspects in certain programmes of measures adopted by Member States.

IPCC (2007) 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4. Agriculture, Forestry and Other Land Use. NGGIP, IGES, Kanagawa, Japan: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

IRENA Indicator fact sheet: IRENA 1 – Area under agri-environment support.

ITC and FIBL (2007). Organic Farming and Climate Change. International Trade Centre (ITC) and Research Institute of Organic Agriculture (FiBL), Switzerland. http://www.intracen.org/Organics/documents/Organic_Farming_and_Climate_Change.pdf (accessed at 20.05.2008).

Joosten, Hans on behalf of the International Mire Conservation Group (IMCG) (2007): Peat should not be treated as a renewable energy source. IMCG statement in response to the European Partliament's Resolution on a Strategy for Biomass and Biofuels (2006/2082(INI)). http://www.imcg.net/docum/peatrenewable.pdf.

Karaczun, Z.M. (2008): PICCMAT Deliverable D6: Synthesis report of case studies. http://climatechangeintelligence.baastel.be/piccmat/files/D6_CS%20Synthesis%20report_final.pdf.

Kasimir-Klemedtsson, A., Klemedtsson, L., Berglund, K., Martikainen, P., Silvola, J. & Oenema,O. (1997): Greenhouse gas emissions from farmed organic soils: a review. Soil Use Manage. 13, 245–250.

Kristensen, L. And J. Primdahl (2006). The relationship bewteen cross compliance and agri-environment schemes. Deliverable 13. A research paper of the Cross Compliance Network. http://www.ieep.eu/publications/pdfs/crosscompliance/D13%20Cross%20compliance%20and%20agri-environment%20schemes.pdf

Kuikman, P.J., W.J.M. de Groot, R.F.A. Hendriks, J.Verhagen and F. de Vries (2003). Stocks of C in soils and emissions of CO2 from agricultural soils in the Netherlands. Wageningen, Alterra, Research Instituut voor de Groene Ruimte. Alterra-rapport 561. Available at: www2.alterra.wur.nl/Webdo*c*s/PDFFiles/Alterrarapporten/AlterraRapport561.pdf.

Lal, R. (2008). Managing soil water to improve rainfed agriculture in India. J. Sustain. Agric. 32, 51-75.

Lesschen, J.P., R. Schils, P. Kuikman, P. Smith, D. Oudendag (2008). PICCMAT Deliverable D7: European quantification results. http://climatechangeintelligence.baastel.be/piccmat/files/Deliverable%20D7%20European%20quantification%20results.pdf.

Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P., Niggli, U., 2002. Soil fertility and biodiversity in organic farming. Science 296, 1694–1697.

Meul, M., S. van Passel, F. Nevens, J. Dessein, E. Rogge, A. Mulier, A. van Hauwermeiren (2008). MOTIFS: a monitoring tool for integrated farm sustainability. Agronomy for Sustainable Development 28, 321-332.

Montanarella, L., R.J.A. Jones and R. Hiederer (2006). The distribution of peatland in Europe. Mires and Peat, Volume 1 (2006), Article 01. International Mire Conservation Group and International Peat Society.

NABU (2008). Die Bedeutung der obligatorischen Flächenstilllegung für die biologische Vielfalt. Fakten und Vorschläge zur Schaffung von ökologischen Vorrangflächen im Rahmen der EU-Agrarpolitik.

New Zealand government (2007). The framework for a New Zealand emissions trading scheme. http://www.climatechange.govt.nz/files/emissions-trading-scheme-complete.pdf.

Olesen, J.E., K. Schelde, A. Weiske, M.R. Weisbjerg, W.A.H. Asman, and J. Djurhuus (2006). Modelling greenhouse gas emissions from European conventional and organic dairy farms. Agriculture, Ecosystems and Environment 112 (2006) 207–220.

Olesen, J.E. and J.R. Porter (2008): Adaptation and Mitigation. PICCMAT Deliverable 10, Workpackage 3. http://climatechangeintelligence.baastel.be/piccmat/adaptation.php.

Oréade-Brèche (2005). Evaluation of agri-environmental measures. http://ec.europa.eu/agriculture/eval/reports/measures/index_fr.htm

Osterburg, B., Nitsch, H., Laggner, A. & Wagner S. (2008): Analysis of policy measures for greenhouse gas abatement and compliance with the Convention on Biodiversity. MEACAP project WP6 D16a.

Pearce, David and Phoebe Koundouri (2003). Fertilizer and Pesticide Taxes for Controlling Non-point Agricultural Pollution. The World Bank Group 2003.

Radov, Daniel, Per Klevnas, James Skurray, David Harris, Brian Chambers, David Chadwick, Roy Dyer and David Nagler (2007). Market Mechanisms for Reducing GHG Emissions from Agriculture, Forestry and Land Management. NERA Economic Consulting, ADAS and IGER on behalf of Defra. Department for Environment, Food and Rural Affairs (Defra), UK.

