Evaluation study of the impact of the CAP on climate change and greenhouse gas emissions

Final Report

Alliance Environnement
October 2018

– ALLIANCE ENVIRONNEMENT –

EUROPEAN COMMISSION

Directorate-General for Agriculture and Rural Development
Directorate C — Strategy, Simplification and Policy Analysis
Unit C4 — Monitoring and Evaluation

European Commission
B-1049 Brussels

Evaluation study of the impact of the CAP on climate change and greenhouse gas emissions

Final Report

Europe Direct is a service to help you find answers to your questions about the European Union.

Freephone number (*)**:**

00 800 6 7 8 9 10 11

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Luxembourg: Publications Office of the European Union, 2019

Catalogue number: KF-04-18-460-EN-N
ISBN 978-92-79-85797-3
DOI: 10.2762/54044

This report is presented by the European Economic Interest Grouping:

-Alliance Environnement-

European Economic Interest Grouping

in collaboration with

Ricardo PLC

The authors and main contributors to this report are:

IEEP: David Mottershead (project manager), Anne Maréchal, Ben Allen, Clunie Keenleyside, Anna Lóránt, Catherine Bowyer

Oréade Brèche: Isabelle Martin, Charlotte Daydé, Célie Bresson, Marie Panarin

Ricardo: Hugh Martineau, Jeremy Wiltshire, Hetty Menadue, Michel Vedrenne, Ancelin Coulon

Case studies:

Croatia: Sonja Karoglan Todorovic, Darko Znaor

Czech Republic: Jaroslav Pražan

France: Charlotte Daydé, Célie Bresson, Isabelle Martin

Germany: Anna Frelih-Larsen, Sophie Ittner

Hungary: Anna Lóránt

Ireland: Silvia Nanni

Lithuania: Romualdas Zemeckis

Netherlands: Erik Gerritsen

Romania: Mark Redman, Irina Toma

Spain: Pierre Milliard, Isabelle Martin, Victor Brenner

EEIG ALLIANCE ENVIRONNEMENT is formed by the following companies:

ORÉADE-BRÈCHE Sarl and
64 chemin del prat - 31320 Auzeville France
Tél. : + 33 5 61 73 62 62
Fax : + 33 5 61 73 62 90
Mail : t.clement@oreade-breche.fr
Represented by:
Thierry CLEMENT

IEEP
11 Belgrave Road – London United-Kingdom
Tél. : + 44 (0) 20 7799 2244
Fax : + 44 (0) 20 7799 2600
Mail : CFroomberg@ieep.eu
Represented by:
Claire FROOMBERG

Oréade-Brèche
ENVIRONNEMENT & DEVELOPPEMENT

Institute for European Environmental Policy

TABLE OF CONTENTS

FIGURES

TABLES

BOXES

LIST OF ACRONYMS AND ABBREVIATIONS

AECM: Agri-Environment-Climate Measure
AIR: Annual Implementation Report
AKIS: Agricultural Knowledge and Innovation System
AL: Andalucia
ANC: Area of Natural Constraint
AQ: Aquitaine
BPS: Basic Payment Scheme
C: carbon
CAP: Common Agricultural Policy
CD: crop diversification
CH_4: methane
CLLD: Community-Led Local Development
CO_2: carbon dioxide
CO_2eq: CO_2 equivalent
CZ: Czech Republic
DE: Germany
DP: Direct Payments
EAFRD: European Agricultural Fund for Rural Development
EAGF: European Agriculture Guarantee Fund
EC: European Commission
EEA: European Environmental Agency
EFA: Ecological Focus Areas
EIP: European Innovation Partnership
ES: Spain
ESD: Effort Sharing Decision
ESI-FUND: European Structural and Investment Funds
ESPG: Environmentally Sensitive Permanent Grassland
ESQ: Evaluation Study Question
ETS: Emissions Trading Scheme
EU: European Union
FA: Focus Area
FADN: Farm Accountancy Data Network
FAS: Farm Advisory System
FD: Floods Directive
FQD: Fuel Quality Directive
FR: France
GAEC: Good Agricultural and Environmental Condition
GHG: Greenhouse Gas
Gt: gigatonne
Ha: hectare
HR: Croatia
HU: Hungary
ICT: information and communications technology

IE: Ireland
ILUC: Indirect Land Use Change
IPCC: Intergovernmental Panel on Climate Change
Kt: kilotonne
LT: Lithuania
LU: Livestock Unit
LUC: Land Use Change
LULUCF: Land Use, Land Use Change and Forestry
M: Measures
MA: Managing Authority
MFF: Multiannual Financial Framework
MMR: Monitoring Measures Regulation
MS: Member State
Mt: Megatonne
N_2O: nitrous oxide
NGO: Non-Governmental Organisation
NH_3: ammonia
NL: Netherlands
PI: Pillar I of the CAP
PII: Pillar II of the CAP
PG: Permanent Grassland
R&D: Research and Development
RDP: Rural Development Programme
RED: Renewable Energy Directive
RO: Romania
SFS: Small Farmers Scheme
SMR: Statutory Management Requirement
ST: Saxony-Anhalt
SWOT: Strengths, Weaknesses, Opportunities, Threats
t: tonne
UAA: Utilised Agricultural Area
UNFCCC: United Nations Framework Convention on Climate Change
VCS: Voluntary Coupled Support
WFD: Water Framework Directive
WTO: World Trade Organisation
y: year

1 INTRODUCTION

Agriculture accounts for 10% of EU greenhouse gas (GHG) emissions and the land on which it is practiced has significant carbon sink potential through soils, trees and other biomass. These pools of carbon are vulnerable to losses (and thus CO_2 emissions) but can be preserved and added to through good management. Sensitive management of emissions sources such as livestock and carbon pools such as soil can minimise agriculture's net GHG footprint. In addition, the extent to which land is used for agriculture affects emissions and can affect the vulnerability of rural sectors to climate pressures, whilst levels of production affect the dynamics of markets around the world with consequent implications for global emissions. The measures and instruments in the Common Agricultural Policy (CAP) which affect where in Europe agriculture takes place, what and how much is produced and how agricultural land is managed therefore have important implications for climate action. These can be positive – for example when farmers are encouraged through policy measures to manage their land in ways which reduce carbon losses or increase the carbon stored there – or negative. An example of negative impact is when policy increases the level of greenhouse gas emissions associated with agricultural production, or encourages farmers to reduce carbon stocks such as trees and hedges.

In addition to the part it plays in emissions, agriculture is both threatened by climate change – to which it needs to adapt – and a potential avenue for solutions for society at large, for example in the form of floodwater management and other "green infrastructure".

This evaluation seeks to understand the impact which certain measures of the CAP have had on reducing GHG emissions, agriculture's vulnerability to climate change and its ability to provide adaptation and mitigation services to society. Most of the CAP measures analysed do not have climate action as their intended purpose but may have it as a secondary purpose. Some, such as those which sustain certain forms of agricultural production responsible for emissions, exist for economic, social and sometimes other environmental reasons. We examine the overall relevance, effectiveness and coherence with each other of all measures and instruments covered by the study in respect of climate action. For those measures which are (or can reasonably be) targeted at climate objectives we look at how efficiently they work to this end and whether they do so in a way which is coherent with the CAP's other economic, environmental and social objectives and delivers EU added-value. We look at the impact on production of these measures as well as the part played by the CAP in driving emissions associated with food, feed and biofuels systems in the bio economy. Finally we consider the factors which have enhanced or hindered agriculture's ability to reduce emissions and to adapt to climate change and make recommendations.

The study is based on the CAP measures and their implementation as they stood following the 2013 CAP reform but takes into account relevant evidence from the period since 2003. We took as our counterfactual an EU without the CAP. As far as possible therefore we seek to understand how net emissions within the EU, and the state of adaptation to climate change, would have differed had the CAP not been in place. We consider the role of emissions leakage – when additional or reduced production within the EU leads to changes outside the Union thereby changing the location of emissions and sometimes their extent. However detailed modelling of such leakage is beyond the scope of this study.

The work covers all 28 EU Member States with a focus on ten of them through case studies which were carried out in order to gather detailed information. We take account of other recent work in the field of evaluation including a study carried out for DG AGRI in 2016 (Ecorys, IEEP and Wageningen University & Research, 2016) and recent evaluations of the greening and forest measures in Rural Development (Alliance Environnement and EFI, 2017; Alliance Environnement and Thünen-Institut, 2017).

The Terms of Reference (ToR) focus the work on 24 specific CAP measures which are listed in Table 1. We also consider the impact of the framework within which those measures must be deployed, which includes cross-cutting objectives and priorities relevant to climate along with a requirement for a minimum proportion of expenditure on certain measures.

1.1 CLIMATE CHANGE MITIGATION POLICY RELEVANT TO AGRICULTURE AND FORESTRY

Climate policy in the EU sits within the 2020 Climate and Energy Framework which is in turn contained within a broader framework of action which has evolved over the last two and a half decades to deliver the EU's international climate commitments under the Kyoto Protocol, the UN Framework Convention on Climate Change and the Paris Agreement of 2015

Box 1: Short history of climate mitigation policy in the EU

- **1991** – A year after the first assessment by the International Panel on Climate Change (IPCC), the European Commission established the first **Community strategy to limit CO_2 emissions** and improve energy efficiency;
- **1997** – The **Kyoto Protocol** is adopted introducing fixed EU targets for certain emissions for the first time. No target specific to agriculture is set
- **2000** – The first European Climate Change Programme (ECCP) is established with working groups on agriculture; sinks in agricultural soils; and forest-related sinks.
- **2005** - Kyoto Protocol enters into force, with commitments relating to the periods from 2008 to 2012 and from 2012 to 2020. In addition, the second ECCP is established in the EU, broadening the ECCP objectives to include (amongst other things) climate change adaptation.
- **2007** - EU leaders establish the **2020 climate and energy framework** which introduces three key targets: to reduce GHG emissions by 20% from 1990 levels; to increase to 20% the share of renewable energy; and to improve energy efficiency by 20%.
- **2009** – The EU "Climate and Energy Package" (20/20/20) adopted, including new ETS targets, effort sharing and the Renewable Energy Directive. The **Effort Sharing Decision** introduces mandatory 2020 targets for Member States' non-ETS and non-LULUCF emissions (including the non-CO_2 emissions from agriculture) and the trajectory to reach them. The Renewable Energy Directive which establishes mandatory renewable energy targets for MS, including a sub-target for transport, enters into force. The debate around indirect land use change (ILUC) from the EU production and consumption of biofuels, including feedstock produced in the EU, on agricultural land, continues in the context of the new policy.
- **2013 – LULUCF Decision**. Mandatory reporting on LULUCF activities, including those related to agriculture, largely based on the rules of the Kyoto Protocol for the second commitment period. However, these activities are not counted towards the targets set by the "Climate and Energy Package" (above).
- **2014** - EU leaders reached political agreement and adopted a renewed **climate and energy framework to 2030** setting out a longer-term ambition to reduce GHG emissions after 2020. The 2030 framework sets out GHG reduction targets at the EU level of 40 per cent in relation to 1990 levels, increasing the target share for renewable energy to 27 and the energy efficiency target to 27 per cent. Most of the reduction is to be achieved in those sectors subject to the EU's Emissions Trading Scheme (ETS) but the other sectors collectively – including agriculture – were to contribute a reduction of 30 per cent. Agriculture's role is dealt with explicitly in the Council conclusions which accompanied the decision, which noted that the "multiple objectives of the agriculture and land use sector, with their lower mitigation potential, should be acknowledged". LULUCF (emissions and removals from forest and agricultural land) is to be accounted through special rules.
- **2013** – The EU adopts a Climate Adaptation Strategy for the first time, following publication of a green and white paper on climate adaptation in 2007 and 2009 respectively.
- **2015** – The Paris Agreement seeks to hold 'the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, [...]' and provide a 'bridge between today's policies and climate-neutrality before the end of the century'. The ILUC Directive is adopted,

amongst other things, limiting the contribution of first generation biofuels grown on agricultural land to EU renewable energy targets.

- **2016** – **The Paris Agreement** enters into force and becomes legally binding on the 195 signatory parties when ratified. It does not commit signatories to any specific target for emissions but they collectively commit to the objective that emissions should be reduced to a level sufficient to keep global temperature within 2° of pre-industrial levels.
- In **June 2018** the EU adopted the Effort Sharing Regulation (ESR) which brought increased ambition and more demanding targets for Member States for reductions in GHG emissions from non-ETS sectors (except LULUCF and maritime transport) to be achieved by 2030.
- In parallel, the EU also adopted the LULUCF Regulation, setting out the rules for accounting (mostly CO_2) emissions and removals from that sector. The ESR brings these emissions within the EU's climate target framework for the first time.
- Later in **2018**, a political agreement was reached on the **"recast" of the Renewable Energy Directive**, which will have significant implications on the broader agriculture sector partly through fundamentally driving demand for agricultural and forest biomass from the energy sector, and partly by establishing so-called "sustainability criteria" for all types of bioenergy (biofuels, bioliquids, biogas and solid biomass).

Source: Own compilation

As is shown by Box 1, the EU evolved its policy framework for climate action in response to the development of international commitments. It is important to note, however, that there are no sector-specific targets at EU level for emissions from agriculture. Mitigation efforts for non-CO_2 GHGs emitted by all sectors outside the ETS are covered under the EU's Effort Sharing Decision (ESD) (Decision No 406/2009/EC) and CO_2 emissions addressed primarily under the LULUCF Decision (Decision No 529/2013/EU) to 2020.

The current ESD agreed in 2009 set a target reduction at EU level of 10% by 2020 with net reduction targets set out as binding national emission ceilings compared to 2005 levels. These range from +20% to -20%, depending on the GDP per capita of each country and are shared across the sectors covered by the ESD. Different target reductions were set for each Member State according to factors such as their level of economic development and the share which agricultural emissions – which are accepted as being hard to reduce – represented.

CO_2 emissions from agriculture are then largely addressed under the Land Use, Land Use Change and Forestry (LULUCF) Decision, relating to forestry, wetlands, cropland and grassland management. The LULUCF Decision provides the guidance and accounting rules necessary for Member States to complete their obligations. The LULUCF decision is not formally part of the 2020 climate and energy package, yet under Kyoto, the EU and its Member States are required to ensure that GHG emissions from the LULUCF sector are compensated by equivalent removals in the same sectors, the so called 'no- debit rule'.

The Paris Agreement restated the necessity of adaptation efforts through climate policy beyond 2020 with a global goal of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response" (UNFCCC, 2015). Article 7 sets out the key adaptation intentions under the Agreement. The EU's intended action on climate adaptation is set out in the Climate Adaptation Strategy (COM (2013)216).

1.2 Adaptation of the EU agriculture sector and society to climate change

1.2.1 Vulnerability of the EU agricultural sector to climate change

Most climate change scenarios predict a minimum increase in average global temperature of 2°C over the pre-industrial level by 2050. Such a rise is expected to alter key biophysical variables in both climate and ecosystems, changing long term trends in localised temperatures, rainfall patterns and also increasing the frequency and intensity of extreme climatic events such as storms, droughts and intense precipitation.

Given its dependence on favourable climatic conditions, agriculture is among the economic sectors most vulnerable to climate change. The main impacts foreseen on the EU agriculture sector are the following. Most are adverse but some may be beneficial to the sector at least in the short run (EEA, EEA, 2017a):

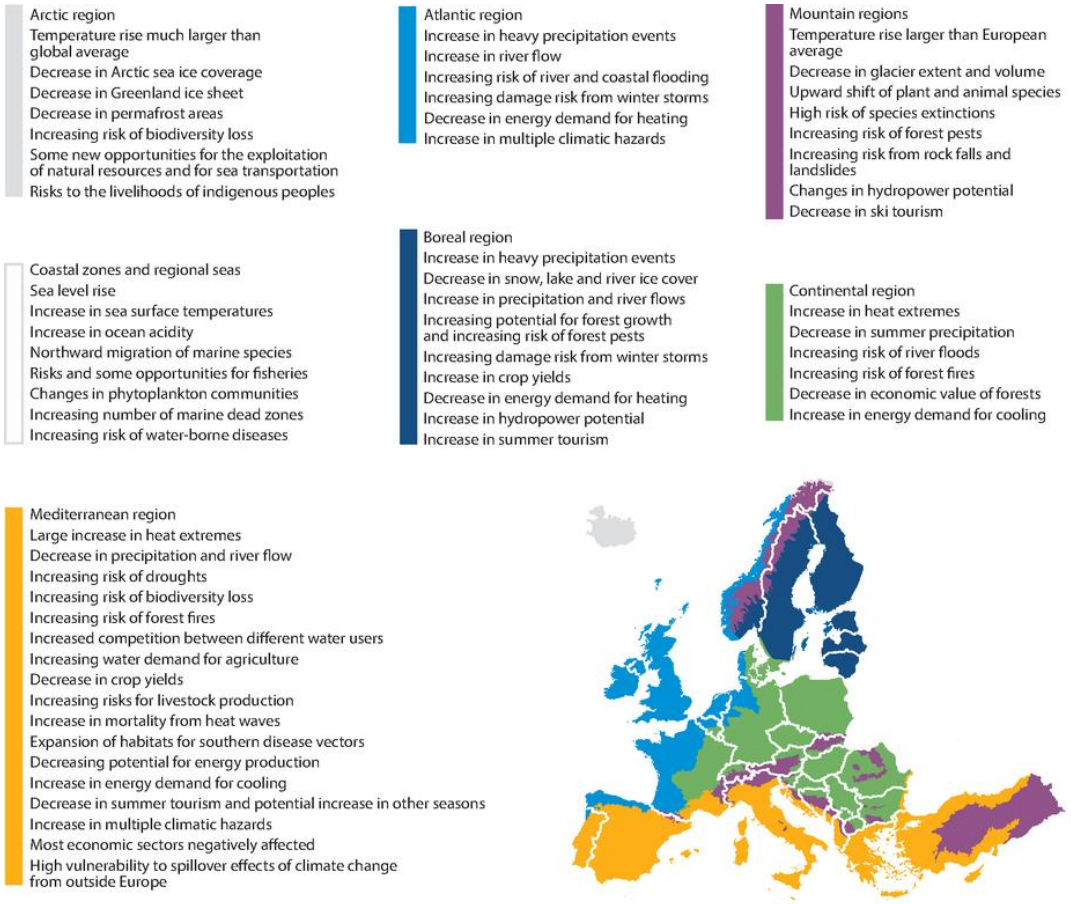
- The increase in the duration of the thermal growing season will lead to the northwards expansion of the areas in which certain crops can be grown (e.g. areas favourable to grassland, wheat and barley are expected to expand in the boreal zone - Finland, Sweden, Lithuania, Estonia, Latvia). This has already been observed. In parts of southern Europe (e.g. Spain), warmer conditions will allow summer crop cultivation to be shifted to the winter in some cases;
- Changes in crop phenology have been observed and will continue leading to a reduced duration of the grain-filling phase of cereals and oilseed crops which can be particularly detrimental to yield;
- The increase in temperature is expected to increase the incidence of crop pests and animal diseases;
- An increase in the occurrence of extreme events (heat waves, droughts and floods), which is already happening, is expected to increase the risk of crop losses and damage to livestock production, especially in central and southern Europe;
- Irrigation demand is projected to increase, in particular in southern Europe where there is already considerable competition between different water users.

A key challenge will be the increased unpredictability of the weather. However current research confirms both the direction of climate change (e.g. making dry regions drier and wet regions wetter) and an increased probability and severity of weather events in the future (EEA, 2017c). The exact magnitude and timing of the various impacts remaining inherently uncertain (Hart et al, 2017) makes effective adaptation both necessary and difficult. Successful adaptation to climate change will require multiple forms of actions and modes of governance. Contingency planning, risk management, and diversifying farming systems and economic activities, as well as targeted actions to limit climate impacts (such as adapting production and crops to water scarcity and droughts), while simultaneously harnessing new, emerging opportunities will all be key elements of successful adaptation in agriculture (EEA, 2017b)

The European agriculture sector will also be affected by climate change impacts outside Europe, due mainly to climate change impacts on agricultural commodities markets or disruptions to transport networks. Both are likely to lead to an increase in price volatility.

The vulnerability of the different Member States to climate change varies significantly according to their exposure, sensitivity and their adaptive capacity. The exposure to climate change depends mainly on the biogeography of the different European regions (see figure below). For example, mountain regions and coastal regions will be affected differently from other regions (see Figure 1).

Figure 1: Key past and projected impacts of climate change for the biogeographical regions of Europe



Source: EEA (2017)

1.2.2 POLICY CONTEXT FOR CLIMATE ADAPTATION IN THE EU

The **EU Strategy on Adaptation** adopted by the Commission in 2013, aims to contribute to a more climate-resilient Europe and enhance its preparedness and capacity to respond to the impacts of climate change at the local, regional, national and EU levels (COWI, 2017). The Paris Agreement has reinforced the goal of *'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change'*.

The objectives of the EU's Climate Adaptation Strategy are to promote action by Member States by encouraging them to develop adaptation strategies which are relevant to their context; to promote better-informed decision making by addressing gaps in knowledge; and to promote adaptation in key vulnerable sectors (of which agriculture is considered to be one) by mainstreaming adaptation action into policies such as those for cohesion, fisheries and agriculture.

Unlike the policy framework for mitigation, the EU's adaptation strategy does not set binding targets or requirements for Member States. Instead it focuses on providing supporting documents and guidance to help Member States to develop their own adaptation initiatives in a coherent way and with respect to subsidiarity. Transboundary adaptation issues are, however addressed at the EU level e.g. economic and ecological interdependence, shared climate change concerns such as floods, coastal management, and water management). The strategy asks for a higher consideration of these transboundary issues. It also comprises a series of documents and supporting guidance to achieve the three objectives of the adaptation strategy, including principles and recommendations on the integration of adaptation activities into the 2014-2020 RDP (i.e. improve information of risks and

defines needs for an improved resilience in 2020). Member States are encouraged to develop adaptation strategies and report these through the Monitoring Measures Regulation (MMR).

The main actions for adaptation that can be supported through public funding can be grouped into five themes (Ignaciuk, 2015):

- Research & development (R&D) for instance to assess the impact of climate change or to support the development of new technologies for farmers (e.g. low fertilizer application technology);
- Capacity building to increase knowledge and mainstream best practices;
- Risk management allowing to improve the resilience against risks due to increased incidence of extreme climatic events and increased prices volatility due indirectly to climate change; better information including timelier and more accurate weather alerts; and promoting the availability of insurance products and other instruments (e.g. Income stabilization tool).
- Infrastructure aiming at increasing resilience or the adaptive capacity in the agricultural sector (e.g. rainwater tanks)
- Funding mechanisms for adaptation activities at the farm level.

1.3 Climate action in the Common Agriculture Policy

The present day CAP contains both a climate action objective, a number of measures (both compulsory and voluntary for farmers and Member States) which are intended to secure climate benefits, and a requirement for a minimum proportion of funding to be spent on environment and climate measures. These arrangements have developed over time.

While climate action was not a stated priority for the CAP prior to 2007, the development of the CAP from 1992 will have affected emissions of greenhouse gases from EU agriculture. In broad terms both price support and coupled payments raise production above equilibrium levels. Where such support is offered in respect of production which is a source of emissions, such as livestock production, it can be expected to raise emissions of associated GHGs within the EU but with a countervailing reduction in emissions outside the EU where production may decrease. Support for GHG-reducing production such as protein crops can reduce emissions within the EU.

The introduction of decoupled direct payments enabled the introduction of a number of measures requiring farmers in receipt of such payments to adopt climate-friendly practices. The 2003 reform introduced so called cross-compliance obligations which required all farmers in receipt of direct payments as well as those receiving area payments under rural development policy to comply with a range of Statutory Management Requirements (SMR) and standards of Good Agricultural and Environmental Condition (GAEC)[1]. In particular, GAEC obligations required Member States to put in place standards to reduce soil erosion and to maintain soil organic matter levels and soil structure, all of which had the potential to be beneficial for carbon storage and sequestration. Within cross-compliance, rules were also introduced to protect permanent pasture by setting limits at national level for the proportion which could be ploughed and thereby give rise to emissions of CO_2.

Prior to 2007, rural development measures in Pillar II were clustered around nine themes (Council Regulation (EC) No 1257/1999), including agri-environment and forestry measures. Forestry measures were intended to promote in particular: sustainable forest management and development of forestry; maintenance and improvement of forest resources; and the extension of woodland areas. Agri-environment measures were intended to promote ways of using agricultural land which are compatible with the protection and improvement of: the environment, the landscape and its features; natural resources; the soil and genetic diversity; an environmentally-favourable extensification of farming and management of low- intensity pasture systems; the conservation of high nature-value farmed environments which are under threat; the upkeep of the landscape and historical features on agricultural land; the use of environmental planning in farming practice; and the improvement of

[1] Council Regulation 1782/2003

animal welfare (introduced in 2003). Member States were obliged to implement the agri-environment measures but free to design them in ways that met their own environmental priorities.

For the period 2007-2013 rural development policy was revised and reoriented around four axes, as set out in Council Regulation (EC) No 1698/2005[2]. A series of objectives were identified in strategic guidance[3] for each of the rural development 'axes'. Under Axis 2 (improving the environment and the countryside) climate change was highlighted for the first time explicitly, stating that "*the resources devoted to axis 2 should contribute to three EU level priority areas: biodiversity and preservation of high nature value farming and forestry systems, water, and* ***climate change***." Importantly, Member States were also required to allocate at least 25% of their total EAFRD budget to Axis 2 measures. Overall, at EU level, the EAFRD budget had increased, from €57,689 million over the period 2000-2006 to €92,200 million for the period 2007-2013.

The 2008/09 Health Check amended a number of CAP rules. Of relevance to climate action, the changes made to the direct support Regulation (Council Regulation (EC) No 73/2009) brought about increased rates of compulsory modulation (transfers from Pillar I Direct Payments to the Rural Development Programme) for the remainder of the budget period to 2012/13, applicable to all payments above €5,000. The additional funds raised were used to provide greater support to Member States' Rural Development Programmes (RDPs) and specifically to those areas, including climate change, which were identified as being 'new challenges'. The preamble to the regulation giving effect to these changes referred to the need for the EU to *'adapt its policies in the light of climate change considerations'* to address commitments made under the Kyoto Protocol, whose first commitment period had started in 2008[4].

The budget allocated to the new challenges also included funds released through additional voluntary modulation, corresponding to Member States' voluntary transfers from Pillar I to Pillar II, and the European Economic Recovery Package (EERP) which aimed to boost "smart" investments in response to the economic and financial crisis of 2008/09. In total, an additional budget of approximately €3 billion (excluding national co-financing) was made available for Member States to spend on these challenges through their RDPs. Of this, approximately 14 per cent was allocated by 19 of the 27 Member States to measures focused on addressing climate change priorities, with the highest proportions allocated in Belgium, the Czech Republic, Germany, Luxemburg, Slovenia, Slovakia and the UK.

Two other changes to the CAP in 2009 with implications for climate were the cessation of specific support for energy crops (which form part of the EU's energy mix and hence impact emissions from energy-using sectors) and the abolition of mandatory set-aside on arable land, which increased the amount of land potentially available for production. The removal of support for energy crops was justified on the basis that binding bio-energy targets would in future drive the development of the biofuels market via the demand side, whilst economic reasons were behind the end of compulsory set-aside

The 2013 CAP reform under Commissioner Ciolos introduced further change in the form of the greening measure. The rationale for greening of CAP direct payments was to further encourage environmentally sustainable and climate beneficial agricultural practices over the majority of the farmed countryside, where direct payments are applied but Pillar II measures are not necessarily in place. The introduction of 'simple, generalised, annual and non-contractual payments' for actions to be taken by the majority of farms over the majority of the farmed land is intended to raise the

[2] Axis 1: improving the competitiveness of the agricultural and forestry sector; Axis 2: improving the environment and the countryside; Axis 3: quality of life in rural areas and diversification of the rural economy; Axis 4: LEADER

[3] Community Strategic Guidelines for Rural Development, Council Decisions 2006/144/EC

[4] Council Regulation 73/2009, recital 9

environmental performance of EU agriculture and thus render it more sustainable. The greening measure includes a number of obligations and choices with direct climate impact, such as crop diversification, stronger protection for permanent grassland likely to be storing carbon, and encouragement for a number of practices on arable land including growing N-fixing crops (likely to reduce emissions from nitrification) and catch crops among others. Some of the practices required by the greening measure replaced measures which were previously part of cross-compliance, or duplicated existing measures. However, it was expected that the greening mechanism, being policed through frequent checks and with the prospect of more stringent penalties than were likely for breaches of cross-compliance, would strengthen the incentives to farmers to comply (Alliance Environnement and Thünen-Institut, 2017).

The 2013 CAP reform also went a step further in terms of incorporating climate priorities into the CAP, by including climate action in one of three new core objectives for the CAP as a whole: viable food production; sustainable management of natural resources and climate action; and balanced territorial development. As a result in 2013 climate action became for the first time an objective for both Pillar I and Pillar II.

Following the 2013 CAP reform, the 'sustainable management of natural resources and climate action' is now one of the three core objectives of the CAP, and climate is addressed under both pillars. Climate-friendly land use and management practices, including investment in climate action, as well as capacity building are supported through a mix of mandatory and voluntary instruments.

Direct payments under Pillar I account for approximately EUR 293 billion or 72% of the overall CAP budget in the current programming period. Cross-compliance requirements apply to these payments covering both statutory management requirements (SMR) as laid down in EU directives and regulations and Good Agricultural and Environmental Conditions (GAEC) as specified by each Member State[5]. These requirements include some which are of relevance to climate action. Compared to the 2007-14 period, the number of GAEC standards has been reduced to seven covering water, soils and landscape, and MS are required to implement all of them. The architecture of direct payments now includes the greening measure, under which 30% of a farmer's direct payment is made conditional on the performance of a series of environmental actions, plus a compulsory top-up payment for young farmers, an optional scheme whereby Member States may offer payment on a simplified basis (and without the greening measure), and an optional scheme for the support of areas of natural constraint. Concurrently, the list of issues on which MS must offer advice to farmers through Farm Advisory Services has been extended and now covers greening payments (among others). For the first time, Pillar I measures are subject to formal monitoring and evaluation requirements alongside Pillar II, with indicators and formal reporting procedures put in place.

Support for **rural development policy (Pillar II)** is co-financed by the EAFRD and national or regional budgets. The EAFRD defines six EU level priorities of which every RDP must address at least four and also cross-cutting objectives of innovation, environment and climate mitigation and adaptation[6]. Priority 5, which has 5 Focus Areas, explicitly addresses resource efficiency and the transition towards a low carbon and resilient economy. The Rural Development Regulation contains a suite of 19 measures and 64 sub-measures. Member States can choose which measures to implement but must make use of the Agri-Environment Climate Measure (AECM). RDPs cover either an entire Member State or, in the case of federal Member States such as France and Germany, a region. The programming period runs until the end of 2020. They are subject to approval by the European Commission. In the current period, new measures include the AECM, a separate organic farming measure, a measure for cooperation and one for risk management. Each Member State is obliged to implement the AECM and the LEADER approach but are free to decide how to design and use these and any other RDP measures to meet their national or regional needs. At least 30 % of the

[5] With the exception of GAEC 6 for which the regulation requires a compulsory ban on stubble burning in addition to any requirements which Member States may design.

[6] Article 5 of Regulation (EU) No 1305/2013

EAFRD contribution to each RDP must be reserved for specific measures relevant to climate change mitigation and adaptation and the environment. These are the measures for: agri-environment-climate and organic farming, Natura 2000, payments to areas facing natural or other specific constraints, forest-environmental and climate services and forest conservation, environment and climate-related 'non-productive' investments and investments in forest development and viability.

2 MEASURES EXAMINED, INTERVENTION LOGIC AND THEORETICAL EFFECTS ON CLIMATE

The CAP measures which are the focus of this study are listed in Table 1 along with their intervention logic (based strictly on analysis of the CAP regulations) and our assessment based on literature and expert judgment of their theoretical impacts on climate. As can be seen from the table, most measures have objectives other than climate action, such as supporting farmers' incomes. Very few measures have an explicit intervention logic for the achievement of adaptation objectives neither for farmers nor for society at large. Only those measures which explicitly mention in either the recital or measure description "adaptation to climate change" or one of the closely related themes "climate resilience", "adverse climate events" and "risks as a consequence of climate change" have been identified as measures with intended effects on adaptation.

A larger number of measures have an intervention logic which involves the mitigation of emissions. These measures with an explicit intervention logic of climate action are the ones we focus on in ESQ7 (efficiency), ESQ9 (external coherence) and ESQ11 (relevance) where in each case the evaluation question asks for an answer focussed on the CAP's climate measures rather than the full suite of CAP measures which are the subject of other ESQs.

The remaining CAP measures which lack an explicit intervention logic towards climate action in the Regulations may still have climate effects. The theoretical effects are set out as far as possible in the table for mitigation. In the case of adaptation, however, the range of theoretical effects is very large and is discussed in the appropriate level of detail in the answer to ESQ5. It has been based on a literature review and case studies.

From the table, it can be seen that the measures with an intervention logic towards climate mitigation are GAECs 4, 5 and 6 plus the Farm Advisory system, both elements (ratio and ESPG) of the greening measure for permanent grassland, and measures 2,4 (non-productive investments), 6, 8, 15 and 16 in the rural development programme. Those with an intervention logic towards adaptation are the Farm Advisory Service plus measures 2, 5, 8, 10, 15, 16 and 17. These are the measures whose efficiency and external coherence with non-climate CAP objectives we evaluate in ESQs 7 and 9. Apart from the voluntary redistributive payment, all other measures are assessed as having at least theoretical impacts on climate mitigation. Adaptation impacts of all measures are examined in ESQ5.

Table 1: CAP measures, intervention logic and theoretical impacts on climate

Measure / instrument	Objective in the regulation	Mitigation explicitly a measure target	Theoretical effects on mitigation	Adaptation explicitly a measure target	Theoretical effects on climate adaptation
Direct payments	Support farm incomes	No	Direct payments enable farming to continue on some land which would not otherwise be farmed. Negative, neutral or positive effects on emissions are possible depending on the use this land would otherwise be put to and how any production on this land would be replaced. It is not possible from theory to predict which of these will arise but the relative performance of EU production systems compared to that of marginal sources of supply can give an indication. Eligibility rules for direct payments determine which farms are subject to cross-compliance and greening requirements. The climate impacts of these rules are discussed below.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Voluntary redistributive payment	Smaller farms cannot achieve the same economies of scale as large ones so need more income support	No	Same as for direct payments	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Greening measure (crop diversification)	Mainly intended to improve soil quality[7]	No	Impacts may arise where the measure causes different crops to be grown than would otherwise have been the case. If this leads to longer rotations, increased soil organic matter may result. The introduction of legumes in place of crops which require mineral N is likely	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

[7] Recital 41 to Regulation 1307/2013

			to reduce nitrification and emissions of N_2O		
Greening measure (permanent grassland ratio)	Maintaining carbon stocks/reducing losses[8]	Yes	Restricts farmers' ability to convert permanent grassland. If this results in such grassland not being ploughed at all then release of soil CO_2 is avoided and on grasslands which are sinks it enables sequestration to continue. If permanent grassland is ploughed then re-seeded with grass these benefits (compared to an absence of controls on ploughing) are reduced.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Greening measure (environmentally sensitive permanent grassland)	Maintaining carbon stocks and, where applicable, sequestration. Areas designated as ESPG should be those that contribute most to carbon sequestration, biodiversity and soil protection	Yes	Ensures that farmers may not convert or plough permanent grassland at all in areas designated as ESPG. In areas already designated under the N2000 directives this is likely to complement and strengthen existing protection. A reduction in ploughing results in avoided soil CO_2 emissions.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Greening (ecological focus area)	To safeguard and improve biodiversity on farms	No	The following EFA options may theoretically change soil carbon stock and biomass above ground via sequestration, as well as reducing the loss of soil organic carbon through erosion: Landscape features: hedges, isolated trees, groups of trees, trees in line; Agroforestry Afforested areas In addition the following EFA options may	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

[8] Recital 42 to Regulation 1307/2013

			change soil carbon stock via sequestration as well as reducing soil erosion: Short rotation coppice Buffer strips The protection of terraces has the potential to reduce soil erosion. Catch crops may reduce GHG emissions if they reduce the need for mineral fertilisation of the following crop, as well as protecting soil from erosion Nitrogen-fixing crops reduce the mineral N requirement of the following crop and thus the scope for N_2O emissions		
Voluntary payment for farmers in areas with natural constraints	Promote the sustainable development of agriculture in areas with specific natural constraints	No	As with direct payments, any impact (other than an income effect) arises if farming is enabled through additional support to continue in areas where it would otherwise cease to exist or be carried out in a different manner. It is not possible to say a priori what the theoretical impact of the measure will be on GHG emissions.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Voluntary coupled support	To support specific types of farming or specific sectors which are important for economic, environmental or social reasons To enable additional support for protein autonomy	No	A variety of impacts is possible. Coupled support to ruminant livestock is likely to raise their numbers compared to the counterfactual, even though support has been restricted by the regulations to that necessary to maintain historic "reference" levels during the period examined by the study. Higher livestock numbers are associated with higher emissions of CH_4 and CO_2. Coupled support for protein crops is likely to reduce N_2O emissions due to a reduced need for mineral fertiliser when compared to a counterfactual in which other crops are grown.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

Small farmers' scheme	Reduce the administrative costs of the management and control of income support	No	The SFS removes the possibility for Member States to sanction participants for breaches of cross-compliance, and exempts all small farmers from the greening measure. Since both of these measures have theoretical benefits to mitigation, the impact of the SFS on emissions must theoretically be to reduce those benefits.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Cross-compliance SMR 1	Improve compliance with the nitrates directive	No	The measure theoretically increases the likelihood that farmers will comply with Nitrates Directive measures involving reduced inputs of mineral fertiliser and manure which may reduce N_2O and CH_4 emissions respectively.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Cross-compliance GAEC1 (establish-ment of buffer strips along water courses)	Protect watercourses from pollution using buffer strips	No	Depending on how a buffer strip is managed (whether it is ploughed and reseeded, for example), buffer strips are likely to improve soil carbon stock and protect soil from erosion.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
GAEC2 (Compliance with authoris-ation procedures for irrigation water)	Reduce water abstraction	No	The measure is used to reinforce control of access to water for irrigation, but could also maintain soil carbon by protecting wetlands which are otherwise at risk of drying out.	No	The measure may have an impact on adaptation to climate change, in particular in areas affected by water scarcity. The link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
GAEC3 (Ground-water protection)	Protect groundwater from pollution	No	Reductions in N application are likely to reduce direct and indirect emissions of N_2O. Reduced pollution of groundwater reduces risk of damage to wetland carbon sinks	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
GAEC4 (minimum soil cover)	Maintain and enhance soil carbon	Yes	Reduction in loss of soil carbon through erosion	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

GAEC5 (site specific erosion controls)	Maintain soil carbon	Yes	Reduction in loss of soil carbon through erosion at sites particularly vulnerable to erosion	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
GAEC6 (Mainten-ance of soil organic matter)	Maintain soil organic matter	Yes	Avoided CO_2 emissions from burning	No	The measure theoretically has an impact on adaptation, as soil organic matter and soil structure affects its water retention abilities. The link is however not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
GAEC7 (Retention of landscape features)	Maintain and increase biodiversity.	No	Protection of biomass landscape features is likely to help conserve/enhance soil carbon stock as well as protecting the landscape feature itself. Protection of these and non-biomass landscape features (e.g. walls) may reduce the loss of soil carbon through erosion.	No	Even though the measure may have an impact on the adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
Farm Advisory Systems	Raise awareness of the links between farm practices and environmental and other standards.	Yes	By requiring the provision of knowledge and information services on cross-compliance and more broadly on environmental issues such as climate change (which is required by EU regulation), this measure is expected to contribute to the diffusion of practices beneficial to climate mitigation.	Yes	By requiring the provision of knowledge and information services on cross-compliance and more broadly on environmental issues such as climate change (which is required by EU regulation), this measure is expected to contribute to the diffusion of practices beneficial to climate adaptation and improve adaptive capacity of farmers.
M1: Knowledge transfer and information actions	Improve technical and economic training and increase capacity to access knowledge and information	No	The measure can be used to spread knowledge and improve access to information about climate mitigation, although Member States are not required to use it for this purpose.	No	The measure can be used to spread knowledge and improve access to information about climate adaptation, although Member States are not required to use it for this purpose.

M2: advisory farm management and relief services	Improve access to advice	Yes	By requiring the provision of knowledge and information services on cross-compliance and more broadly on environmental issues such as climate change (which is required by EU regulation), this measure is expected to contribute to the diffusion of practices beneficial to climate mitigation.	Yes	By funding farm advisory services that are asked to inform farmers on climate change, and by supporting the diffusion of knowledge and innovation, this measure is expected to contribute to the diffusion of practices beneficial to adaptation
M3: Quality schemes	Enhance market opportunities	No	It is theoretically possible that low GHG intensity, or the use of specific management practices linked to climate benefits, could be adopted as quality criteria and that this could incentivise reductions in emissions by farmers participating in a scheme.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
M4: Investments in physical assets	Support provision of physical infrastructure	Yes (support for non-productive investments is linked to the objectives of agri-environment climate schemes).	Productive investments contributing to climate mitigation can include: animal housing and equipment in cattle production and other ruminants (cow sheds, milking units, manure and slurry storage/processing, winter housing); animal housing and equipment in pig and poultry production (housing with high animal welfare standards, manure and slurry storage/ processing); farm buildings in plant production (facilities for postharvest treatment and storages for field crops); support and cover constructions for perennial crops; biomass processing for energy (new units and equipment for processing biomass pellets and briquettes); biogas stations (biogas power stations including local distribution of heat); and food processing equipment. Non-productive investments contributing to climate mitigation include: capital works within the framework of an AEC contract and restoration of wetlands and moorland. The GHG impacts of many investments are complex and can include negative ones.	Yes	The measure is expected to have an impact on the adaptation to climate change through support to infrastructure related to adaptation and support for non-productive investments linked to the objectives of agri-environment climate schemes. The potential effects of the measures are analysed in ESQ5.