RIVM - Milieu en- Natuurplanbureau (2004). Evaluation of the Dutch manure policy. RIVM, Bilthoven.

Rougoor, C. and W. van der Weijden (2001). Towards a European levy on nitrogen. A new policy tool for reducing eutrophication, acidification and climate change. Centre for Agriculture and Environment, Utrecht.

Runge, T. and B. Osterburg (2007). A result-oriented approach to reward N-efficiency improvements, FAL,

Schils, R.L.M., J.E. Olesen, A. del Prado and J.F. Soussana (2007). A review of farm level modelling approaches for mitigating greenhouse gas emissions from ruminant livestock systems. Livestock Science 112 (2007) 240–251.

Smith, P. D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko (2007a). Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Smith, Pete et al. (2007b). Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems and Environment 118 (2007) 6–28

Smith, Pete et al. (2008). Greenhouse gas mitigation in agriculture. Phil. Trans. R. Soc. B (2008) 363, 789–813.

Söderholm, P. and A. Christiernsson (2008). Policy effectiveness and acceptance in the taxation of enviornmentally damaging chemical compounds. Environmental Science and Policy 11 (2008), 240-252.

SRU – Sachverständigenrat für Umweltfragen (German Advisory Council on the Environment) 2008: Umweltgutachten 2008 – Umweltschutz im Zeichen des Klimawandels. Kurzfassung. http://www.umweltrat.de/02gutach/downlo02/umweltg/UG_2008_kf.pdf.

Thomas, R.J., 2008. Opportunities to reduce the vulnerability of dryland farmers in Central and West Asia and North Africa to climate change. Agric. Ecosyst. Environ. 126, 36-45.

UNEP (2008): Assessment on peatlands, biodiversity and climate change. Executive summary. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=523&ArticleID=5723&l =en..

Von Witzke, Harald and Steffen Noleppa (2007) Methan und Lachgas - Die vergessenen Klimagase. Wie die Landwirtschaft ihren Beitrag zum Klimaschutz leisten kann. Ein klimaschutzpolitischer Handlungsrahmen. Commissioned by WWF Germany. WWF, Frankfurt am Main.

Westhoek, H, R. van den Berg, W. de Hoop, and A. van der Kamp (2004). Economic and environmental effects of the manure policy in The Netherlands: synthesis of integrated ex-post and ex-ante evaluation. Water Sci Technol. 49 (3), 109 – 116.

Willey, Zach and Bill Chameides (2007) (eds.). Harnessing Farms and Forests in the Low-Carbon Economy. How to Create, Measure and Verify Greenhouse Gas Offsets. Duke University Press, Durham & London.

World Wide Fund for Nature (WWF) (2005). EU Funding for Environment – A handbook for the 2007 – 13 programming period.

Zahm, F., P. Viaux, P. Girardin, L. Vilain, C. Mouchet (2006): Farm Sustainability Assessment using the IDEA Methods. INFASA symposium March 16 and 17 2006, Zentrum Paul Klee Bern, Switzerland. http://www.idea.portea.fr/fileadmin/documents/En_savoir_plus/IDEA-BERN_2006.pdf.

Annex 1: description of the PICCMAT practices

The following description of PICCMAT practices is based on Flynn et al. (2007).

Catch crops: The provision of temporary vegetative cover between agricultural crops, which is then ploughed into the soil is termed a catch crop or green manure, and winter cover crops are also in this category. These catch crops add carbon to soils and may also extract plant-available N unused by the preceding crop, thereby reducing N_2O emissions and reducing amount of fertilizer N that needs to be added.

Zero tillage: Advances in weed control methods and farm machinery now allow many crops to be grown without tillage (zero tillage or no till). In general, tillage promotes decomposition, reducing soil C stores and increasing emissions of GHGs, through increased aeration, crop residue incorporation into soil, physical breakdown of residues, and disruption of aggregates protecting SOM. Therefore zero tillage often results in soil C gain.

Reduced tillage: Reduced tillage or conservation tillage can take many forms including ridge tillage, shallow ploughing and rotovation, or scarification of the soil surface. All cause less soil disturbance than conventional deep tillage with a mouldboard plough. Reduced tillage decreases decomposition, increases soil carbon stocks and decreases GHG emissions via decreased aeration and crop residue incorporation. Adopting no-till may also affect emissions of N_2O, but the net effects are inconsistent and not well-quantified globally.