M5: Disaster risk reduction	Support actions to reduce the probable consequences of natural disasters and investments to restore land and production potential where they have occurred	No	Landscape features (e.g. hedges) created as part of preventative or restorative action may also increase carbon stock.	Yes	The measure is expected to improve the resilience to climate change thanks to preventive actions (e.g. support for investments in drainage systems in northern regions where more rain is expected in the coming years) as well as restoring actions after adverse climatic events. The measure may have unintended positive or negative effects, they are analysed in ESQ5.
M6: farm business and development	Assist farm business development	Yes	Identified in the EAFRD regulation as a measure with the potential to contribute to climate action, although not explicit in the wording of the article. Further detail is provided in the delegated act detailing the content of the business plans required as part of this measure (Art. 5). It must include the details of the actions, including those related to environmental sustainability and resource efficiency.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
M7: Basic services and village renewal	Raise growth potential and promote sustainability of rural areas	No (but increasing renewable energy is referred to)	Under 7.2 (including investments in renewable energy and energy saving), investments can include: - facilities to produce and use regenerative energy in rural municipalities (e.g. district heating networks to use and process heat of bioenergy plants); - establishing distribution networks for heat/ electric/ gas power from biomass or other renewable sources; While 7.6 (for the maintenance, restoration and upgrading of the cultural and natural heritage of villages, rural landscapes and high	No	Even though the measure may have an impact on the adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

			nature value sites including related socioeconomic aspects and environmental awareness actions) may support studies relevant to climate mitigation such as territorial studies for the design of local AEC measures and information on the actions		
M8: forest investments	Extend and improve forest resources (including agroforestry) as climate friendly land use. Support investment and management, including resilience and fire prevention.	Yes	Afforestation and agroforestry affect carbon stock (in soil, biomass and dead organic matter).	Yes	As far as adaptation is concerned, **M8.3 and M8.4** are expected to improve forest resilience thanks to improved risks management (pest control, fire prevention, restoration). **M8.5** is meant to improve the resilience of forest to climate change (i.e. introduction of adapted species, of mixed stands…). The sub-measures may have unintended positive or negative effects, which are analysed in ESQ5.
M10: Agri-environ-ment-climate	Support farmers or groups of farmers to change or maintain their agricultural practices to contribute to climate change mitigation and adaptation and that are compatible with	Yes	Examples of mitigation activities funded include: Maintain permanent pasture; Restriction on peat cutting; No grazing; No fertiliser application; Limits to fertiliser application; Grass cover; Green cover; Erosion prevention strips; No tillage; Ploughing-in of crop; Buffer strip; Fallow; Rotation with legumes; No burning of straw, stubble or cut residue; Management of non-aquatic landscape feature; Strips or patches for wildlife; Maintain area out of production; Take area out of production; Traditional grass management; Grazing regime; No machinery;	Yes	The measure has diverse potential as regards adaptation: **M.10 1** may improve farms and more generally 'society' resilience by establishing areas of semi-natural vegetation and landscape elements and promoting practices that improve water retention, limit soil erosion, resilience to floods, etc. For instance, diversification, improved management of landscape features, increase use of forage crops, etc. are some examples

	protection and improvement of environment and landscape, natural resources, soil and genetic resources.		Management plan; Overwinter stubbles; Mulching regime; Tillage regime; Runoff furrows Traditional crop management; Rotation; Traditional orchards; Pruning regime; Management of water features; Water level management		of practices that can be promoted within these measures. M10.2 may improve resilience thanks to the conservation, use and development of resilient varieties (e.g. more resilient to droughts). The sub-measures may have unintended positive or negative effects, they are analysed in ESQ5.
M11: Organic Farming	Respond to society's demand for increasingly environment and welfare-friendly farming practices	No	Generally lower direct emissions per hectare farmed than conventional systems due to greater use of soil management systems and legumes. Longer rotations likely to increase sequestration where soil is a sink, but also increase ILUC. Such leakage is discussed in section 3.2 but is otherwise outside the scope of this study. Organic systems avoid the use of mineral fertiliser and use biological N-fixing where appropriate, leading to a reduction in direct N_2O emissions compared to conventional systems.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
M12: Natura 2000 and Water Framework Directive	Compensate farmers for specific disadvantages arising from them having to farm in N2000 areas and meet requirements going beyond those applying outside such	No	Payments to conserve and restore wetland and peatland in Natura 2000 areas will contribute to carbon sequestration where these areas have carbon rich soil. Possibility of ILUC if the payment helps to secure compliance with restrictions on production.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

	areas.				
M13: Areas facing natural constraints	Encourage continued use of agricultural land	No	High level of uncertainty in the outcome of this measure: on the one hand it can be seen to be preventing land abandonment and loss of grassland (with the result of protecting C stocks in soil); but on the other hand it can be seen to be driving grazing practices where the practice would otherwise be abandoned (with the result of driving GHG emissions) and/or preventing succession to forest or other wooded land). Land abandonment is implicated as a major cause of the increasing intensity of forest fires (through increased accumulation of fuel load, lack of actions that prevent fires, later detection and response to fires, etc.)	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
M14: Animal welfare	Encourage high standards of animal welfare	No	No relevant activities to climate mitigation identified. Activities are detailed in the accompanying delegated act (Art. 10) and refer to water, feed and animal care, housing conditions, outdoor access and avoiding mutilation of animals.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.
M15: Forest-environ-ment-climate			Likely to contribute to maintaining the status quo for removals by providing support to forested land and protecting carbon stock in soil and above ground biomass. Main mitigation activities supported include restructuring (relevant to mitigation, involves the maintenance of diverse forest edge or second crown layer to preserve forest microclimate and prevent the carbon content of the forest soil); low impact silviculture, e.g. protection of the forest soil and ensuring its development, soil friendly harvesting, transporting and regeneration methods	Yes	Eligible actions is expected to improve climate resilience by undertaking sustainable forest management practices. The measure may have unintended positive or negative effects, they are analysed in ESQ5.

			(continuous cover instead of clear cutting); and other practices such as leaving groups of trees after final felling, preservation of wetland habitats, repression of aggressively expanding non-indigenous tree and shrub species.		
M16: Coopera-tion	Support a variety of forms of cooperation including joint actions to secure greater environmental and climate benefits by acting on a larger scale/un-broken area	Yes	Can contribute to driving research in climate mitigation actions with the result of improving the knowledge base and improving capacity to deliver them.	Yes	Support under M16 may promote adaptation to climate change thanks to i) support for the elaboration and diffusion of innovative practices, ii) better planning of resource management, iii) support to the diversification of holdings' activities. The measure may have unintended positive or negative effects, they are analysed in ESQ5.
M17: Risk Management	Assist farmers in addressing the most common risks facing them	No	No mitigation impact unless those providing insurance to farmers insist on risk prevention measures which have incidental benefits to mitigation. For instance, an insurer might insist on the planting of trees or hedges to manage floodwater which have the incidental benefit of adding to carbon stocks.	Yes	By improving the resilience to shocks linked to climate changes (i.e. climatic hazards, economic crisis, etc.) the measure supports the adaptation of holdings to climate change. The measure may have unintended positive or negative effects, they are analysed in ESQ5.
M19: Leader	Support community-led development actions	No	CLLD strategies can include climate actions and support towards transition to a low carbon economy and reducing GHG emissions. However this measure has a capacity strengthening role rather than driving the climate actions.	No	Even though the measure may have an impact on adaptation to climate change, the link is not explicit in the regulation. The potential effects of the measures are analysed in ESQ5.

More detail of these measures and the extent to which Member States deploy them under climate relevant priorities is in Annex 1.

3 GENERAL PRINCIPLES AND METHODS FOR THE EVALUATION

3.1 MAIN METHODOLOGICAL TOOLS

We use a variety of tools to cast light on the evaluation study questions, generating quantitative and qualitative data as appropriate. Different techniques are used for different types of question, and the detailed descriptions below report on the techniques we use in particular cases. Table 2 summarises the main types of tool we used.

Table 2: Description of the data collection and analytical tools

Method/Tool	Brief description of tool	Type of tool	Relevant ESQ
Data collection tools			
Simulation	To quantify the impact of CAP measures on GHG emissions by combining uptake data reported by Member States with relevant emissions factors from literature, using a modelled baseline with which to contextualise the results.	Quantitative	ESQ 1-4
Documentary research / Literature Reviews / Statistical data analysis	To draw on the available literature, key unpublished grey literature and other datasets (statistical etc.) to: - Establish the counterfactual situation; - Map MS/Regions' implementation decisions; - Examine the causal relationship between the actions or management practices supported by a policy instrument/measure and the main outcomes and how these might differ geographically in different biophysical or climatic situations; - To establish the key drivers and pressures influencing the agriculture, forest sectors and rural areas more generally, the state of the environment and key threats to help inform the counterfactual /baseline situation as well as to enable an assessment of relevance; - To review the effects of previous CAP instruments/measures; - To review the range of factors influencing *inter alia* the effectiveness and efficiency of measure implementation; To identify any issues of coherence	Qualitative & quantitative	All
Questionnaire based surveys	Used to gather data from a small, non-representative sample of farmers in each of ten case study Member States about their experience of climate pressures and relevant CAP instruments. Also used with farm advisors to gain information on the extent of uptake of different types of innovation.	Qualitative (because of sample size)	ESQs 5,6,10
Case studies	Used to provide a detailed picture of CAP implementation and climate action in ten Member States.	Qualitative & quantitative	All

Method/Tool	Brief description of tool	Type of tool	Relevant ESQ
Analytical tools			
Cost-effectiveness analysis	Comparison of the benefits of a policy instrument with the costs involved in securing them.	Quantitative	ESQ7
Coherence matrix and scoring	Used to analyse the coherence between regulations and/or intervention logics. Standardised approach used for the assessment of the internal and external coherence of different CAP instruments and the way they have been applied in Member States/regions.	Qualitative	ESQs 10 & 11

3.2 EMISSIONS LEAKAGE

Climate change is a global phenomenon driven mostly by the impact of net GHG emissions. To fully account for GHG emissions and removals which result from changes to agricultural systems within the EU caused by the CAP, there is a need to consider any resultant GHG emissions elsewhere.

The occurrence of GHG emissions outside the local agricultural production system boundary, as a result of local change (e.g. implementation of an agricultural measure to modify environmental impact), may be referred to as leakage. The term is used to mean net emission change, including emissions, mitigation of emissions, and removals (removals from the atmosphere of GHGs, also termed sequestration) outside the system boundary.

An example of leakage is GHG emission through loss of soil organic carbon, when there is land use change (LUC) in another place, as a consequence of a measure that decreases production of a crop where the measure is implemented. This example deals with emissions from indirect land use change (ILUC), and this is an important type of leakage because the leakage can be large relative to the direct GHG emissions (or mitigation of GHG emissions) at the site of measure implementation.

Besides ILUC, leakage can include the GHG emissions and removals associated with displaced agricultural production (i.e. the net emissions associated with the production process), and change in emissions from production of inputs (e.g. fertilisers).

We note that carbon leakage is a term used also in other contexts, such as in emissions trading, and is used to safeguard the competitiveness of industries that are covered by the European Union Emissions Trading System, and are exposed to significant risk of carbon leakage.

3.2.1 METHODS OF ESTIMATING LEAKAGE, AND LIMITATIONS

Estimation of leakage in an agricultural context is complex and subject to high levels of uncertainty. The consequences of changes in production are related to market and political forces and occur in an industry which is highly dispersed and disaggregated, with many small operators (farmers) throughout the world. Furthermore, production is related to yield (e.g. production per unit area for crops) and the area of land used for production. A change in production area will not necessarily lead to an increase in production area elsewhere (with potential land use change) because the change in production area may incentivise, perhaps indirectly, improvements in yield. Where change in production occurs, and ILUC is attributed to that change in production, there is no exact location of the ILUC, so the consequential emissions cannot be estimated with any certainty, especially when estimates are not scaled up over large regions and time periods.

It is certain that net GHG emissions occur from land use change activity, and that the emissions can be large relative to emissions from annual agricultural production of a particular product. It is the

allocation or attribution to particular production sectors or particular production changes that is not known, and is difficult to estimate.

Methods for estimating leakage in the context of agricultural production have been mainly focussed on emissions associated with ILUC, in the context of the GHG mitigation potential of biofuels. Many of these studies are focused on the consequences of changing land use to produce specific crops that are used for biofuels, such as oilseed rape, corn (grain maize) and oil palm. Reports of studies more relevant to this review are also available, and include a wider analysis to inform policy decisions and evaluations.

Two main types of method have been used, with some methods that combine aspects of both.

- **Modelling approaches.** Econometric models have been used to predict changes in trade flows as a consequence of policy or market-driven scenarios for change in agricultural production. Changes in land use and GHG emissions are then also predicted.
- **Simplified allocation.** GHG emissions from land use change, for each region or country in the world, are estimated using land use statistics and carbon stock change factors. The emissions are allocated to the land used for agricultural production in various ways, depending on the detail of the method. Weightings can be applied for yield or the proportion of production traded internationally, for example.

Outputs from models can be used together with simplified allocation of emissions.

Full quantification of leakage, even when complex modelling is involved, is subject to high uncertainty. Quantification of leakage requires predictions of future impacts, and the results cannot easily be validated because the actual allocation of LUC to policy and activity changes in another place cannot be observed or measured (European Commission, 2010). An attempt to compare modelled vs observed LUC has concluded that most ILUC models overestimate ILUC emissions because they do not properly account for cropland that is not fully used (O'Connor, 2015).

3.2.2 Leakage pathways relevant to CAP measures

Many CAP measures change or influence production at a local level. For example, buffer strips may be funded under the RDP which potentially can reduce the available area for food production, even if the impact on productive area of this particular measure is negligible so far. Any CAP measures which influence production levels will have an economic and market influence beyond the agricultural system concerned.

The main pathway for leakage considered here is the net change in GHG emissions outside of the MS implementing a measure that is induced by a change in production. Production changes include:

- changes in crop production for food, livestock feed, energy and fibre;
- changes in production from livestock farming, predominantly production of food.

The net change in emissions elsewhere (the leakage) is a mix of emissions from production systems, and from LUC.

3.2.3 The approach used in this study to recognise potential leakage

The system boundary in this study is the area to which a policy measure is applied (usually a Member State (MS), or the whole EU), and the production system that is influenced. We have reviewed literature with a focus on quantified estimates of leakage associated with mitigation of GHG emissions.

3.2.4 Estimates of leakage

Our review identified many studies of emissions leakage. There has been much work on ILUC that relates to biofuel production and presumed emissions savings from biofuels. Other studies have taken a wider view of leakage, to include ILUC, other emissions from production, and emissions from the production of inputs. Values from a selection of recent studies are presented in Table 3.

Table 3. Leakage values (reduction in local mitigation as a result of effects outside the system boundary) from recent studies.

Reference	Leakage (%) High	Low	Notes
Domínguez et al., 2016	35%	14%	Non-CO_2, so omits net LUC emissions, which are dominated by C stock change and therefore CO_2 net emissions.
Fellmann et al., 2017	No data	91%	
Doorslaer et al., 2016	91%	64%	
Laborde, 2011	108%	11%	Biofuel-related, accounting for ILUC; range is for crops typically grown in the EU. A value of more than 100% indicates that ILUC outside the system boundary as a result of mitigation undertaken within the system gives rise to more emissions than are saved within the system.

The values in Table 3 illustrate the wide range of leakage values in the literature. This range reflects differing study scopes (e.g. inclusion or not of LUC emissions), differing methodologies (a variety of models are used, usually with a selection of scenarios), and high uncertainty. The uncertainty is, in part, because the modelling approaches generate predictions of trade flows and how these change in response to changes in production. Further uncertainty results from policy assumptions (e.g. the degree of subsidy for mitigation actions), and from differing assumptions about the possible extent of yield elasticity in response to price change.

It is commonly reported that leakage is greater for mitigation of livestock production emissions than it is for mitigation of crop production emissions. For example, Fellmann et al. (2017) report that most emission leakage is caused by EU imports of animal products, which are responsible for more than 90% of additional emissions outside the EU. However, the literature examined did not contain estimates of leakage disaggregated by livestock and crop production systems. Livestock and crop production systems are interlinked, with many crop products being used for animal feedstocks.

Overall there is a wide range of estimates for leakage of GHG net emissions, with high uncertainty widely acknowledged.

3.3 THE USE OF CASE STUDIES

Case studies have been used within this evaluation study as a tool for gathering information for two main reasons. The first is the lack of available homogenous and consistent information at EU level about the impact of most of the CAP measures covered by this evaluation on climate change and GHG emissions, for which data is required to answer the ESQs and which is often context specific. The second reason is the variety of different implementation choices that can be taken in Member States in relation to the CAP measures covered.

Ten case study countries were chosen for this evaluation representing a range of farming systems, biogeographical conditions and climate challenges. They were Croatia, Czech Republic, France, Germany, Hungary, Ireland, Lithuania, Netherlands, Romania and Spain. The case studies were carried out at a national level, but with a particular focus on a single administrative region in the federal Member States (Aquitaine in France, Saxony-Anhalt in Germany and Andalucía in Spain[9]) to

[9] Since adaptation challenges vary to a greater extent between regions than mitigation ones do, the regions were chosen to include adaptation challenges.

source more detailed information on the way the CAP measures operate in practice and the implications for climate mitigation and adaptation.

All case studies followed the same general approach and applied the same methodology. A case study template and guidance was prepared by the core study team to seek as much homogeneity as possible and to allow the results of the case studies to be synthesised in a streamlined way. All case study leads also received a data pack containing the existing data available to the core study team for their Member State. An online briefing session was carried out with all case study experts prior to commencing the work to explain the context of the evaluation study, its purpose and objectives and to go through the methods and data collection needs in detail, and this was followed by regular exchanges throughout the implementation of the case study work.

The case studies provide detailed and context specific qualitative and quantitative information to complement the EU-wide information collected to inform the analysis and answers to the ESQs. The information was gathered through interviews with key stakeholders including advisers and representatives of the farming, forestry and wider rural sectors, government officials and climate researchers and NGOs, and by sourcing and analysing national / regional literature, statistics and other data sources.

All information from case studies has been carefully interpreted in terms of what generic conclusions can therefore be drawn from them for the analysis and answers to the ESQs.

The case studies were also supplemented by two short surveys to gather specific information on the take up of adaptation techniques and technologies, which was addressed to advisers and farmers' representatives; and on the extent of knowledge and take up of mitigation actions which was addressed to farmers. In both cases, the short survey questionnaires were sent to a non-representative sample of advisers and farmers in the 10 case study countries. On average nine farmers and 23 farm advisers responded per Member State, with the response rate by farmers depressed by three Member State administrations which chose to administer the farmer survey themselves for data protection reasons but failed to elicit any responses.

3.4 LIMITATIONS OF OUR METHODS

The quantitative method we use to estimate the impact of CAP measures on emissions is limited by two main factors. The first is whether the impact of a measure on emissions is suitable for quantification at all. Uptake figures are available for all measures, but sometimes there is not a direct enough link between how much a measure is used, and the impact it has – if any – on climate action. For example, there is not a direct enough link between the provision of advice to farmers and any changes they may make in their land management practices to enable an impact of advice measures on the reduction of emissions to be quantified. This problem is not confined to "soft" measures such as advice. The result of the greening permanent grassland ratio is also indeterminate since data does not exist to show whether it has prevented grassland from being ploughed or not. Whether grassland is ploughed has a large impact on GHG emissions, so because this information is unavailable the impact of the permanent grassland ratio cannot be quantified.

Even where quantification is possible there are often difficulties in establishing the impact of individual measures since multiple measures frequently apply to the same land. These may be multiple CAP measures or a combination of CAP and non-CAP measures. This is the case, for example, with land subject to restrictions under the Natura 2000 Directives. Some Member States make CAP payments available to support farmers who comply with such restrictions but the overall impact is achieved jointly by the CAP and the Natura Directives. Judgment of the extent to which CAP

measures, rather than other legislation, are causing the impacts under analysis is not an exact science.

The analysis of the CAP's effectiveness in improving resilience to climate change is mainly based on qualitative evidence from literature review and the case studies and so does not rigorously prove causality. Quantification of effects on adaptation is in any case particularly difficult at EU level (or indeed at any level of aggregation). Quantitative analysis of data from Member States' Annual Implementation Reports (AIR) allowed assessment of the level of uptake of RDP measures. However, several characteristics in the AIR data limited the relevance of their analysis for the assessment of climate action effectiveness. For example, output data are provided at measure level whereas the relevant scale would be 'type of operation'. Non-financial data for each Focus Area do not disaggregate the different measures which might be contributing. Finally, data for some Managing Authorities and Member States were absent.

The email survey of farmers, foresters and advisers encountered difficulties in some Member States due to concerns about data protection. In each of these cases the Managing Authority undertook to administer the survey itself but in three Member States (HU, IE and NL) the MA achieved no or a very limited response. The surveys, being small scale, were never intended to provide statistically representative data but these response rates further limited their usefulness. In order to strengthen the analysis the results of the surveys were triangulated with literature and interviews.

The analysis of production for ESQ13 was mostly based on literature review and on the results from previous ESQs. When possible, additional analysis was performed based on FADN and/or Eurostat data. The limitations of FADN data are that the FADN dataset is derived from a sample of farms above a certain economic size and thus does not represent the whole population of direct payments' beneficiaries. Moreover it does not provide information on farmer practices.

Box 2: Limitations associated with using FADN data

FADN data is based on a survey of a representative sample of commercial farms in each Member State. To make it possible to interpret the results at national scale each farm is given a weighting factor on the basis of economic size, farm type and region. Some general limitations with the use of such data are:

- The FADN dataset is based on a sample of farms above a certain economic size and thus does not represent the whole population of CAP payment beneficiaries. For example, part-time and semi-subsistence farms may be excluded.
- In order to ensure representativeness of the results presented, weighting factors provided with the dataset are used. When a group composed of just a few farmers is analysed, some bias might appear. For this reason, and also for confidentiality reasons, no results are presented when a group contains less than 15 farmers for this analysis.
- FADN data do not provide information on management practices. In particular, although the carbon storage capacity of grassland might differ depending on management practices (fertilisation) such practices cannot be directly assessed using FADN data.

4 RELEVANCE TO NEEDS (ESQS 10 AND 11)

ESQ10: To what extent do the CAP objectives for climate action correspond to the actual needs within the EU~ at European, Member State and farm level?

ESQ11: To what extent are the examined CAP measures relevant in contributing to climate action and the related specific objectives (pursue climate change mitigation and adaptation, energy efficiency and shift to a zero-carbon (carbon neutral) and climate resilient economy)?

This chapter evaluates the relevance of the CAP objectives to climate action and the relevance of the CAP measures and instruments to meeting those objectives. Relevance is 'the relationship between the needs and problems in society and the objectives of the intervention'[10]. In the case of this study, the examination is of the climate action needs in the EU (at the EU, national, and for adaptation, farm level) and the objectives of the CAP and its measures and instruments as covered by this study.

The answers to both questions draw on the same methodology and needs assessment. ESQ10 considers the extent to which the CAP's objectives relating to climate action correspond to the needs at EU, Member State and farm level whilst ESQ11 considers the extent to which CAP measures are relevant to climate action and related specific objectives. We examine both these questions together.

4.1 PROCESS AND METHODOLOGICAL APPROACH

The method identifies from the CAP Regulations the general and specific objectives relating to climate action for the CAP as a whole. This is complemented by an identification of the EU climate action needs from climate-related legislation set out in the EU's Climate and Energy framework to 2020. These include the Effort Sharing Decision, the Commission Decision on LULUCF, the Renewable Energy Directive and the EU Climate Adaptation Strategy. Objectives and targets for 2020 are used as this is the timeframe during which the current CAP has influence, although action taken in the current programming period will also have relevance to 2030 and mid-century objectives. Climate action needs at the national/regional and farm level are identified for the ten case study Member States from relevant literature (such as national climate strategies and RDPs needs assessments), surveys of farmers and farm advisors, and case study interviews.

The climate objectives of the CAP are then compared using subjective judgment with the needs and problems identified at the EU, Member State and farm level. The degree of relevance of CAP objectives to climate action needs is assessed in a semi-quantitative way using a cell matrix, using a three-point scoring system with comments included within the cells to record the reasons and evidence for the judgement made. This contributes to an overall assessment (in section 4.4) of the relevance of the CAP's climate objectives to EU, national and regional needs and problems. These results are summarised for the EU situation and with reference to the national and regional findings for the case study countries.

The relevance of each CAP measure and instrument (hereafter measures) is then assessed against these objectives and needs on the basis of the RDP needs assessments for each case study country, intervention logic for specific CAP measures, case study data, farmer survey data and expert assessment. This is followed by a qualitative analysis of the extent to which the CAP as a whole provides the tools necessary to address the climate needs and problems at EU, national and regional level. The analysis in section 4.2 is summarised by measure, first for the EU situation and secondly with reference to the findings for the case study countries.

4.2 ANALYSIS

4.2.1 THE CAP'S OBJECTIVES FOR CLIMATE ACTION

The objective of the CAP as a whole for climate action is set out by article 110 (b) of Horizontal Regulation 1306/2013 as "sustainable management of natural resources and climate action, with a focus on greenhouse gas emissions, biodiversity, soil and water". Although only mitigation is mentioned explicitly, it is clear from other references in the regulation that a contribution to climate adaptation is also one of the CAP's objectives. Article 5, for instance, lists "climate resilient agriculture" as one of the priorities against which Member States must programme their RDP expenditure. It also permits Member States to create a sub-theme within their RDP dealing with both

[10] Better Regulation guidelines Chapter VI - Guidelines on evaluation (including fitness checks) - https://ec.europa.eu/info/sites/info/files/better-regulation-guidelines-evaluation-fitness-checks.pdf

mitigation and adaptation and empowers them to grant higher rates of financing for the measures programmed in this way. Climate mitigation and adaptation are also stipulated by the Rural Development Regulation as "cross-cutting" objectives for all Member State RDPs. It is clear, therefore, that climate adaptation is fully integrated within the formal objectives of the CAP.

Regulation 1305/2013 on rural development provides more detail of what is meant by "climate mitigation". It should include both *"limiting emissions in agriculture and forestry from key activities such as livestock production, fertiliser use and […] preserving carbon sinks and enhancing carbon sequestration with regard to land use, land use change and the forestry sector".* (Recital 4). The scope of the CAP's general objective therefore covers both agriculture and forestry sectors, and the objective of increasing sinks as well as reducing emissions. These general objectives are reflected in the objectives for a number of the individual measures. Recital 42 to Regulation 1307/2013 on Direct Payments, for example, lists carbon sequestration as the particular objective of the maintenance of permanent grassland required by the greening measure.

Article 5 of Regulation 1305/2013 then sets down a number of priorities and sub-priorities, of which those shown in Table 4 are identified in Article 2 of Regulation 215/2014 as contributing to climate objectives for the purposes of the ESI-FUND tracking mechanism (described in more detail in ESQ7). A number of other priorities (for instance Priority 1C – fostering lifelong learning and vocational training) may also be relevant to climate but are not tabulated here since they are not identified by Article 2.

Table 4: RDP sub-priorities relevant to climate according to Regulation 215/2014

Sub-priority number	Content
3B	Supporting farm risk prevention and management
4A	Restoring, preserving and enhancing biodiversity, including in Natura 2000 areas, and in areas facing natural or other specific constraints, and high nature value farming, as well as the state of European landscapes
4B	Improving water management, including fertiliser and pesticide management
4C	Preventing soil erosion and improving soil management
5A	Increasing efficiency in water use by agriculture
5B	Increasing efficiency in energy use in agriculture and food processing
5C	Facilitating the supply and use of renewable sources of energy, of by-products, wastes and residues and of other non-food raw material, for the purposes of the bio-economy
5D	Reducing greenhouse gas and ammonia emissions from agriculture
5E	Fostering carbon conservation and sequestration in agriculture and forestry
6B	Fostering local development in rural areas

Source: Regulations No 215/2014 and 1305/2013

The CAP does not set any quantified objectives for the reduction of GHG emissions or the increase of sinks, but it does require that the SWOT analysis on which Member States' RDPs are based should assess specific needs for climate mitigation and adaptation, and that a minimum proportion of RDP spending should be on "climate change mitigation and adaptation as well as environmental issues" (RDP regulation, recital 22). Although some of the measures which Member States may use to satisfy this requirement – such as payments to areas with natural constraints – do not necessarily always contribute to climate action objectives, it is clear that the Rural Development Regulation installs both mitigation and adaptation, along with environmental issues, as priority objectives to which funding should be directed in preference to others.

4.2.2 EU NEEDS

Climate-related needs at the EU level are expressed in a range of legislative and other commitments setting policy on GHG emission reductions, the policy framework (for instance, energy policy) within which such emissions will be achieved and the EU's strategy for adaptation to climate change. The EU is required to reduce overall GHG emissions and report (but not yet reduce) LULUCF emissions and has set itself targets for energy efficiency, the reduction of primary energy consumption and an increase in the share of renewable energy in the EU's energy mix. There is also a commitment in relation to the EU budget that a minimum budget share should support climate action. These commitments and targets are summarised in Table 5.

Table 5: The EU's principal climate commitments

Topic	EU commitment or target
Reducing GHG emissions	Kyoto Protocol: 20% reduction between 1990 and 2020
LULUCF	Report emissions to UNFCCC but no EU target commitment until 2021 No-debit requirement as set out under the Kyoto Protocol.
Energy Efficiency	Reduce primary energy use to 1,474 Mtoe by 2020 – a 20% reduction from the level for 2020 forecast in 2007
Renewable Energy	20% share by 2020 (Directive 2009/28/EC) with an increase to 27% by 2030 proposed by the Commission and under discussion
Climate adaptation	2013 Strategy (COM(2013)216): promote adaptation by Member States; promote better decision making; promote adaptation in key sectors, including agriculture
EU Budget	Climate action objectives must « represent at least 20% of spending » in the 2014-2020 period[11]

Source: own analysis of relevant documents

No target is set by the Kyoto Protocol for emissions from agriculture, although the sector is part of the overall Kyoto target (Annex B of the Protocol). However, within the EU, agriculture is addressed partly (in respect of non-CO_2 emissions) through the EU's Effort Sharing Decision (ESD), which sets targets for those economic sectors that are not subject to the EU's Emissions Trading Scheme (ETS) (except LULUCF and maritime transport). Agriculture emissions therefore count towards the shared ESD targets for each Member State, but the target is not further disaggregated to individual sectors within the ESD. In practice, the 'shared' nature of the ESD targets could enable the ESD target to be met without further action taken in the agriculture sector and even an increase in emissions in some cases, provided that action taken by other sectors was sufficient (e.g. Matthews (2016)). CO_2 emissions from agriculture, such as from cropland or grazing land management are reported under the LULUCF Decision, but it does not require (or allow) these emissions and removals to be counted towards the formal GHG emission targets in the EU to 2020.

As well as reducing their own emissions, agriculture and forestry can play a significant role in achieving other targets, for example by providing space for renewable energy infrastructure, such as solar PV or wind turbines, the production or collection of wastes and residues to produce energy, or the provision of biomass for energy and transport biofuels. The renewable transport fuel sub-target in the current Renewable Energy Directive (RED) is also relevant to both the production and use of biofuels in an agricultural context.

The EU's forest strategy (COM 2013/659) contains a number of objectives in relation to climate action. In particular, Member States are encouraged to use rural development funds to improve the resilience, environmental value and mitigation potential of forest ecosystems and to adapt to climate change. It is important to maintain and enhance adaptive capacity through fire prevention and other adaptive actions. The strategy discusses the role of wood as a source of renewable energy and endorses the growth of the EU's bioeconomy subject to appropriate safeguards to guarantee sustainability. It identifies Member States' RDPs as its main source of funding.

[11] European Council conclusions of 7-8 February 2013

The only CAP objective which gives direct effect to the EU level budgetary objective (that climate action objectives must represent at least 20% of spending in the 2014-2020 period) is Article 59(6) of the Rural Development Regulation. This requires that at least 30% of rural development spending must be on a subset of rural development measures with a climate and environmental focus. It is worth noting here that an objective to spend at least 30% of the CAP's funds on climate measures rather than a wider subset would have been more obviously relevant.

The CAP's objectives of climate mitigation and adaptation are clearly relevant to EU level needs represented by the Kyoto commitment and adaptation strategy respectively, whilst its sub-priorities are relevant to a range of EU needs as shown in Table 6.

Table 6: Sub-priority relevance to EU level needs

Sub-priority	Relevant EU-level need(s)
3(b) (risk management)	Adaptation strategy
4(a) (biodiversity)	Adaptation strategy, LULUCF (conservation/creation of biomass)
4(b) (water management)	Adaptation strategy
4(c) (soil)	Kyoto Protocol commitment and LULUCF
5(a) (efficient water use)	Adaptation strategy
5(b) (energy efficiency)	Energy Efficiency (final consumption) target
5 (c) (supply renewable energy sources)	Renewable energy target, and Kyoto
5(d) (reduce GHG/ammonia emissions)	Kyoto Protocol GHG commitment
5(e) (carbon conservation and sequestration)	Kyoto Protocol, LULUCF decision
6(b) (local development)	Adaptation strategy mainly but development could also involve reductions in emissions

Source: own analysis

4.2.3 National and regional needs in case study Member States

Agriculture is a significant source of GHG emissions in the case study countries, with enteric fermentation and agricultural soils being the two largest sources in all ten as shown by Table 7. All ten case studies thus have a clear need to reduce GHG emissions from agriculture, including both livestock and arable farming, although only four set a target for the sector. The Czech Republic, Germany, France and the Netherlands have set quantified GHG emission reduction targets covering all or in the Netherlands' case part (intensive horticulture under glass) of the sector. These targets are set out in Table 8 below. Andalucía has a target for emissions per capita, rather than sectoral targets. In Croatia and Hungary there are no national policies in place requiring agriculture, forestry or other rural sectors to reduce emissions, whilst Lithuania and Romania also have no quantified target. Ireland has an aspiration to achieve carbon neutrality (taking both agricultural emissions and LULUCF into account) by 2050.

Table 7: Distribution of agricultural GHG emissions between source types in the case study Member States (% of total agricultural emissions)

Member State	CZ	DE	ES	FR	HR	HU	IE	LT	NL	RO
Enteric Fermentation	34.1	44.2	40.1	44.8	40.1	31.8	56.9	35.6	44.3	44.0
Manure Management	21.0	16.8	28.5	10.5	19.2	18.0	9.3	10.2	26.9	9.9
Agricultural Soils	40.8	35.1	28.7	43.4	38.0	47.5	31.6	52.9	28.5	45.5
Liming	1.9	2.8	-	1.1	0.5	-	2.0	0.9	0.4	
Urea Application	2.2	1.1	1.3	-	2.2	1.0	0.1	-	-	-

Source: own compilation from UN data

The table shows that three categories of GHG emissions – from enteric fermentation and manure management (livestock) and from agricultural soils (arable farming) make up a high proportion of agricultural GHG emissions in all ten case study Member States/regions. The CAP's objective of reducing emissions is thus relevant to all ten. The extent to which CAP measures exist which are relevant to the patterns of emissions shown in Table 7 is discussed in section 4.3.2. The share of agricultural emissions in total non-ETS emissions varies widely between Member States. As a result, although emissions reduction objectives are relevant to all, the degree to which Member States will pursue them as a priority is likely to vary.

Table 8: GHG emission targets specific to agriculture in case study Member States

Member State	Target*	Source
Czech Republic	Reduce NOx emissions from agriculture, forestry and fisheries to 34 kt/year by 2030. NH_3 is allowed to increase from its current level to 61 kt/year by 2030 due to an anticipated increase in livestock numbers	Climate protection policy of the Czech Republic (2017)
France	Reduce agriculture emissions by at least 12% by 2028 compared to 1990	National Low Carbon Strategy (Ministry of Ecology 2015)
Germany	31-34% reduction by agriculture by 2030 compared to 1991 baseline	German Climate Action Plan 2050 (BMUB 2016)
Ireland	Carbon neutrality by 2050 taking both GHGs and LULUCF into account	National Mitigation Plan for Agriculture, Forestry and Land Use sectors, 2017
The Netherlands	Reduce emissions by intensive horticulture to 4.6 Mt CO_2eq by 2020	Agreement between the Dutch Government and the intensive horticulture sector

Source: own analysis **Note:** expressed in the form written in the RDP

Member States report more detailed climate needs in their RDPs. It is notable that there are relatively few explicit references to either 'climate', 'mitigation' or 'adaptation' in the needs assessments in the RDPs. For the case study RDPs, all 10 include climate as a term somewhere in the needs assessment, yet there are only 19 cases of 'climate' as a term being used in the needs description out of 279 individual needs identified by the ENRD for these ten Member States in its RDP screening exercise. Adaptation is mentioned explicitly only in two cases (ES-AN, NL) and mitigation only once (ES-AN). In most of the case study countries (DE-SA, CZ, ES-AN, FR-AQ, HR, IE, and RO) climate is mentioned in just one of the needs for those countries. Of course, the lack of use of these terms does not indicate that climate action is not a need, with pressures on soils, fire risk, or nitrate pollution all being examples of needs that are climate-relevant. More specifically, mitigation is mentioned less frequently than adaptation when needs are expressed.

In order to further illustrate the relevance of the CAP's climate objectives to the needs identified in their own territories by Member States, Table 9 shows the number of case study Member States who listed a need in their RDP corresponding to each climate-relevant sub-priority. The sub-priority against which expenditure has been programmed has not been taken as conclusive evidence. We have taken the Member State's statement of needs as being a more authoritative guide to these than are the sub-priorities against which it has programmed expenditure[12]. The RDP's sub-priorities have been judged to be relevant to a Member State's expressed needs even in cases where a Member State has programmed no expenditure against the sub-priority in question, so long as the need is

[12] For instance, the Czech Republic has a need relating to risk management but has not scored expenditure to sub-priority 3b.

expressed in terms which explicitly and unambiguously indicate that the sub-priority is of relevance. This is the case where needs expressed by a Member State explicitly mentioned the subject matter of a sub-priority (for example "to improve energy efficiency in agriculture") but not if they did not (for example "improve agricultural competitiveness"). Where possible the relevance of sub-priorities to needs relating to forestry has been identified separately from agriculture. Because the table only records where a need has been expressed explicitly it is likely to understate the extent to which Member States have needs which correspond to the sub-priorities. All Member States also listed at least one need explicitly relevant to adaptation, and a row has been included in the table to show such needs even though there is no sub-priority which explicitly refers to adaptation

Table 9: Climate-relevant focus areas reported as needs in case study RDPs

Sub-priority	CZ	DE (ST)	ES (AL)	FR (AQ)	HR	HU	IE	LT	NL	RO
3b - Improve risk management (A)	x		x	x	x	x	x	x	x	x
4a - Increase biodiversity (A)	x	x	x	x	x					x
4b - Improve water management (A)	x	x	x	x	x	x	x	x	x	x
4c - Prevent soil erosion/improve management (A, M)		x	x	x	x	x	x		x	x
5a - Efficient water use (A)	x	x	x	x	x	x	x		x	x
5b - Energy efficiency (agriculture) (M)		x		x		x	x		x	
5c - Supply/use of renewable energy/raw material for bioeconomy (M)	x		x	x	x		x	x	x	
5d - Reduce GHG emissions (A)	x			x		x	x	x	x	x
5e - Carbon conservation/sequestration (agriculture) (M)	x			x			x	x		
5e - Carbon conservation/sequestration (forestry) (M)				x			x	x		
6b - Local development (A)		x	x	x	x	x				x
Adaptation (general) (A)	x		x	x	x	x				x

Source: Own analysis of ENRD analysis of Member States' published 2014-2020 RDPs (original versions). **Notes:** (A = adaptation, M=mitigation)

Table 9 shows that each of the sub-priorities relevant to climate action is relevant to the needs expressed by at least three of the case study Member States. The CAP sub-priorities relevant to the highest number of needs identified by the case study Member States are improved water management (a need explicitly identified in all case study RDPs) and more efficient water use (all but Lithuania). The prevention of soil erosion or improvement of soil management (all except the Czech Republic and Lithuania) was the sub-priority relevant to the second largest number of explicitly identified needs. By contrast, few Member States explicitly identified needs to protect and sequester more carbon in agriculture or forests. Only the Netherlands, however, identified no need relating to forestry, with Croatia and Hungary needing to increase forest areas and Sachsen-Anhalt to preserve them (both of which have the potential to improve carbon conservation and sequestration even if not explicitly done for that purpose).

Studying the list of needs expressed by Member States in their RDPs is an imperfect means of identifying true climate-relevant needs, which are not always explicitly stated in the RDP. The Czech RDP is a case in point. It does not explicitly identify either the reduction of soil erosion or improved soil management as needs. However, both national policy and the way the Czech Republic has implemented the CAP demonstrate that reducing soil erosion is indeed a priority. The Czech Republic has, for example, designated ESPG outside its Natura 2000 areas using the carbon content of soil as a criterion, from which a national need to reduce soil carbon loss by curtailing farmers' ability to plough their land can be inferred.

Seven out of the ten case studies explicitly identify the reduction of GHG emissions from agriculture as a need, with Andalucía, Croatia, and Sachsen-Anhalt omitting to do so. Whilst all but two of the RDPs identify a need to protect soil from erosion, few explicitly identify a need for carbon conservation and sequestration either in agriculture or forests. This may be because the EU's climate and energy framework (to 2020) does not include specific targets for reductions of emissions or increases in removals in the LULUCF sectors[13].

Only three Member States stated a need to conserve and sequester carbon through forestry. However, four other Member States (ES, DE, HR and HU) stated forestry needs, with Germany, Hungary and Croatia all aiming to preserve or increase their forest area. Ireland's RDP does not elaborate on whether the required storage of carbon should take place in forests or on farm.

Further insight into the climate mitigation needs of Member States can be gained from the reports they are required to provide to the IPCC under Article 10 of the Commission's LULUCF Decision. Member States must describe the main actions they are taking which are relevant to LULUCF emissions, and may also choose to describe their priorities in tackling LULLUCF emissions, although they are not required to do so. The identification by Member States of priorities in their LULUCF reports which closely correspond to several of the CAP sub-priorities underlines the relevance of these to Member State needs.

4.2.4 NEEDS AT FARM LEVEL

Evidence of needs at farm level is provided by the results of an open public consultation on the future of the CAP carried out for the Commission in 2017 (Ecorys, 2017). When asked to identify up to three of the most important environmental challenges facing agriculture, from a list of eight options, 17% of farmers identified the reduction of soil degradation. The most popular answer was reducing the loss of biodiversity (20%). Rationalising the use of water (13%) and reducing environmental risks such as fire and floods (5%) were mentioned by fewer farmers. 58% of farmers felt that the CAP addressed these challenges only to some extent, or not at all. Prevention of biodiversity loss was the option most frequently (21%) identified by farmers for which the CAP should do more, with prevention of soil degradation in second place (18%).