Residue management: Residue incorporation, where stubble, straw or other crop debris is left on the field, and then incorporated when the field is tilled, is used in some areas for water conservation, but also enhances carbon returns to the soil, thereby encouraging carbon sequestration. However, incorporation can increase N_2O emissions and therefore net benefits in terms of climate mitigation may be highest when residues with high N content are removed. Composting these residues and then returning them to the soil may reduce N_2O emissions in relation to incorporation untreated, while retaining benefits in terms of reduced requirements for mineral fertiliser. Therefore three main types of residue management can be distinguished, which have different effects on carbon and nitrogen:

1. Leaving crop residues on the field instead of burning or removal

2. Composting of crop residues and returning them to the field

Extensification: Extensification is possible by decreasing production per ha. Lowering crop production can be done by decreasing fertilization rates (fertilizer and animal manure) and reduced tillage (number of times and/or depth).

Optimising fertilizer application: This measure can be subdivided into 3 options: changing fertiliser rates, fertiliser placement / precision farming and fertiliser timing / split application. Being more efficient in your fertilizer application (at the right time of the crop growth and under the most optimal weather and soil conditions) gives a change to lower the fertilizer rates. Precision farming and placement is giving the right amount of fertilizer at the right time and can reduce fertilizer use. A correct timing of fertilizer application, e.g. not under wet conditions which lead to a higher emission, and split applications of N will lower the emission of N2O.

Fertilizer type: Three types of fertilizer exist (standard fertilizers, fertilizers with nitrification inhibitors and slow release fertilizers). Each type and each subtype have their own influence on the emission of ammonia (related to crop type (arable/grass), temperature, soil type etc.). Optimizing the choice of fertilizer might therefore decrease emission of N2O. Nitrification inhibitors are compounds which prevent the turnover of ammonia into nitrate. They can be applied in animal manure and fertilizer and can lead to a decrease in fertilizer use or a higher N uptake in arable crops and grassland. Slow release fertilizers are fertilizers in which N is slowly released. So there might be less losses of fertilizer and fertilizer application can be reduced. They also reduce the emission factor of N2O from fertilizer.

Rotation species: This measure consists of inclusion of different crop types in crop rotations (growing various crops on the same piece of land in a planned sequence), which can considerably increase carbon sequestration. This includes (i) use of more forage crops in rotations; (ii) replacement of continuous two-course rotations of row crops with crop rotations of winter cereals; (iii) elimination of summer fallow; (iv) use of more winter crops; (v) winter cover crops.

Adding legumes: Adding nitrogen-fixing crops such as beans, peas, soya or clover to rotations of cereals reduces N fertiliser requirements and related emissions, and can increases soil organic carbon. Legumes can be included into cereal rotations as a separate crop, as a second crop (when the land would otherwise be bare fallow) or under the major crop.

Permanent crops: Transition from row crops to perennial grasses can increase carbon sequestration. Perennial grasses contribute to an increase in SOC through deposition and decay of plant material on the surface and by root growth. When grasses are established on previously cultivated land, the process not only improves grassland conditions, it also results in an increase of SOC. The rate at which this occurs is determined by the particular species of grass as well as regional specific climatic and soil conditions.

Agroforestry: Growing farmland trees (tree crops, shelterbelts, hedgerow, alley cropping) is a practice of allowing trees and crops to grow together. Windbreaks and shelterbelts are single or multiple rows of trees or shrubs planted for environmental purposes. Alley cropping can be implemented in marginal agriculture. Research has documented optimal tree planting levels to be from 3 to 6 % of the cropped field area. The species, location, layout, and density of the planting depend on the purpose and planned function of the practice. The best trees to grow together with crops are those with deep roots so they do not compete with crops for water and nutrients.

Grass in orchards and vineyards: Growing grass will protect soil the soil against erosion and improve soil properties on orchards and vineyards. Grass usually is ploughed under or desiccated to accommodate the primary crop being produced on the site. This practice is used to control erosion, add fertility and organic material to the soil, improve soil texture, and increase infiltration and aeration of the soil.

Optimising grazing intensity: This method consists of adjusting the size of the herd to the grazing capacity of the area. This practice enhances soil C sequestration by reducing soil disturbance and increasing the amount of plant biomass carbon added to the soil. Furthermore, grazing leads to higher C stocks compared with cutting. A good implementation of rotational grazing may greatly improve manure distribution across growing pastures, reducing maintenance fertilizer requirements or even eliminated them.

Length and timing of grazing: This measure can be subdivided into two measures: Emission of N_2O is higher under wet conditions so no grazing during wet periods will decrease emission of N_2O. Wet conditions can be expected during spring and autumn with much rain and less evaporation.

The emission factors for grazing are higher as the sum of emission from stable and applying animal manure (liquid manure). So for the emission of N_2O it would be better to have animals kept in the stable (in case of liquid housing systems). An advantage of both measures is that stable manure can be applied under more controlled circumstances than deposited manure (and urine patches). So this reduces use of fertilizer and decreases emission of N_2O. However, stabled animals require feed to replace grazing and therefore may require more use of concentrates and/or conserved grass. This will lead to a higher energy consumption which will enlarge the emission of CO_2.