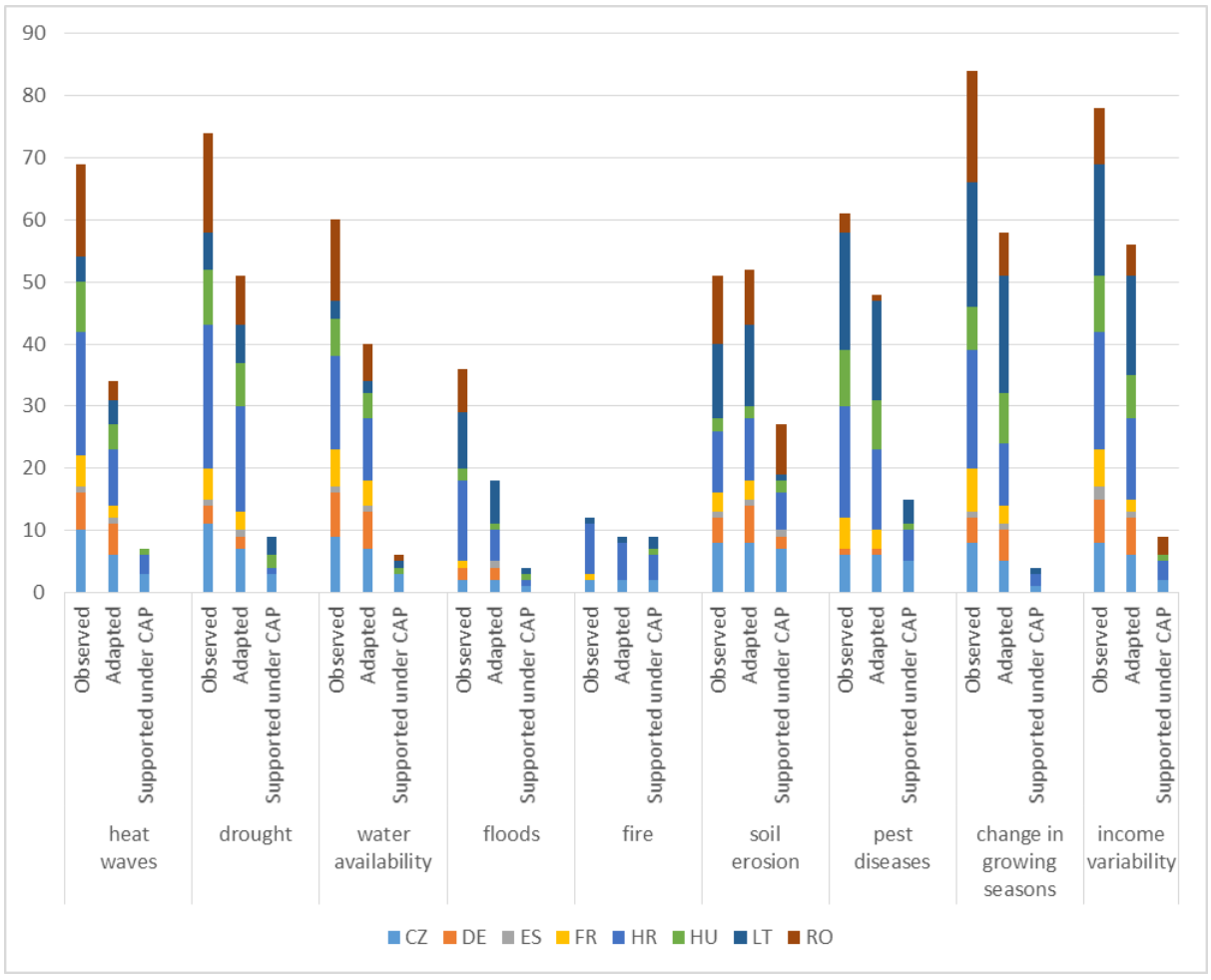
Farmers were also asked specifically what they saw as the most important objectives the CAP should pursue in order to tackle climate change. The most popular response was "providing sustainable renewable energy sources" (20%), followed by "improving climate change adaptation and enhancing the resilience of agricultural systems" (16%) and "fostering carbon conservation and sequestration in agriculture and forestry" (15%). A high proportion of farmers felt that afforestation (19%) and improved forest resilience (18%) should be objectives of the CAP.

The farmers and foresters participating in the small-scale survey carried out for this evaluation were asked which of the climate-related pressures identified by the literature review (see ESQ5) they had observed; which they had adapted to and whether the CAP had supported such adaptations. The results are shown in Figure 2. Overall only a small proportion of those farmers and foresters who

[13] LULUCF sectors do however count towards the EU's quantified emission limitation under the Kyoto Protocol, therefore still necessitating accounting and reporting from these sectors

reported that they had experienced and adapted to climate pressures acknowledged that the CAP had helped them to do so. This does not mean that it did not. It is probable in some cases that respondents have underestimated the CAP's relevance to their own needs– most notably in the case of income volatility where the vast majority of farmers benefit from the stabilising effect of direct payments. The results of the survey show, however, that the CAP's climate sub-objectives of better water management (drought, floods, water availability), improved risk management (fire, floods) and better soil management with reduced soil erosion each correspond to needs reported by farmers and foresters themselves. Other needs mentioned by farmers, however, such as the need to accommodate changing growing seasons are not explicitly referred to in the CAP sub-objectives.

Figure 2: Farmer and forester views on climate pressures experienced, adapted to and supported by the CAP



Source: survey of farmers and foresters in case study Member States

Individual farmers and foresters do not have mitigation needs in the sense that – unlike failure to adapt – failure to mitigate does not by itself compromise the short-term viability of an individual farm or forest enterprise. Farmers and foresters cannot thus be said to have private mitigation "needs" even though their actions can and do affect emissions. Despite this, the survey showed that those farmers and foresters who were aware of which actions would reduce emissions were likely to consider those actions to be relevant to their own farm.

4.3 ASSESSMENT OF RELEVANCE

4.3.1 RELEVANCE OF CAP OBJECTIVES TO EU CLIMATE ACTION NEEDS

Based on the analysis in the previous sections, the CAP's climate action objectives (including the sub-priorities relevant to climate from the RDP regulation) are set out below with our assessment of their relevance to EU, Member State/regional and farm (or forest) level needs.

Table 10: Scoring of CAP climate sub-priorities against EU, Member State and private needs

CAP sub-priority (from Article 5 RDP Regulation)	Relevance to EU level needs	Relevance to Member State/regional needs (from case studies)	Relevance to farmers' and foresters' needs
Improved risk management	The EU faces a range of risks relevant to agriculture and forestry, such as increased social, economic and environmental impacts from migration or territorial instability resulting from climate-related damage to economic performance arising from heat waves, floods, droughts, etc.	Most identify improved risk management as a need in the RDP	Farmers and foresters in the survey identified a wide variety of risks to which they are exposed, to which better risk management can be relevant. Improved forest resilience identified as a priority in the consultation.
Biodiversity	Farmers and foresters control most of the land on which the EU's goals for land-based species and land habitats must be achieved.	Six out of ten explicitly state biodiversity needs in their RDPs. All have biodiversity obligations under the Natura 2000 Directives.	Farming and forestry both rely on ecosystem services from biodiversity which are influenced by climate. Recognised by the highest proportion of farmers as a need in the consultation.
Improved water management	Priority in Water Framework Directive	Identified as a need in all ten RDPs	Farmers and foresters in the survey reported having observed and adapted to droughts
Prevent soil erosion/improve soil management	EU policy requires accounting for LULUCF emissions now and will set targets in future.	Most identify soil protection and management as an RDP need and all MS will have a LULUCF target in future	Recognised as a need by farmers and foresters in the survey and consultation
More efficient use of water	Priority in Water Framework Directive	Water stress and vulnerability to drought identified in CZ, RO, DE, FR(AQ) and other case studies	Farmers in survey have observed and adapted to drought and poor water availability
Increased energy	The EU has a target to	Individual Member	Farming and forestry

efficiency	reduce energy consumption by 20% by 2020	States have targets under the Energy Efficiency Directive to which agriculture and forestry can contribute	are not energy-intensive overall, but energy efficiency can be important at site level
Renewable energy	An EU priority addressed by the Renewable Energy Directive 28/2009/EC and its proposed replacement	All Member States have national targets for the minimum share of renewable energy in final consumption as required by the Directive. Agriculture and forestry can contribute biomass.	Farmers saw increasing the supply of renewable energy as a desirable objective for the CAP.
Limiting emissions in agriculture and forestry	EU-level policies do not directly require reductions in emissions from agriculture but achievement of the CAP objective contributes to EU targets.	Although only five MS have set targets for GHG emissions from agriculture, seven have RDP needs and livestock and arable emissions are important in all ten.	Farmers and foresters did not express an intrinsic need (as opposed to one incentivised by a policy instrument) to reduce emissions, although emission reductions sometimes occur as a co-benefit of actions taken for private benefits.
Carbon sequestration	The EU currently accounts to the UNFCC for LULUCF emissions and will in future need to ensure LULUCF sinks remain. Agriculture and forestry contain major carbon sinks with opportunities to create more.	All except NL identify carbon sequestration as a priority in RDP and/or LULUCF Art.10 report	Farmers and foresters in the consultation saw this as a high priority for the CAP.
KEY			
Relevant	The climate objectives for the CAP at a) EU or b) national/regional level are fully relevant to the identified climate related needs and problems. Both the CAP, other EU policy instruments and decisions, Member States and/or farmers and foresters share common objectives.		
Partially relevant	The climate objectives for the CAP at a) EU or b) national/regional level are partially relevant to the identified climate related needs and problems. For example, if the CAP's objective was to tackle emissions in the livestock sector, but significant emissions were also caused by other sectors to which the objective did not apply, it would be partly relevant.		
Not relevant	The climate objectives for the CAP at a) EU or b) national/regional level are not relevant to the identified climate related needs and problems. For example, if the CAP's climate objective was to tackle emissions via reductions in livestock but neither other EU policy, Member States nor farmers themselves shared such an objective, and emissions were being tackled in other ways, it would not be relevant.		

Source: Own compilation based on the analysis in this study.

4.3.2 RELEVANCE OF EACH CAP MEASURE AND INSTRUMENT AGAINST EU LEVEL NEEDS

ESQ11: To what extent are the examined CAP measures relevant in contributing to climate action and the related specific objectives (pursue climate change mitigation and adaptation, energy efficiency and shift to a zero-carbon (carbon neutral) and climate resilient economy?

Table 11 provides a summary of the assessment of relevance of the individual CAP measures covered in this evaluation with the elements of climate objectives and needs set out at the EU level to which the CAP can contribute. This is based partly on the intervention logic for the individual measures (i.e. whether they are explicitly aimed at climate action) along with the scope and requirement of the actions supported through their implementation. This assessment shows that a number of the CAP measures have some relevance (full or partial) to the EU's mitigation and adaptation needs in rural areas.

Measures addressing climate mitigation through the CAP fall into three broad categories. Those that support the reduction of GHG emissions from activities in rural areas; those that support the increase of carbon removals (in soils or biomass); and those that support the provision of biomass or low-carbon energy that replace the emissions of more GHG intensive sources of materials or energy both in rural sectors and economy wide. Adaptation measures are wide ranging, addressing specific land management actions to improving the climate resilience of agriculture, forestry and rural areas or addressing potential risks and remediation actions.

The EU's need to mainstream climate spending into the CAP is given effect in Pillar II by the requirement placed on Member States to spend 30% of the RDP budget on environment and climate measures. This may only be fulfilled through the use of certain measures: M4; M8; M10; M12 (Natura Directive only); M13 and M15. In the case of M4 recital 22 to the Rural Development Regulation states that the expenditure which meets the budgetary requirement should be environment and climate-related, although M4 itself is a measure which can be used for a wide range of purposes. This combination of measures provides the potential to support both mitigation and adaptation actions. However the regulation does not necessarily require Member States to offer support for climate actions at all or beneficiaries to take it up if they do. Spending can be directed to other environmental goals instead. Moreover, more than half of spending on this group of measures is on M13. This measure allows Member States to provide support for the additional costs to farmers who operate in mountain areas or areas with other biophysical constraints. The latter can include climate related constraints in the form of short growing seasons and/or aridity. These payments provide support for farmers whose production and economic activities are constrained by the environmental and climate conditions in the areas (defined by Member States) in which they are farming. Approximately 17% (€25.6bn) of the EAFRD expenditure is programmed towards M13[14] covering an area of just under 53 million hectares (~30 % of the EU's utilised agricultural area)[15]. However, the measure itself simply provides financial compensation for the perceived costs arising from these and other constraints. The support farmers receive does not have to be spent adapting to climate change or mitigating emissions. For this reason we judge M13 to be at best partially relevant to the objective of climate action.

[14] 17.3% in the period from 2014-2020 https://enrd.ec.europa.eu/sites/enrd/files/w11_anc_faqs.pdf

[15] Based on an EU UAA figure of 175 million ha in 2015 (Eurostat figures). 28% are mountain areas, 69% are areas with other significant constraints, and 3% are areas with specific constraints. (These figures have to be regarded as preliminary figures (as of February 2017), since the new ANCs delimitation has not been established in all Member States). Source: ENRD

Table 11: Relevance of CAP instruments and measures to EU Climate needs

EU level objective	Emission reductions		Increasing removals	Replacing emissions	Climate adaptation
Direct payments (excluding cross-compliance – see below)	N	N	N	N	N
Voluntary redistributive payment	N	N	N	N	N
Greening (crop diversification)	P	N	N	N	P
Greening (PG ratio)	N	N	R	N	N
Greening (ESPG)	N	N	R	N	N
Greening (EFA)	P	N	P	N	P
Voluntary payment ANC	N	N	P	N	N
Voluntary coupled support	P	N	N	N	N
Small farmers' scheme	N	N	N	N	N
Cross-compliance	P	N	P	N	P
Farm Advisory Systems	P	N	P	N	R
M1: Knowledge & info	P	P	P	P	P
M2: Advisory services	R	R	R	R	R
M3: Quality schemes	P	N	N	N	N
M4: Physical assets	R	R	P	R	R
M5: Disaster risk reduction	N	N	P	N	R
M6: Farm business and dev	P	P	N	P	P
M7: Basic services	P	P	P	R	P
M8: Forest investments	R	R	R	R	R
M10: Agri-Env-Climate	R	R	R	N	R
M11: Organic Farming	P	N	P	N	P
M12: N2000 & WFD	N	N	P	N	P
M13: ANC	N	N	N	N	P
M14: Animal welfare	N	N	N	N	P
M15: Forest-Env-Climate	R	N	R	N	R
M16: Cooperation	P	P	P	P	P
M17: Risk Management	N	N	P	N	R
M19: Leader	P	P	P	P	P

Score	Meaning	Judgement criteria
N (Red)	Not relevant (N)	The instrument / measure is designed or implemented in a way that does not respond to the needs or climate objectives set out with respect of the scope of the CAP regulations. i.e. there is no climate focus set out for the measure in the regulation and the implementation of the measure would not lead to positive contributions to the objectives.
P (Orange)	Partially relevant (P)	The instrument / measure is designed or implemented in a way that can respond to the needs or climate objectives set out with respect of the scope of the CAP regulations. i.e. some aspects of the measure are not climate focussed and the climate focus is not explicitly mentioned in the regulations
R (Green)	Relevant (R)	The measure is designed or implemented in a way that responds to the needs or climate objectives set out with respect of the scope of the CAP regulations.

Source: Own compilation; See Annex 2 for more details. **Notes:** The EU needs relating to the column titles are described in Table 5. A distinction should be noted between the column for reducing GHG emissions – which is the process by which emissions that are happening from agricultural

practices are reduced as a result of the implementation of the measure – compared to the increase in removals and maintenance of stocks column – which is the process by which emissions are not increased as a result of the measure being implemented, or where the measure leads to an increase in removal of emissions from the atmosphere. Measures/instruments highlighted in bold are required to be implemented by Member States.

Table 11 shows that the CAP interventions that are relevant or partially relevant to the EU's climate needs are primarily voluntary for Member States to implement, with the exception of the greening measures, the Farm Advisory Service and the agri-environment-climate measure. Although uptake of some voluntary measures is high, CAP measures which are either mandatory for Member States (as is the greening measure), or mandatory for farmers (as are the cross-compliance rules set by Member States) are lacking in respect of emissions from the livestock and cropland management. The result is that Member States are not required – and do not have the means through compulsory measures – to reduce non-CO_2 emissions from livestock and cropland.

Table 7 shows that livestock and cropland emissions make up a large proportion of agricultural GHG emissions. The two largest sources of GHG emissions from agriculture in the EU are non-CO_2 emissions (N_2O and CH_4) from livestock (enteric fermentation and manure management) and from managed agricultural soils. Despite this the CAP measures relevant to emissions from livestock are all optional, with the exception of SMR1 in cross-compliance. The latter, however, simply reinforces controls on manure management required under the Nitrates Directive (for water quality purposes) rather than introducing further requirements to address N_2O emissions as a whole. No compulsory measure in the CAP requires reductions in GHG emissions from livestock. Optional measures through which Member States may choose to address livestock farming can take the form of advice and training (M1 & 2), investment support for better collection and management of manure (M4, M7), encouragement of lower or more appropriate stocking density (M10.1) or the development of innovative approaches (M16). It is important to stress that Member States are only required to make available the agri-environment-climate measures (M10)[16] and the Leader measure themselves but are not required to offer options relevant to non-CO_2 emissions[17]. Nor are they required to put in place other measures that may help to reduce livestock-related emissions. Furthermore, there are no greening requirements (the only other compulsory environmental measures) that address livestock-related non-CO_2 emissions. The CAP measures are therefore not relevant to a significant proportion of the EU's climate mitigation needs.

The need to reduce emissions from managed agricultural soils is better addressed than livestock emissions by the measures available in the CAP. The compulsory greening requirements relating to permanent grassland (and ESPG) address conversion and ploughing risks[18], although some conversion is permitted and ploughing and re-seeding is permitted on all permanent grassland unless it has been designated ESPG. The framework for cross compliance GAEC in the Regulation offers one of the more potentially comprehensive means of addressing soil-related emissions across farmland in the EU. GAEC 4, 5 and 6 are aimed at, and GAEC 7 can help in preventing erosion and maintaining organic matter can help to reduce soil-related emissions. However, the extent to which this framework results in actual or potential emissions from soils being addressed depends on Member States. Member States set almost all of the detailed GAEC rules (GAEC 6, under which the Regulation requires a ban on stubble burning, being the exception) and so determine which of these emissions are addressed in practice. As demonstrated in ESQ 1-4 the way these criteria are defined can lead to significant areas being excluded from the requirements, thereby reducing the relevance of the soil-related GAECs to the EU's climate needs. SMR1 which reinforces compliance with the Nitrates Directive is relevant to emissions from arable land in addition to livestock, but as discussed above does not require additional reductions beyond the legal baseline.

[16] Or to require M10 support to be targeted towards reducing livestock-related emissions
[17] As set out in Council Regulation No. 1303/2015 (Article 32).
[18] To arable or other agricultural land-use that may increase soil-related emissions.

The compulsory AECM measure can support a range of practices to help address soil-related emissions, if the Member States choose to focus it in this way. Other measures (such as M8, 12 and 15) can be used to address soil related emissions, such as through afforestation or by changing forest management practices, but farmers are not required to take up any of these measures. There are thus a number of rural development measures able to address soil-related emissions, yet their voluntary nature for Member States and beneficiaries limits their relevance in practice.

Against the EU's climate action needs, a greater number of measures appear relevant or partially relevant to adaptation, than to mitigation, although these again are pursued for environmental management purposes and much more rarely through dedicated adaptation measures (COWI, 2017). For further elaboration of this point, see ESQ5.

The evaluation of greening measures under the CAP (Alliance Environnement and Thünen-Institut, 2017) reviews the relevance of those measures to environmental and climate needs finding that there is considerable variation between the relevance of the different components of the EFA measures. Components with a broad range of relevance across environmental and climate objectives include short rotation coppice, agroforestry and catch/cover crops. The evaluation of the forest measures under the CAP (Alliance Environnement and EFI, 2017) reviewed the relevance of the forest measures to various environment and climate priorities showed that the forest measures, supported by other horizontal measures such as M1 and M4, were relevant to addressing climate adaptation and mitigation needs, partly due to the flexibility afforded to the implementation of the measures.

4.3.3 Relevance of each CAP measure and instrument to national/regional needs in the case study countries.

The climate related needs expressed at the Member State or Regional level in the case study countries are summarised in Table 9 in ESQ10 above. Here we examine the extent to which the measures and instruments are relevant to these needs based largely on analysis of the legislation, the information provided by the case studies, cross referenced with an assessment of the RDP needs and measure programming information collected centrally.

The case studies show that there is great diversity in the climate action needs and in approaches to addressing those needs in the EU. This diversity of impacts makes it difficult to draw conclusions on whether the CAP measures are relevant to climate action, as this varies by country and context. There are cases where the same measure may be both relevant and not-relevant when applied in different contexts, as a result of the way the measure has been implemented, targeted or the level of expenditure associated with it. The following text highlights examples where CAP measures are relevant or not to Member State or regional needs set out in the case studies.

Measures relevant for mitigation are not always communicated or articulated as having mitigation benefits. For example in Saxony Anhalt, the inclusion of support for the preparation of forest management plans in M16, combined with support for forest renaturation (restructuring) under M8 and payments for forest ecosystem services under M15 provide a package of measures to increase resilience of forest ecosystems against climate change. However, despite these measures being funded primarily to address biodiversity needs, this does not detract from their relevance in addressing climate mitigation.

The measures programmed against specific climate needs are not always relevant to the extent of those needs. For example, the Czech Republic has expressed in its RDP a need to reduce GHG emissions in agriculture and increase sequestration[19]. This need is targeted against focus areas 5D (reduce GHGs) and 5E (carbon conservation and sequestration). Yet in the programming of RDP measures, only the advice measure (M1) and Forest measures (M8) are programmed against these priorities and only against focus area 5E. There are no measures programmed against focus area 5D.

[19] As written – "Reduce the greenhouse gases in agriculture and intensify their fixation"

The forest measures and advice measure can both support GHG emission reductions, but through different means. The afforestation of agricultural land (M8.1) can be judged as relevant to carbon conservation and sequestration needs, but only partially relevant to reducing GHG emissions in agriculture, and is dependent on the type of land converted to forests and addresses only those converted areas. The forest measures have limited relevance to addressing the primary GHG emission sources in CZ agriculture, namely the 56.1% of livestock-related emissions, and CZ has not targeted other measures at those needs. They can however address the stabilisation of agricultural soils, which account for 40.8% of emissions, although it is noted that the area of uptake of the measures is low in the current programming period, limiting their relevance in practice. Another examples was cited in the evaluation of forest measures under the CAP highlighting that despite the measures being relevant to addressing climate needs, in some cases the limited budgets and the limited access of the forest holders to the measures limits the ability of the measures to address local needs (Alliance Environnement and EFI, 2017).

Measures with relevance to addressing a specific climate need can be limited through modest funding allocations. For example, in Hungary, the livestock sector and agricultural soils make an almost equal contribution to agricultural GHG emissions, and have been increasing for the past few years. The use of the investment measure (M4) is relevant to addressing some of the livestock-related emissions by improving manure management. However, only 1% of the M4 budget has been allocated to addressing focus area 5d, and therefore suggests that in practice little effort is being programmed to addressing emissions from this part of the sector under this focus area. It is unclear from the information reviewed whether livestock-related emissions are being addressed through the use of M4 prioritised against other focus areas.

It is important to be clear about the balance of climate needs expressed in Member States in their agriculture and forestry sectors (e.g. reducing emissions, increasing sinks, adapting to pressures), and the role agriculture and forestry can play in economy wide climate action. For example, a number of case studies cite the importance of providing renewable energy, particularly from biomass (e.g. short rotation coppice, agro-forestry or energy crops in Ireland). There are situations in which this can provide climate mitigation benefits to the economy, through the substitution of high GHG intensity energy sources (such as coal). Yet in the agriculture and forest sectors, the use of biomass in this way would lead to a reduction in the carbon sink in these sectors, or at best the provision of only a temporary sink. With all case study Member States having an implicit need to reduce livestock and soil-related emissions, with limited measures and potential to do so, these carbon sinks and stocks will be essential to helping rural sectors move towards net-zero emissions.

Most case studies report that the adaptation needs in the RDP are or have the potential to be met by the measures programmed against those needs, although in some cases there is evidence to suggest CAP measures are working counter to these needs and that climate adaptation practices are leading to pressures on other environmental objectives. For example, efficient water use is an identified need in all of the case study countries (with the exception of Lithuania). In Andalucía, the main identified issue for the agricultural sector concerning adaptation to climate change is water management and the water and energy efficiency of irrigation. Support for irrigation is relevant to addressing water adaptation needs in the region, yet this support is also provided to regions where resources are under pressure (such as the Jaen and Guadalquivir valley). In these cases, irrigation support, even for more efficient irrigation systems could lead to maladaptation and exacerbate the pressure on water resources. The adaptation benefits to agricultural production may therefore only be temporary in nature, with longer term implications for the sector in these areas of high water stress. Changing crop types or diversifying agricultural incomes could be a more relevant response in such areas. In Aquitaine, a similar effect is seen where irrigation support for grasslands in summer can help adaptation in drought areas, yet places further pressure on limited water resources.

4.4 Conclusions

Both the CAP's general objectives for climate action and the more specific sub-priorities set out in the Rural Development Regulation are broadly framed, and as a result each correspond to a range of

needs expressed at EU, Member State and, in most cases, farm level. We did not find evidence of needs relating to agriculture or forestry in a climate context at either Member State or farm level to which no CAP objective was relevant.

The EU's objective of spending at least 20% of the overall EU budget on climate relevant actions, as set out in the MFF, is given partial effect by the requirement that at least 30% of the Rural Development Programme budget must be spent on climate change mitigation and adaptation and environmental land management through support for a limited range of measures. Minimum spending requirements on climate (and environment) objectives, are necessary to focus public money towards addressing climate needs. However, as the measures that form the focus of this spending include support to ANCs, which makes a limited contribution to climate mitigation and/or adaptation, it can be said that only part of the allocation to these measures contributes directly to climate objectives. Whilst climate and environment objectives are highly interrelated, articulating clearly the requirement for climate relevant expenditure could help to improve the focus of CAP measure implementation and uptake towards climate action needs. This would not preclude counting some of the same expenditure towards a separate indicator used to monitor expenditure on the environment, where there are clear synergies in implementation.

At farm and forest level the sub-priorities of carbon sequestration (per se), increasing the share of renewable energy and GHG mitigation are not necessarily shared by farmers themselves given that they may not always yield private benefits. However, actions which contribute to these objectives frequently have co-benefits which do accrue to farmers or foresters. The CAP's climate objectives are therefore relevant to the needs of farmers and foresters in this context.

Overall the suite of CAP measures addressed in this study (as listed in Table 11) is partially relevant to the EU's climate needs, but constrained by the lack of compulsory implementation of some of the most relevant measures as well as the absence of mandatory Pillar I measures targeted at emissions from livestock farming and the use of nitrogen fertiliser (with the exception of SMR1).

CAP measures are more relevant to adaptation needs than mitigation, but their relevance is again constrained by their voluntary nature. Whilst voluntary measures enable Member States and farmers the flexibility to target the needs in their territories with the appropriate interventions, there is no requirement for farmers to take up those measures in areas where needs have been identified. This is compounded by the farmers perceived needs not always corresponding with the climate needs identified by the RDP managing authority, i.e. farmers often focus on adaptation challenges rather than mitigation.

The case studies show that there is great diversity in the climate action needs and in approaches to addressing those needs in the EU. This diversity of impacts makes it difficult to draw conclusions on whether the CAP measures are relevant to climate action at Member State level, as this varies by country and context. The following conclusions can be drawn from the evidence collected:

- Measures relevant for mitigation are not always communicated or articulated as having mitigation benefits, however this does not detract from their relevance in addressing climate mitigation needs.
- Mitigating emissions from livestock requires a broader combination of approaches and activities than that which is available through current CAP measures. Given that livestock production (enteric fermentation and manure management) has the highest contribution to GHG emissions from agriculture, the CAP should include measures to directly address these emissions and require their use in Member States.
- Most case studies report that the adaptation needs in the RDP are or have the potential to be met by the measures programmed against those needs.

EFFECTIVENESS (ESQS 1-6)

Section 5 below provides an evidence base for the CAP's impact on GHG emissions which is used to answer ESQs 1-4 in sections 6 to 9. Section 10 then considers the CAP's effectiveness as a means of encouraging climate adaptation, and section 11 looks at innovation.

5 EVIDENCE BASE FOR ASSESSING THE CAP'S IMPACT ON GHG EMISSIONS

5.1 INTRODUCTION

This chapter evaluates the effectiveness of CAP measures and instruments in contributing to climate action, with a focus on mitigation actions and the impact on GHG emissions. Adaptation is addressed by another specific ESQ (ESQ5).

The impact of CAP measures has been quantified where appropriate and feasible given the suitability and reliability of data available to the study. GHG emissions and removals are quantified by activity, region (Member State) and farm type and are based in part on measure uptake data as reported by Member States in their Annual Implementation Reports (AIRs). The quantification of mitigation is limited by the available uptake data; a qualitative review of CAP measures accompanies the quantification to address gaps in the analysis where quantification of the GHG impacts was not possible. This strengthens the understanding of causality between measure use and climate mitigation impact and provides information relating to potential leakage. The qualitative assessment is also used to better understand the combined impact of CAP measures.

5.2 EVIDENCE BASE

The evidence base is used to identify (where possible) the impact on GHG emissions and removals from the use of CAP measures. The evidence base is formed of:

- GHG reporting under the UNFCCC to provide an overview of wider sectoral trends, not factoring in CAP measures;
- A quantitative review of CAP measures and their impact on GHG emissions (supported by a qualitative review where relevant);
- Estimated data from the simulation of GHG emission reductions and removals achieved through the uptake of selected CAP measures (developed for this evaluation).

5.2.1 GHG REPORTING UNDER THE UNFCCC

In the current programming period, GHG emission reporting to the UNFCCC is used as a context indicator (C45) to establish wider trends related to the CAP climate mitigation objectives. It is important to understand the basis for the information used to establish the context indicator and the trends that are represented. The indicator captures emissions from the following reporting categories:

- Enteric fermentation (3A) (CH_4)
- Manure management (3B) (CH_4 and N_2O)
- Rice (3C) (CH_4)
- Managed Agricultural Soils (3D) (N_2O)
- Cropland (including land converted to cropland) (LULUCF) (4B) (CO_2)
- Grassland (LULUCF) (4C) (CO_2)

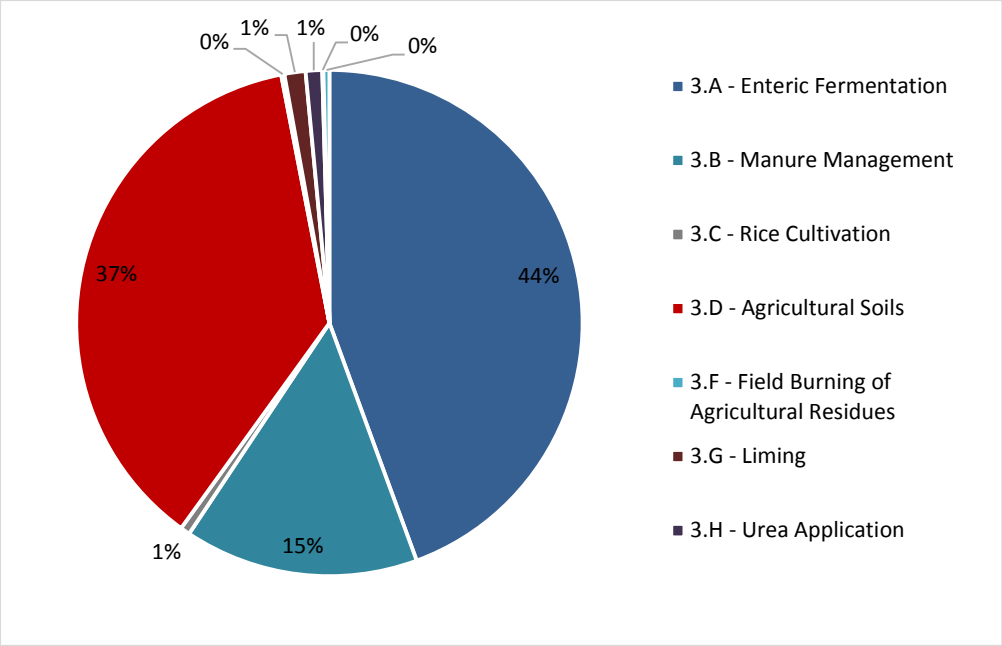
Category 3 reports on the emissions from the agriculture sector which is subject to the Effort Sharing Decision (ESD) targets, whereas category 4 reports on emissions from agriculturally managed land, but under the Land Use, Land Use Change and Forestry (LULUCF) Decision. For Context indicator C45, the net emissions from agriculture are presented, which includes agricultural soils under grassland and cropland. Together they show that there has been a fluctuation of emissions since 2005 with emission levels currently below 2005 levels, but with significant upward and downward

variations since 2010. Emissions from UNFCCC category 3 reduced from a 2005 baseline until 2012 and have seen a progressive increase since. This is likely to be as a result of livestock numbers leading to increased emissions from enteric fermentation (methane) and increases in total nitrogen fertiliser usage across the EU 28 (Eurostat). During this period, there has been a decline in emissions from category 4 from cropland and grassland.

It should also be noted here that the reporting of emissions from categories 3 and 4 is not limited to land that is managed under the CAP.

In 2016, GHG reporting to the UNFCCC indicates that the EU agriculture sector (inventory sector, not the economic sector) accounts for ~10% of the total GHG emissions reported by the EU28 Member States (amounting to ~430 million tonnes of CO_2 eq.). This share includes emissions arising from: enteric fermentation (CH_4 from livestock, accounting for 44% of the sector emissions); management of agricultural soils (N_2O and to a lesser extent CO_2, accounting for 37%); manure management (CH_4 and to a lesser extent N_2O; accounting for 15%); and other (including liming, urea, rice cultivation, field burning of agricultural residues and other carbon-containing fertilisers, accounting for 4%) (EEA, 2017) This excludes LULUCF and energy used on farms. When considering the LULUCF emissions specifically from crop land and grassland the total emissions are 69 million tonnes, 94% of which arise from cropland and 6% from grassland.

Figure 3: Breakdown of agricultural emissions by inventory category

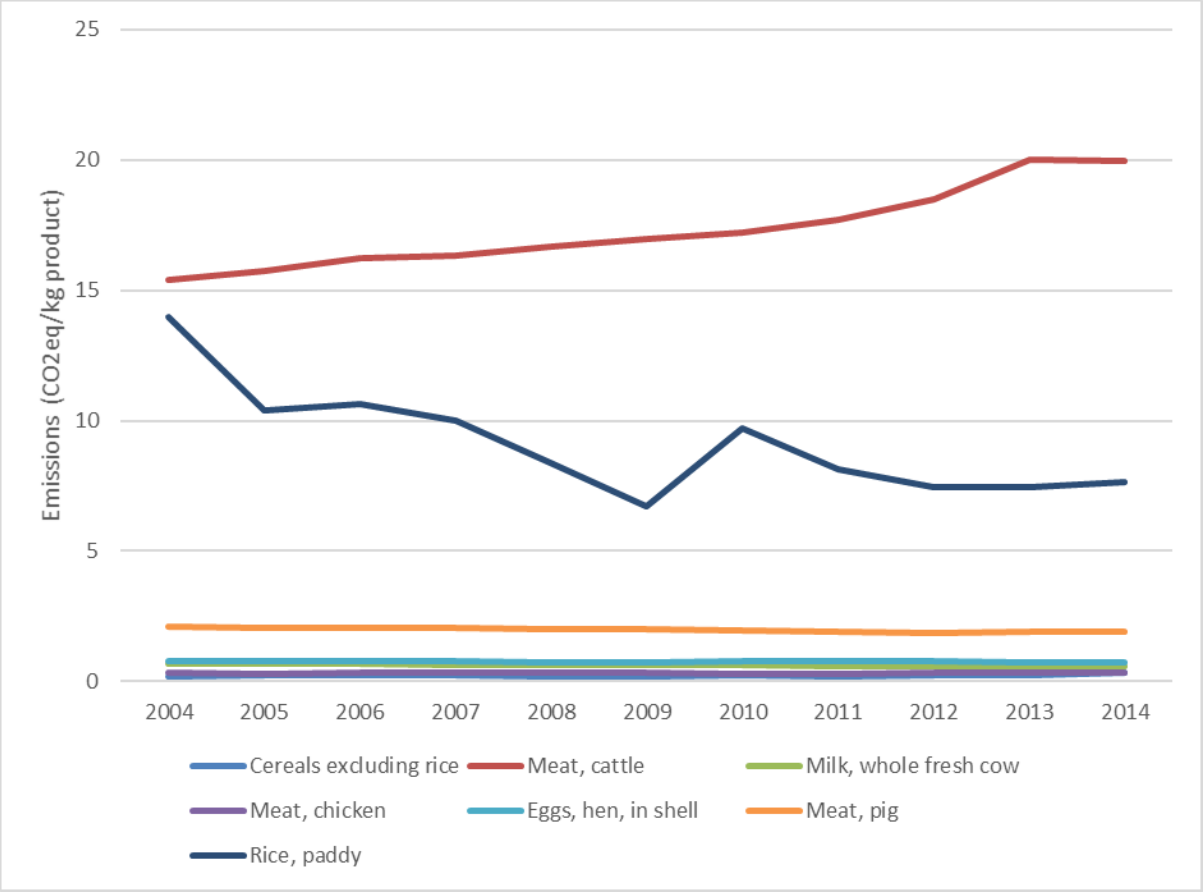


Source: EEA

At the same time, the emission intensity reporting indicates that the GHG emissions per unit of production have fallen slightly for certain farming systems (dairy, pigs and poultry). However, in the case of cattle there has been an overall increase Figure 4. Emission intensity is measured by GHG emissions (kg CO_2eq) per commodity (kg product)[20]; for consistency with the terminology used in this report, the commodities are presented by farming system.

[20] Emissions intensity takes account of the GHG emissions per unit of output and is calculated by measuring the inputs such as feed and fertiliser used in production and dividing total GHG emissions by the output of a farm enterprise. This gives a CO_2eq figure per unit of output (kg of meat, litre of milk or tonne of wheat etc). This is useful as it contextualises emissions by offering an assessment of productivity rather than simply giving absolute emissions numbers. However the quantitative analysis in this report is based on absolute reductions in emissions.

Figure 4: Emission intensity by farming system for the EU28



Source: FAOSTAT

At farm level, energy consumed on site (e.g. by farm equipment, livestock housing, etc.) can emit between 10 and 20% of the total holding GHG emissions. This is 2.8% of EU final energy consumption.

Soil carbon stocks in the EU-27 have been estimated at 75 billion tonnes (EEA, 2017e)[21], with about 50% of this in Member States with large peatland areas (Ireland, Finland, Sweden and the United Kingdom). In terms of carbon stock change, grassland can be a carbon sink or a source depending on cultivation and management practices. Cropland soils are a carbon source (Frelih-Larsen et al, 2016). The carbon stock change in soils under different land use and management is a complex area and highly dependent on local circumstances such as climate, soil type, precipitation, in addition to management practice. Some scenarios for soil carbon change are presented in section 5.3 below.

5.2.2 A REVIEW OF CAP MEASURES AND THEIR IMPACT ON GHG EMISSIONS

To illustrate the chain of causality for CAP measures and their impact on GHG emissions, CAP measures have been split into four categories, as follows:

(1) **Payments whose primary intervention logic is to support income and/or production.** These measures may affect mitigation (either positively or negatively) via production effects and as a result of land use change where they cause land to be used for agricultural production which would otherwise have served some other purpose. In the case of VCS for protein crops, whose intervention logic is to support livestock farming, there can also be a localised effect on nitrification. The measures include: decoupled direct payments, support in areas facing natural constraint in Pillars 1 and 2; and voluntary coupled support.

[21] The estimate is from 2004, before Croatia joined the EU

(2) Measures which encourage or require specific **land management practices** resulting in emission reductions (e.g. zero tillage, nitrogen efficiencies, soil cover etc.) and removals (e.g. reversion to grassland, protection of wetlands and peatland, etc.). The measures in this category include: greening; standards for GAEC; support for the creation and management of forests (e.g. M8 & 15); agri-environment-climate commitments; payments for organic farming; compensation payment for Natura 2000 agricultural areas; etc.
(3) **Capital investments** for infrastructure and technologies – this can include investments to improve energy efficiency in farm machinery and livestock housing and manure storage and management systems, installation of biomass boilers, establishing wetland. The measures include: investments in physical assets; investments in the creation, improvement or expansion of all types of small scale infrastructure, including investments in renewable energy and energy saving; and investments in forestry technologies and in processing, mobilising and marketing of forest products.
(4) **Soft measures** to improve capacity and uptake through knowledge sharing, training, advisory services, etc. The measures include: knowledge transfer; advisory services; farm and business development (business plans); establishment and operation of operational groups of the EIP for agricultural productivity and sustainability; support for implementation of operations under the CLLD strategy (LEADER); and the Farm Advisory System.

These four kinds of measure are discussed in turn below.

5.2.2.1 CAP measures supporting viable food production

Direct payments

Direct payments can in principle affect GHG emissions both positively and negatively. The basic direct payment has been decoupled from production with the objective that it should not affect production decisions, and there is literature to demonstrate that this is indeed the case for individual farmers (although some studies have posited that the income effect on individual farmers may dispose some of them to take on more production risk). The small farmers' and redistributive payments operate like the basic direct payment in this respect and so are expected to have little if any impact on production. As Voluntary Coupled Support is tied to production, the expectation might be that this has the effect of maintaining production. VCS has been since 2014 limited to the support needed to maintain production at historic reference levels. This section reviews the impact of income support and VCS payments.

Efforts to model the impact of direct payments on production using CAPRI data show that in aggregate direct payments are helping to keep land in agricultural production across the EU. The model provides a comparison with a counterfactual. Whilst land abandonment occurs in practice, the modelled results suggest that more land would have been abandoned had direct payments not been in place. The scenario modelled reports that direct payments are responsible for increases in GHG emissions, nutrient surpluses and pesticide inputs by 2.3 to 2.5 percent (Brady et al, 2017). The findings of the Scenar 2030 (JRC 2017) project show a similar (modelled) trend that direct payments maintain the utilised agricultural area. The JRC's modelling compares a reference scenario based on current CAP structure to future scenarios with and without direct payments. The scenarios with direct payments show maintenance of UAA where the scenarios without direct payments show a decline in UAA by ~7%. Results from the Scenar 2030 report should be viewed with some caution in this context as they do not look at direct payments in isolation and include fluctuations in the overall budget available for agriculture across the EU and liberalisation of trade scenarios.

Voluntary coupled support

Voluntary coupled support is intended to maintain certain production activities which endure difficulties and which are important for economic, social and/or environmental reasons. Since 2014 the scope of the scheme has been limited to maintaining historic levels of production. Member States are required to calculate the level of support using fixed quantitative limits based on recent production data. If actual production of eligible products exceeds these limits, support must be scaled down pro-rata. This ensures budget discipline but does mean that VCS can in practice support production above historic levels. More importantly, since coupled payments have existed for many years the historic reference levels are themselves higher than would be the case in a no CAP scenario.

If successful VCS thus by definition maintains production at a level beyond the counterfactual situation without coupled support. The impact on GHG emissions will vary according to the type of production supported and any eligibility requirements. Support to ruminants will impact associated enteric emissions, whilst support to protein crops could reduce emissions of N_2O and increase sequestration compared to the counterfactual scenario in which other crops were grown. Eligibility rules relating to livestock stocking density may limit the extent to which farmers without access to additional land may increase production, and also prevent soil erosion which would otherwise have occurred.

VCS is mainly used to support the production of beef and veal (41% of expenditure), milk (12.2%) and sheep and goats' meat (12%), but with 10.6% of spending supporting protein crop production.

Table 12: Principal sectors supported through Voluntary Coupled Support

Sector	Quantitative limit for support (million heads or hectares)	Total EU heads/hectares (million)	Number of Member States	Total budget 2017 (€m)	Average payment per head or hectare (€)
Beef and veal	19.3 (heads)	65.1 (heads)	23	1713	88/head
Milk	12.2 (heads)	23.3 (heads)	19	889	73/head
Sheep and goats	49.7 (heads)	86.1 (sheep - heads)	21	583	12/head
Protein crops	4.7 (ha)	1.7 ha	15	469	99/ha

Sources: DG Agri, Eurostat (t_apro_mt)

Table 12 shows that the quantitative limits applicable to existing VCS schemes would enable support to be granted at the average rates shown to 52% of EU dairy cattle and almost 30% of beef cattle. By contrast the quantitative limit for protein crops greatly exceeds the area actually grown in the whole EU, even though it relates to just 15 Member States.