Grassland renovation: In order to establish new and better consociations, a direct human-controlled effect on grasslands species composition can be achieved by a controlled deferred grazing, temporarily closing to the animals the areas chosen to freely evolve, normally by letting the desired grasses to enter the graining phase and disseminate the seeds subsequently increasing their presence in the plants community. The practice must be followed by a thorough grazing management in order to allow the growth of the chosen species. Thus, is clearly fundamental the timing of grazing on the grasslands, paying particular attention to the flowering/graining phases of the species and the subsequent presence/absence of the livestock over the area. Deferred grazing is a particular kind of the above described practice (rotational grazing) to which it is suggested to refer.

Optimising manure storage: Improper management of manure or slurry, including poorly designed storage, can lead to significant GHG emissions. It is estimated that between 5 to 30% of global CH_4 emissions are derived from livestock manure. Such emissions are affected by (i) the type of livestock, (ii) storage conditions (slurry, solid etc...) and temperature. Therefore, appropriate storage and management is of special importance. The following activities should be considered:

- Covered storage in tanks, reducing surface area
- Composting: CH_4 originated from manure is produced by anaerobic decomposition of organic matter, therefore the processes that promote aerobic decomposition, such as composting, will result in less CH_4 emissions. A good composting process, as well as sufficient oxygen supply, has to be guaranteed in the manure heap, especially after solid fraction separation from slurry, otherwise overall emissions may not decrease.
- Passively aerated compost. To increase aeration and promote the composting process, it is possible to place plastic pipes on the bottom of compost bins, which have a chimney-like effect, caused by exothermic reactions occurring inside the manure, that force outside intake oxygen to pass through the composting material
- Reducing airflow. Emissions may be reduced by preventing air exchange between the stored excreta and the atmosphere, either by covering slurry or by reducing air exchanges between the slurry pit and the air in indoor storage.
- Lowering pH. Changes in the balance between ammonia and ammonium inside slurry storage may reduce emissions, and can be achieved by lowering the pH value of the slurry using either inorganic and organic acids.
- Cooling. Reducing stored manure temperature, as well as providing better aeration, may result in a decrease CH_4 emission, since as temperature increases, higher rates of methanogenesis occurred in all manure storage types, especially in slurry.

Application techniques for manure: The application techniques used to supply manure to the fields may strongly affect GHG emissions e.g. avoiding application of manure in autumn and winter results in a higher use efficiency of N manure, thus causing a general decrease of GHG emissions. Also, application techniques like deep incorporation or injection can contribute to the reduction of GHG emissions, as slurry is introduced under the top soil layer.

Application to cropland vs. grassland: There are two scenarios for manure application location and what other additions will be necessary on the land which it is not applied to; applying all manure to grassland and using mineral fertilisers on cropland only, or applying all manure to cropland and using mineral fertilisers only on grassland.

Management of organic soils (Peatland restoration and management): Organic soils contain high densities of C, accumulated over many centuries, because decomposition is suppressed by absence of oxygen under flooded conditions. To be used for agriculture, these soils are drained, which aerates the soil, favouring decomposition and therefore high fluxes of CO_2 and N_2O. Methane (CH_4) emissions are usually suppressed after draining, but this effect is far outweighed by pronounced increases in N_2O and CO_2.

The mean response of restored organic soils that were formerly cultivated show that reduction in CO_2 from oxidation of peat is an order of magnitude higher than the increased emissions of CH_4 from restored peat soils; yet, there is a large range and variability on these estimates. Factors affecting the balance include the type of organic soil, for how long the high water table is maintained during the year (e.g. year-round versus seasonal) and the level of CO_2 emissions from the cultivated organic soil (Kasimir-Klemedtsson et al., 1997; Freibauer et al., 2004; Smith et al., 2008).

Therefore, organic soils used for agriculture make a significant contribution to climate change. The most important mitigation practice, is avoiding the drainage of these soils in the first place, or re-establishing a high water table where GHG emissions are still high.

Many areas of organic soils in Europe which are currently used for agriculture were drained in the past and therefore have artificially reduced water tables. Measures to undo this artificial drainage, such as blocking drainage pipes, mitigate GHG emissions and have a beneficial impact on carbon storage. A full GHG budget reveals a clear climatic benefit of rewetting drained peats. Blocking old drains may also be worthwhile to reduce erosion and physical removal of C stocks, as research suggests that subsurface piping increases over time causing particulate carbon loss from drained peat slopes to increase exponentially. Once the measure is in place, the mitigation effects will continue year on year without further intervention.