Academic and other literature does not present a clear picture of the impact of VCS on production or GHG emissions. The impact carried out by the European Commission to support its 2018 legislative proposals (European Commission, 2018) used modelling by the JRC to estimate that removal of coupled support would reduce production in the beef sector by 2.5%, the dairy sector by 0.7% and the sugar sector by 4.9%. Reductions in ruminant herds on this scale would be expected to have a significant impact on enteric emissions of GHGs. Using the same CAPRI model, Jansson et al (2018) show that removing voluntary coupled support for ruminants would reduce beef production and GHG emissions in the EU by approximately 2 Mt CO_2eq/year, with approximately three quarters of this offset by an increase in emissions outside the EU. Jansson et al (2018) conclude from this that the current provision of VCS to ruminants contributes to GHG emissions at the EU level.[22] At Member State level a study considering both the abolition of the milk quota and the introduction of coupled payments in Italy (Cortignani and Dono, 2018) observed an increase of 5.5% in the number of dairy cows in Italy. Furthermore, they found that coupled payments provided for ewe lambs and rice led to increases of 5.5% and 0.6% respectively. Groeneveld (Groeneveld et al, 2016) found that, in the Netherlands, larger farms were more likely to increase the number of cows following the CAP reform (therefore not necessarily solely as a result of VCS) than smaller farms who tended to be constrained by land availability. They also found that the Dutch policies aimed at preventing intensification were successful.

An OECD study (OECD, 2017) using the CAPRI model to examine different scenarios estimated that under a 'no voluntary coupled support' scenario in which "no VCS are disbursed and other features of the CAP 2014-20 are implemented, land set aside would be increased by nearly 12% compared to the scenario in which all of the 2013 reforms, including VCS, are implemented[23]". This suggests that the VCS payment reduces that area that would otherwise be set aside (i.e. on which there would be no production). The GHG impacts of bringing land into production rather than setting it aside are complex, and depend both on the type of production and the way in which set aside land is managed. Bare fallow can be worse in GHG terms than land managed as grassland or in an arable rotation

[22] See section 3.2 for a discussion of emissions leakage.

[23] The reference scenario projects the CAP to 2020 without the 2013 reforms.

(Alliance Environnement and Thünen-Institut, 2017). In terms of production, the 'no VCS' scenario appears to have an impact on the area under pulses (which increases by 27% between 2014 and 2020 with VCS compared to less than 2% without it). Livestock numbers remain relatively stable except for sheep and goat numbers which increase under the different scenarios including that without VCS. However, the growth in sheep and goat numbers under the scenario without VCS is reduced. Overall, the study notes that "the differences in area and livestock numbers noted above are generally less marked [from a] production [perspective]".

Conversely a recent evaluation of coupled support suggests that it has minimal impact on production flows (Agrosynergie EEIG, 2015). The impact of coupled support under Article 68 of the previous regulation on production between 2007 and 2013 was assessed in relation to two broad categories of support available: specific disadvantages; and quality. The impact of the support was deemed to have limited (beef) or zero (dairy) effect for sectors targeted owing to specific disadvantages. However, in the same category, the support was found to contribute to a slowing down of the declining trend in production for the sheep sector.

Where production effects are found, the changes in GHG emissions which arise directly from production itself need to be considered alongside any changes to emissions which would occur if the additional production had not taken place. In principle, additional production resulting from coupled support could lead to the continuation of agricultural activity which is less GHG intensive than alternative uses for the land. For instance, an extensively grazed pasture which is no longer supported by VCS might be ploughed and converted to intensive arable production, releasing soil carbon and with emissions also from the use of fertilisers. However, the extent to which such changes can occur is constrained by other policy instruments and notably by the permanent grassland ratio and ESPG designation, in addition to the physical characteristics of the land which may make it unsuitable for arable farming. The proportions of beef, veal and dairy cattle which receive support – and thus the areas of agricultural land involved – are high, and the impact of other policies restricting ploughing of permanent grassland such that it is unlikely that significant areas of agricultural land would be converted to arable production were coupled support not to be available.

If Member States wished to target the use of VCS to extensive livestock systems they could use eligibility rules to do so. Among other possible restrictions, Member States may limit the number of animals in respect of which each farmer may receive coupled support. They may express such limits as an absolute number of animals per farmer, or as a stocking density in which case farmers with more land may claim more support. However, Table 13 shows that few of the case study Member States had done so.

Table 13: Eligibility rules for livestock VCS in case study Member States

Member State	Livestock sectors supported through VCS	Stocking density rules or limits on claims?
Czech Republic	Beef, dairy, sheep and goat	No
Spain	Beef, dairy, sheep and goat	No
France	Beef, dairy, sheep and goat	Some limits exist in relation to the maximum numbers of animals in respect of which payments will be made per beneficiary.
Croatia	Beef, dairy, sheep and goats	No
Germany	None	Not applicable
Hungary	Beef, dairy, sheep and goats	No
Ireland	None	Not applicable
Lithuania	Beef, dairy, sheep and goats	No
Netherlands	Beef sheep and goats	
Romania	Beef, dairy, sheep, goat, buffalo	Some limits exist relating to the minimum and maximum numbers of animals in respect of which payments will be made per beneficiary.

Source: own analysis of Member State notifications to the Commission

The table shows that only two of the nine case study Member States offering coupled support to livestock have placed any limit on the extent to which individual farmers may claim. Only France and Romania have done anything to damp the incentive to extra production, by placing some limits on the numbers of animals for which each farmer may claim.

The overall net impact of VCS on GHG emissions within the EU is difficult to judge. Additional enteric emissions and emissions from manure management associated with livestock numbers that are higher than would be expected in a counterfactual scenario must be balanced against any positive impacts from the protection of sensitive soils. The positive impact of additional protein crop production must also be taken into account. However the scale of support to the livestock sector and the fact that case study Member States had mostly not taken the most obvious step to target it on extensive livestock rearing suggests that negative impacts on GHGs are likely to outweigh the positive.

Support to areas of natural constraint under Pillar II

Under Pillar II, support for areas with specific natural constraint (ANC) operates as additional support to direct payments. It is intended to maintain agricultural production in areas with natural or specific handicaps (namely steep land in mountain areas, other mountain areas and land with other specific constraints – such as poor soil quality or low water levels) and prevent land abandonment. The measure is more commonly used under Pillar II as a multi-annual land management contract, and only Denmark opted to support ANC under Pillar I. Regardless of the area of land receiving support (either under Pillar I or 2), the impact of the measure on livestock production – the most usual type of farming in ANC areas - is difficult to establish for the current programming period (Ecorys, IEEP and Wageningen University & Research, 2016). Since the ANC payment is not coupled it is unlikely to be significant.

Changes in emissions due to changes in soil carbon and other biomass in Areas of Natural Constraint are possible. The measure is intended to enable farming to continue in areas where it otherwise might not and there is potential for a change in GHG emissions as a result. This can occur if, for example, natural succession follows the abandonment of previously farmed land with a resultant change in the volume and composition of biomass (Nunes, Figueiredo and Almeida, 2012). Erosion effects with the subsequent loss of soil carbon are also possible, and these can take a number of forms. For instance, in Scotland there have been instances where the replacement of sheep farming by uncontrolled grazing by wild deer has increased erosion. Elsewhere in regions where soil is held in place on steeply sloping ground through terrace systems, the abandonment of such systems may result in the loss of significant soil carbon (Rodrigo-Comino et al, 2017).

5.2.2.2 CAP measures supporting changes to land management practices

CAP measures supporting changes to land management practices include: greening; payments for afforestation/creation of woodland, establishment and maintenance of agro-forestry systems, prevention of damage to forests from forest fires and natural disasters and catastrophic events, and forest-environmental and climate commitments; agri-environment-climate commitments; payments for organic farming; compensation payment for Natura 2000 agricultural areas; and standards for GAEC.

Greening payment

Regulation 1307/2013 established the greening payment, linking 30 per cent of the direct payment to delivery of three greening components: crop diversification; permanent grassland and ecological focus area.

In relation to mitigation, the greening payment could contribute to emission reductions and removals in the ways set out in the table below.

Table 14: Mitigation actions supported by greening

Greening	Relevance to mitigation
Crop diversification	No direct impact on mitigation, but was found in the greening evaluation to have led to some switching out of cereals into leguminous crops plus anecdotal evidence suggested an impact on the length of crop rotations.
Ecological focus area	Protection and enhancement of carbon stocks in farmed landscapes

	through, for example, establishment of hedges and buffer strips.
Permanent grassland	Maintenance of permanent grassland protects and enhances soil carbon stocks.

Source: (Alliance Environnement and Thünen-Institut, 2017; Hart et al, 2017)

Recently modelled estimates (Louhichi et al, 2017) indicate that the greening permanent grassland component is considered to drive limited change in farming practice (affecting ~1.5% of EU farmland) and the EFA component is considered to have led to change affecting ~2.4% of EU farmland (Louhichi et al, 2017).

The ESPG measure is primarily designed to protect areas important for biodiversity which have been designated under the Natura 2000 Directives, although Member States may also designate other areas including those with high carbon soils. Only six Member States have designated outside their Natura 2000 areas and land so designated is just 4% of the Environmentally Sensitive Permanent Grassland designated[24]. Performance by Member States against the permanent grassland ratio has been affected by significant changes to the definition of permanent grassland and the way it is applied by some Member States. These changes led to an increase of 1.5 million ha of permanent grassland eligible and declared between 2014 and 2015 in 15 Member States such as Finland (+880%) and France (+8%), while it decreased by -5.3 million ha in 12 Member States, including in Spain, where more than 2.19 million hectares (31%) became ineligible in 2015 (mainly wood pastures). The extent to which the permanent grassland ratio protects land from ploughing, maintaining soil carbon and sequestration activity is discussed in section 6.1.1.

The impacts of the EFA and ESPG measures on GHG emissions are simulated in section 5.3 below. The impact of the permanent grassland ratio – the greening measure directly aimed at the protection of soil carbon – is discussed in section 6.1.1.

EAFRD measures supporting changes to land management practices

Under the current EAFRD Regulation (1305/2013), attention is given to integrating environment and climate change (and innovation) within Rural Development Programmes (RDPs) as cross-cutting thematic priorities. To this end, 30% of funds are earmarked for climate actions and environmental issues (Article 59). Further, the framework within which RDP measures sit is designed to enhance strategic planning of policy priorities. Climate change is a cross-cutting theme to the policy priorities and therefore should be reflected across all aspects of implementation. In particular, climate change features in the priority to promote resource efficiency and support the shift toward a low-carbon and climate-resilient economy in the agriculture, food and forestry sectors (Priority 5), and Priority 4 (to restore, preserve and enhance ecosystems related to agriculture and forestry).

The EAFRD Regulation identifies the key measures intended to contribute to Priorities 4 and 5 as

- Afforestation and creation of woodland
- Establishment of agroforestry systems
- Investments improving the resilience and environmental value as well as the mitigation of potential forest ecosystems
- Agri-environment-climate
- Organic farming
- Natura 2000 and Water framework directive payments
- Payments to areas facing natural or other specific constraints
- Forest-environmental and climate services and forest conservation

The integration of cross-cutting priorities is often implicit and the identification of climate action needs has not been systematically carried out (Ecorys, IEEP and Wageningen University & Research, 2016). The significance of this finding in relation to this evaluation is that while many CAP measures are recognised as having mitigation potential, the extent to which this potential is likely to be realised in the current programming period is low if it is not driven by strategic planning.

A review of CAP measures under EAFRD is set out below to identify those which may be used to fund climate mitigation actions.

[24] Belgium (Flanders), Czech Republic, Italy, Latvia, Luxembourg and United Kingdom (Wales).

Table 15 below shows each of the EAFRD measures which supports land management practices and which is identified in Table 1 as having a theoretical impact on climate mitigation. The final column of the table assesses the extent to which data is available which can be used to assess overall impact. Where no such data is available we give a brief judgment about likely impact where possible. Where uptake data is available the measure is included in the simulation of emissions described below and is shown in Table 22.

Table 15: CAP measures under EAFRD supporting changes to land management practices

CAP measure	Climate mitigation potential	Extent of climate mitigation potential
M03: Quality schemes for agricultural products and foodstuffs: (new participation in quality schemes; information and promotion activities implemented by groups of producers in the internal market)	Quality schemes may include farm certification schemes for products recognised as going beyond the standard environmental protection requirements. Climate change is not specified by the article.	If the basis for the quality scheme is that the product has a lower carbon footprint or reduced GHG emissions, the impact could be quantified. However, based on reporting of RDPs for the current programming period, there is no indication that MSs have adopted this measure to contribute to climate mitigation.
M05: Restoring agricultural production potential damaged by natural disasters and catastrophic events and introduction of appropriate prevention actions	Landscape features (e.g. hedges) created as part of preventative or restorative action may also increase carbon stock.	Not quantifiable without detailed surveys of individual sites
M08: Investments in forest area development and improvement of the viability of forests (8.1: afforestation/creation of woodland establishment; 8.2: maintenance of agro-forestry systems; 8.3: prevention of damage to forests from forest fires and natural disasters and catastrophic events)	Under 8.1, the types of species and areas where afforestation will be carried out must first be identified in the RDP together with a description of the environmental and climatic conditions to avoid adverse effects. Also includes tending, thinnings or grazing as appropriate, regulating competition with herbaceous vegetation and avoiding the building up of fire-prone undergrowth material. Under 8.3 activities include: specified number of trees planted and retained per ha and specified type of tree species. The expected environmental benefits should be identified in the RDP. The effect is also improving resilience and with active management, we encourage better growth, thus sequestering more carbon. .	Afforestation affects carbon stock (in soil, biomass and dead organic matter). Agro-forestry affects carbon stock (in soil, biomass and dead organic matter). A difference will exist between establishing and maintaining agro-forestry; however, this is not reported by the available uptake data.
M10: Agri-environment-climate: (10.1: agri-environment-climate commitments)	Examples of mitigation activities funded include: Maintain permanent pasture; Restriction on peat cutting; No grazing; No fertiliser application; Limits to fertiliser application; Grass cover; Green cover; Erosion prevention strips; No tillage; Ploughing-in of crop; Buffer strip; Fallow; Rotation with	Each contract will vary according the land management needs. Reporting on uptake is more detailed in the current programming period to provide more detail as to the broad types of activities funded.

	legumes; No burning of straw, stubble or cut residue; Management of non-aquatic landscape feature; Strips or patches for wildlife; Maintain area out of production; Take area out of production; Traditional grass management; Grazing regime; No machinery; Management plan; Overwinter stubbles; Mulching regime; Tillage regime; Runoff furrows Traditional crop management; Rotation; Traditional orchards; Pruning regime; Management of water features; Water level management	
M11: Organic farming (M11.1 payment to convert to organic farming practices and methods; M11.2 payment to maintain organic farming practices and methods)	Several activities associated with organic farming will have a positive impact on climate mitigation; however, M11 does not specify the practices and methods as these are defined in the organic farming legislation. In general, organic farming will result in reduced inputs.	The measure can be regarded as contributing to emission reductions to the extent that the support provided by the CAP is contributing to reduced inputs, and the associated mitigation potential which can be achieved through this land management practice. This ignores ILUC (see section 3.2).
Natura 2000 and Water Framework Directive Payments (12.1 compensation payment for Natura 2000 agricultural areas)	Relevance to mitigation through the protection of landscapes with high C soils, e.g. peat land and wetland	Payments to conserve and restore wetland and peatland in Natura 2000 areas will contribute to carbon sequestration as these areas have carbon rich soil.
Payments to areas facing natural or other specific constraints	High level of uncertainty in the outcome of this measure: on the one hand it can be seen to be preventing land abandonment and loss of grassland (with the result of protecting C stocks in soil); but on the other hand it can be seen to be driving grazing practices where the practice would otherwise be abandoned (with the result of driving GHG emissions).	Impacts on GHG emissions are not quantifiable and it is likely that the net impact will be marginal owing to the conflicting nature of the impacts identified (where one will cancel out the other)
Animal welfare	No directly relevant activities to climate mitigation identified. There may be some indirect efficiency gains. Activities are detailed in the accompanying delegated act (Art. 10) and refer to water, feed and animal care, housing conditions, outdoor access and avoiding mutilation of animals.	Secondary benefits in terms of production efficiency may improve GHG intensity of production
Forest-environmental and climate services and forest conservation (15.1 payment for forest-	Supports forest habitats and the conditions for natural forest regeneration with high diversity. Main mitigation activities supported include restructuring (relevant to mitigation, involves the maintenance of diverse forest edge or second	Likely to contribute to maintaining the status quo for removals by providing support to forested land and protecting carbon stock in soil and above ground biomass. However, the extent to which this measure is driving

environmental and climate commitments)	crown layer to preserve forest microclimate and prevent the carbon content of the forest soil); low impact silviculture, e.g. protection of the forest soil and ensuring its development, soil friendly harvesting, transporting and regeneration methods (continuous cover instead of clear cutting); and other practices such as leaving groups of trees after final felling, preservation of wetland habitats, repression of aggressively expanding non-indigenous tree and shrub species.	changes to land management practices affecting the extent of removals is likely to be less significant as there will be a balance in the types of commitments signed between changes in potentially changing the management practices (disturbing the carbon stocks in soil), while however increasing the sequestration as managed forests will increase growth (thinning practices, etc.). The main impact on GHG emissions is likely to occur from specific land management requirements stipulated in the commitments signed.

Cross compliance

Under cross-compliance a distinction should be made between Statutory Mandatory Requirements (SMR) and standards for Good Agricultural and Environmental Condition GAEC). The former comprises a list of related requirements stipulated by EU legislation (which are required regardless of the CAP); but cross compliance provides a framework for inspections and acts as a driver of compliance. The extent to which such a behavioural effect occurs cannot be estimated since activity data are not collected.

Table 16: Relevance of SMR and GAEC standards to climate mitigation

GAEC standard	Link with climate mitigation
SMR 1 Compliance with standards set under the Nitrates Directive	Some of the measures required to protect watercourses can be expected to protect soil carbon and/or reduce nitrification
GAEC 1 Establishment of buffer strips along water courses	Maintain soil carbon in permanent grassland and soils; subject to management of the buffer strip
GAEC 2 Where use of water for irrigation is subject to authorisation, compliance with authorisation procedures	Maintain soil carbon as a result of protected wetlands (otherwise at risk of drying out)
GAEC 3 Protection of ground water against pollution: prohibition of direct discharge into groundwater and measures to prevent indirect pollution of groundwater through discharge on the ground and percolation through the soil of dangerous substances, as listed in the Annex to Directive 80/68/EEC in its version in force on the last day of its validity, as far as it relates to agricultural activity	Maintain soil carbon as a result of protected wetlands (otherwise at risk of pollution)
GAEC 4 Minimum soil cover	Maintain and enhance soil carbon
GAEC 5 Minimum land management reflecting site specific conditions to limit erosion	Maintain soil carbon
GAEC 6 Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubble, except for plant health reasons	Reduced GHG emissions from burning and maintained/enhanced soil carbon
GAEC 7 Retention of landscape features, including where appropriate, hedges, ponds, ditches, trees in line, in group or isolated, field margins and terraces, and including a ban on cutting hedges and trees during the bird breeding and rearing season and, as an option, measures for avoiding invasive plant species	Maintain and enhance soil carbon. Maintain non-soil biomass.

Source: adapted from Frelih-Larsen et al (2016)

5.2.2.3 CAP measures supporting capital investments

Capital investments for infrastructure and technologies are supported by CAP measures under EAFRD. Examples of the types of capital investments supported in relation to climate mitigation are collected below based on activities supported in the previous programming period (2007-2013), as captured by the ENRD projects database (Table 17).

Table 17: Examples of RDP funded investments during the 2007-2013 programming period

Project title	MS	Project description	Mitigation impact
Setting up a biogas plant	CZ	4 anaerobic digesters and two generators. Included a tank for slurry from pig production	Installed capacity of the plant is 1.153 kwh. Emission savings from use of renewable energy not quantified, nor is the impact from slurry storage. Emission savings from a plant of this type and size could be 1.8 kt/y.
Energy, Forest and Climate Change (ENFOCC)	ES	Climate and energy management plans for 47 towns; actions involved: improved energy efficiency in public buildings (using Enegest tool); purchase of sustainable boilers to reduce CO_2 emissions (biomass boilers); carbon footprint of six agri-food products (EneGest tool)	Energy savings of €250,000 across 47 towns
Upgrading a forestry company's machinery in order to produce biomass in Czech Republic	CZ	Support to purchase a tractor and chipper to process shrubbery and trunk wood then used for biomass	Supplies biomass for the municipal heating station
Testing the transferability of landscape management to other Natura 2000 sites	DE	Support to identify appropriate ways of recovering wood fuel through landscape maintenance.	41 pilot areas (300 ha); on average maintenance costs were reduced by 35% with costs of using woody plants and shrubs for energy use rather than burning on site 25% lower comparatively; GHG balance was positive even with the extensive use of technology

Source: (ENRD, 2013b)

The CAP measures supporting these types of activities in the current programming period include: investments in physical assets; investments in the creation, improvement or expansion of all types of small scale infrastructure, including investments in renewable energy and energy saving; and investments in forestry technologies and in processing, mobilising and marketing of forest products. The relevance of each of these measures to climate mitigation are described in Table 18.

Table 18: CAP measures under EAFRD supporting capital investments

CAP measure	Climate mitigation potential	Extent of climate mitigation potential
M04: Investments in physical assets: (investments in agricultural holdings; investments in processing/marketing and/or development of agricultural products; investments in infrastructure related to development, modernisation or adaptation of agriculture and forestry;' non-productive investments linked to the achievement of agri-environment-climate objectives)	Investments under this measure can superficially be grouped into two: productive and non-productive investments. The main difference is eligibility for co-financing rates. Climate mitigation can be targeted through both types of investments. Productive investments contributing to climate mitigation can include: animal housing and equipment in cattle production and other ruminants (cow sheds, milking units, manure and slurry storage/processing, winter housing); animal housing and equipment in pig and poultry production (housing with high animal welfare standards, manure and slurry storage/ processing); farm buildings in plant production (facilities for postharvest treatment and storages for field crops); support and cover constructions for perennial crops; biomass processing for energy (new units and equipment for processing biomass pellets and briquettes); biogas stations (biogas power stations including local distribution of heat); and food processing equipment. Non-productive investments contributing to climate mitigation include: capital works within the framework of an AEC contract and restoration of wetlands and moorland. Other activities (not relevant to mitigation) include: fencing, restoration of landscapes and features, and dry stone walls.	Indicators for reported uptake data are limited in detail which limits the extent to which mitigation potential can be simulated with any accuracy.
M07: Basic services and village renewal in rural areas (specifically: 7.2: investments in creation, improvement or expansion of all types of small scale infrastructure; and 7.6: studies/investments)	Under 7.2 (including investments in renewable energy and energy saving), investments can include: - (re)construction/ rehabilitation of municipal roads and bridges; water supply/ sewage system or other water management infrastructure; facilities to produce and use regenerative energy in rural municipalities (e.g. district heating networks to use and process heat of bioenergy plants); - establishing distribution networks for heat/ electric/ gas power from biomass or other renewable sources; While 7.6 (for the maintenance, restoration and upgrading of the cultural and natural heritage of villages, rural landscapes and high nature value sites including related socioeconomic aspects and environmental awareness actions) may support studies relevant to climate mitigation such as territorial studies for the design of local AEC	Limited reporting to determine the extent of infrastructure investments funded explicitly by sub-measure 7.2. Sub-measure 7.6, while relevant, the impact on climate mitigation cannot be determined as it is dependent on improvements achieved to the design and uptake of AEC measures. Moreover, low uptake compared to other EAFRD measures (both planned and realised).

	measures and information on the actions	
M08: Investments in forest area development and improvement of the viability of forests (8.6: investments in forestry technologies and in processing, mobilising and marketing of forest products)	Under 8.6 activities may include: establishing firebreaks; use of grazing animals; communication equipment.	Impact cannot be quantified as the outbreak of avoided fires and the extent of damage avoided is unknown.

5.2.2.4 'Soft' CAP measures

The role of soft measures is to improve the capacity of farmers and their advisors and to facilitate uptake of other measures. Soft measures typically include: technical advice and support; training in agri-environmental management; peer group and cooperative initiatives; and measures based on information and communications technology (ICT).

'Soft' measures are required as part of cross-compliance in the form of the Farm Advisory Service and can also be also supported by Pillar II. There is limited analysis to assess their impact. In terms of production, soft measures are generally accepted to guarantee little by way of higher returns (Charatsari, Folinas and Lioutas, 2010). Labarthe and Laurent (2009) noted however that better educated and trained farm managers are more likely to make successful changes to farm-management practices and to become more innovative and flexible. Knickel et al (2009) argue that often there is a gap between the need for change and farmers' willingness to adjust on the one hand, and a lack of capacity to support change within the agencies responsible for innovation and advisory services on the other. However, as discussed by Hyland et al (2015), there are large variances between farmer attitudes and acceptance of soft measures. Their study divided farmers into four types according to their attitude to the environment as shown in Box 3.

Box 3: Farmer attitudes and acceptance of soft measures

A) The Environmentalist - high awareness of climate change and environmental responsibility. High implementation of mitigation measures but somewhat low perceived sense of the risks of climate change and lower likelihood to implement adaptation measures. A general consensus from farmers in this group that the manufacturing and use of fertiliser, along with methane from ruminants and the management of their manure, contribute towards climate change.

B) The Dejected – risk averse personality which combined with awareness influences likelihood to implement mitigation and adaptation measures. Although such farmers are aware that climate change is occurring and that livestock farming contributes towards the problem, there is an evident lack of understanding concerning how emissions are generated.

C) The Countryside Steward – High sense of environmental responsibility but low awareness of environmental problems. Attached to the land and the wider environment. For example, a high proportion of Countryside Stewards perceive methane emissions from livestock as being unproblematic. A low behavioural capacity to implement mitigation or adaptive measures is consequently born from the Countryside Steward's low senses of awareness and perceived risk. Interestingly, the proportion of university-educated members is significantly lower in this cluster in comparison to the other types

D) The Productivist - Farmers within this type are defined by their lower sense of environmental responsibility, with maximising production their principal motivation. They tend not to see climate change as a threat to their own enterprise and to denounce emissions from other industries as being a major cause of climate change, while placing little blame on the livestock sector.

Source: Hyland et al (2015)

Soft measures within cross-compliance

Regulation 1306/2013 sets out the requirement for Member States to establish a system for advising beneficiaries on land management and farm management – referred to as the Farm Advisory System (FAS) (Article 12).The FAS provides the basis for advisory activity relating to legislative compliance and it may provide "Information on the prospective impact of climate change in the relevant regions, of the GHG emissions of the relevant farming practices and on the contribution of the agricultural sector to mitigation through improved farming and agroforestry practices and through the development of renewable energy projects on farm and energy efficiency improvement on farm."

EAFRD soft measures

Several measures under EAFRD include 'soft' components which will likely contribute to climate mitigation. The relevance of CAP measures in this regard to GHG emissions is set out in Table 19 below.

Table 19: 'Soft' CAP measures under EAFRD

CAP measure	Climate mitigation potential	Extent of climate mitigation potential
M01: Knowledge transfer and information actions (vocational training and skills acquisition actions; demonstration activities and information actions; short-term farm and forest management exchange as well as farm and forest visits)	Training and skills acquisition may contribute to climate mitigation if targeted. E.g. training for farmers to better understand the linkages between climate change and agriculture. No requirement to target mitigation in the legislation.	For M01 and M02 it is not possible to quantify the impact on GHG emissions based on outreach indicators. It is most likely to arise from changes in management practices some of which (e.g. uptake of an AECM) will be captured in relation to other measures.
M02: Advisory services, farm management and farm relief services (to help benefiting from the use of advisory services; the setting up of farm management, farm relief and farm advisory services as well as forestry advisory services; training of advisors)	Advisory services may target the improvement of climate performance specifically, or cross compliance, requirements under the water framework directive, the sustainable use of pesticides regulation or the plant protection regulation (among other things). Although climate change is specified in the article wording, Member States have flexibility as to whether or not they choose to include climate friendliness.	
M06: Farm and business development	Identified in the EAFRD regulation as a measure with the potential to contribute to climate action, although not explicit in the wording of the article. Further detail is provided in the delegated act detailing the content of the business plans required as part of this measure (Art. 5). It must include the details of the actions, including those related to environmental sustainability and resource efficiency.	No evidence to determine the uptake.
M16: Co-operation (16.1: establishment and operation of operational groups of the EIP for agricultural productivity and sustainability)	Can contribute to driving research in climate mitigation actions with the result of improving the knowledge base and improving capacity to deliver them.	The effect on GHG emissions cannot be gauged by uptake or outreach. Too much uncertainty to quantify the impact although many research projects have been supported with relevance to climate mitigation - Examples of relevant studies funded include: Cost-effective farm management practices and tools to enhance

		carbon storage; How to develop agroforestry systems; Best practices for fertiliser use (focussing on horticulture); Practices to enable biomass mobilisation in forests; Sustainable forest management measures to improve forest mitigation and adaptation; Grazing management practices that benefit carbon content of soils; Identifies measures and tools for reducing emissions; success and fail factors; Operationalising mixed farming systems (which are better equipped at recycling N, P and C and reduce the need to import feed and fertiliser; thus contributing to mitigation); How to improve the agronomic use of recycled nutrients from livestock manure and other organic sources; One component identifies practices to reduce carbon footprint and methane emissions; How to mainstream precision farming; Profitability of protein crops; Options to enhance production and use of renewable energy on the farm; New methods for improving soil organic matter content.
M17: Risk management	No relevant activities to climate mitigation identified	N/A
M19: Support for LEADER local development (19.2: LEADER: support for implementation of operations under the CLLD strategy)	CLLD strategies can include climate actions and support towards transition to a low carbon economy and reducing GHG emissions. However this measure is a capacity strengthening one rather than driving the climate actions.	The extent of mitigation is not possible to quantify; examples of relevant projects include introductory classes on renewable energy in Spain; setting up a renewable energy visitor centre in Germany; awareness raising in Bulgaria on electric vehicles in rural areas.

5.3 SIMULATED QUANTIFICATION OF GHG EMISSIONS AND REMOVALS

The literature review shows that there is limited evidence to establish the link between CAP measures and climate mitigation. While there is a large body of research establishing the potential of certain land management practices, farm investments and soft measures to contribute to climate mitigation, understanding how the CAP is used to support these mitigation actions and the extent to which it is effective is less well established. The main challenges preventing this include:

- Lack of a baseline
- The level of detail in some of the uptake data
- The wide range of potential biogenic emissions depending on specific circumstances
- Difficulties aggregating GHG emissions reported at project level.

With these caveats, we have developed a GHG simulation according to the mitigation potential of CAP measures based on uptake data.

The simulation is limited in the following ways:

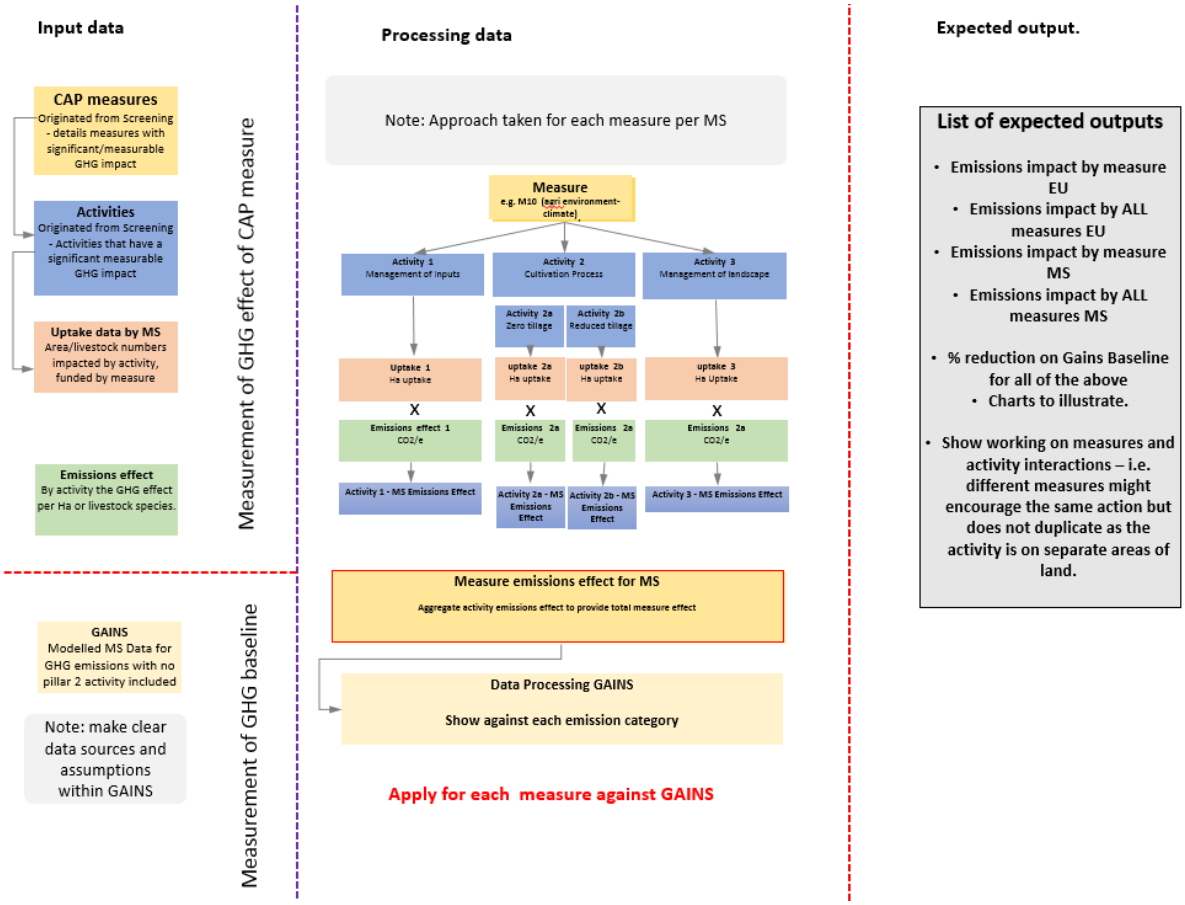
- Mitigation actions funded by CAP measures have been generalised
- Emission pathways are simplified to focus on the main processes
- Varying level of detail in the uptake indicators (with some more relevant to the simulation than others)
- Exclusion of CAP measures where no relevance to the uptake indicator and emission pathways could be established
- Baseline used to contextualise results (from GAINS model) already includes Pillar I CAP measures

Details of the methodology are provided in the following sections together with the results from the simulation. The methodology sets out:

- How the baseline for the simulation was established
- Which CAP measures are included in the simulation, together with the uptake indicators which have been used and the emission pathway allocated in each case
- The ranges of factors used to estimate the mitigation potential of the CAP measures selected

An overview is presented below to illustrate how the method is applied.

Figure 5: Illustrative overview of the GHG simulation



Source: Own compilation

5.3.1 ESTABLISHING THE BASELINE

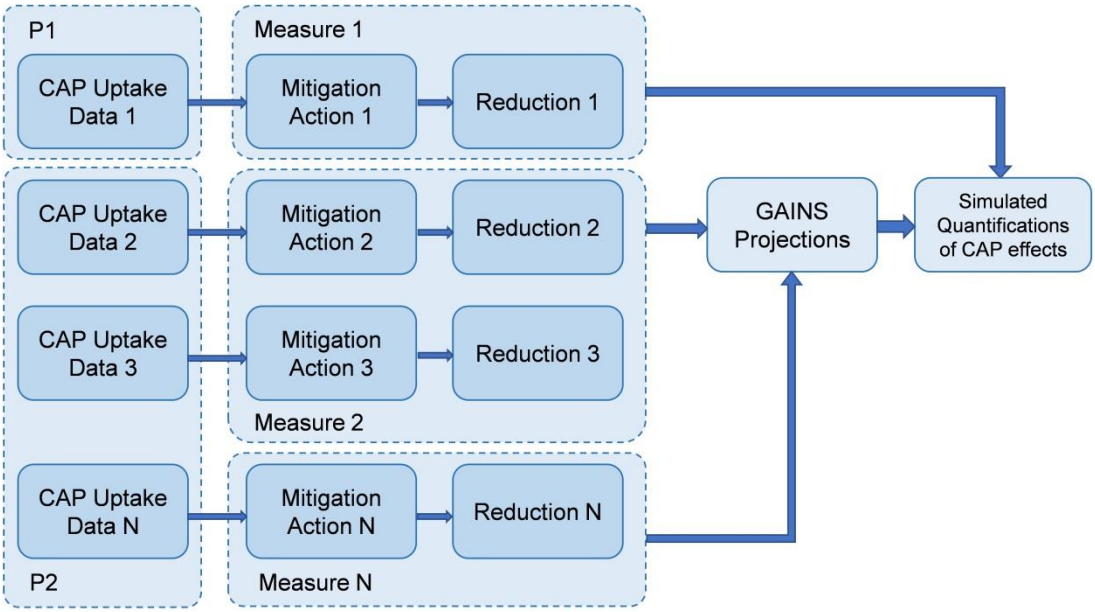
The GHG – Air Quality Interaction and Synergies (GAINS) model contains information about the expected evolution of GHG emissions and activity variables for a number of scenarios underpinned by a number of assumptions. In GAINS, activity drivers for emission projections enter calculations externally using projections from different internationally-recognised sources. In the specific case of agricultural scenarios for Europe, these come from the CAPRI model in consistency with the macroeconomic scenarios developed for the European Union by DG ECFIN. CAPRI is a modelling system for the agricultural sector of the EU and it uses a unified, complete and consistent data base, which is derived from various sources such as national statistics on slaughtering, herd size, crop production, land use, farm and market balances and foreign trade, as well as regional statistics. This model also allows considering the effects of different policy initiatives on activity variables. With these activities, GAINS estimates GHG emissions through the application of a consistent methodology across all countries and if any discrepancies between these and the emissions reported to UNFCCC are found, these are investigated and calibrated (Höglund Isaksson et al, 2016).

The use of GAINS emissions projections is useful for contextualising the estimated mitigation of GHG from CAP reporting data in terms of the expected evolution of such emissions until 2020. For example, the estimated mitigation of GHG produced by a measure using a specific uptake value, put in conjunction with the trend of the projections may indicate whether its presence can bring about reductions, stabilisations or even increases in the tendency depicted by the GAINS emissions.

The methodology for quantifying the effect of the difference CAP measures on GHG emissions and removals involves multiplying CAP uptake data, which often refers to specific areas of land or livestock units covered by the measure, by mitigation action factors taken from scientific literature. The product of these two variables constitutes an emissions change (either negative or positive) which is then directly reflected on the GHG emissions of their respective years (Figure 6). While some

of the CAP measures focus on specific GHG, all quantifications are made and aggregated in CO_2 equivalent mass.

Figure 6: Methodology of the simulated quantification of CAP effects



Source: Own compilation

In this respect, the selected GAINS scenario was the Thematic Strategy for Air Pollution (TSAP) scenario to 2050, which sets objectives for reducing certain air pollutants by adopting the latest EU environmental legislation (Oenema et al, 2012). Although this scenario was developed for air pollution abatement policies, it provides GHG emission estimates that reflect the latest EU policy instruments in agriculture, such as the following initiatives:

- The 'Health Check' of the Common Agricultural Policy (CAP) and Council Regulations (EC) No 1290/2005, No 1698/2005, No 1234/2007, No. 73/2009 and Regulations (EU) No 1305-1308/2013.
- Abolition of the 'Set aside' (regulation 73/2009) and milk quota regulations.
- Agricultural premiums are largely decoupled from production levels.
- The World Trade Organisation (WTO) December 2008 Falconer proposal.
- The biofuel targets for 2020 of the EU Energy and Climate package as modelled by PRIMES.
- The nitrates and water framework directives' impacts have been translated into increasing efficiency of fertiliser use over time, with consequences for the amount of fertilizer applied.
- CAP Pillar I, including greening.

5.3.2 CAP MEASURES INCLUDED IN THE GHG SIMULATION AND THEIR EMISSION PATHWAY

As described in section 5.2.2 – only some CAP measures are expected to have a quantifiable impact on GHG emissions. In addition, only certain CAP measures have suitable uptake indicators available for the purposes of this simulation. Therefore, only a selection of CAP measures could be included in the simulation – as presented in Table 20 and Table 21. Notable omissions include EFA fallow land, in respect of which the simulation cannot calculate a single year's impact on emissions, the permanent grassland ratio and basic direct payments.

Table 20: CAP measures quantified

Pillar I						
Mitigation action	CAP measure	Uptake indicator	Emission quantified	Removal quantified	GHG	Comment
Zero tillage	EFA	EFA area for buffer strips EFA area for strips along forest	Change of carbon stock in soil		CO_2	Applies only to new strips.
Wetland/ peatland conservation/ restoration	PG	Area of ESPG designated and declared		Change of carbon stock in soil	CO_2	The 2017 greening evaluation states that the criteria for designation does not only consider wetland and high SOC soils, therefore ESPG is unlikely to be all wetland or peatland.
Existing woodland on agricultural land	EFA	EFA area for afforested areas		Change of carbon stock in soil and above ground biomass	CO_2	This just accounts for the afforested area declared for EFA, not the management.
Improved nitrogen efficiency	EFA	EFA area for catch crops	Nitrification and denitrification pathways in soil and manure (including from leaching).		N_2O	Catch crops are one component of this mitigation action. The uptake indicator will underestimate the area of land managed with improved nitrogen efficiency.
Biological N fixation in rotations and in grass mixes	EFA	EFA area for nitrogen fixing crops	Nitrification and denitrification pathways in soil and manure (including from leaching)		N_2O	See above - Improved nitrogen efficiency
Short rotation coppice	EFA	EFA area for short rotation coppice		Change of carbon stock in soil	CO_2	Includes no consideration of change in N_2O emission - that is a different pathway and assessment would require knowledge of N application rates compared with a counterfactual

Pillar II						
Mitigation action	CAP measure	Uptake indicator	Source quantified	Sink quantified	GHG	Comment
Reduced tillage	M10.1	Soil cover, ploughing techniques, low tillage, Conservation agriculture	Change of carbon stock in soil		CO_2	Reduced tillage primarily impacts GHG emissions through reduced emissions; however, it also removes CO_2 through enhanced soil C stock. This interaction is not reflected in the GHG simulation. Net emissions are simulated and presented as emission (source). There are also savings in fuel use compared to ploughing, but these cannot be quantified.
Zero tillage	M10.1	Soil cover, ploughing techniques, low tillage, Conservation agriculture	Change of carbon stock in soil		CO_2	Combined with reduced tillage- see above.
New agroforestry	M08.2	OI_M08_area_8.2		Change of carbon stock in soil and above ground biomass	CO_2	This measure will also support emission reductions from changes of carbon stock in dead organic matter. However, the main impact on GHG emissions is from CO_2 removal from enhanced soil C stock. Net emissions are simulated and presented as sink (removal).
Wetland/peatland conservation/restoration	M12.1	OI_M12_area_12.1		Change of carbon stock in soil	CO_2	Also linked to AECM and M04.4. There is also likely to be duplication of the mitigation effect with the greening permanent grassland measure. (note explanation below)
Woodland planting	M08.1	OI_M08_area_8.1		Change of carbon stock in soil and above ground biomass	CO_2	This measure also supports emission reductions from changes of carbon stock in dead organic matter. However, the main impact on GHG emissions is from CO_2 removal from enhanced soil C stock. Net emissions are simulated and presented as sink (removal).
Management of existing woodland on agricultural land	M08.2	OI_M08_area_8.2		Change of carbon stock in soil and above ground	CO_2	Combined with new agroforestry – see above

				biomass		
Optimised feeding strategies for livestock	M10.1	Animal feed regimes, manure management	Manure management		N_2O	
Feed additives for ruminant diets	M10.1	Animal feed regimes, manure management	Enteric fermentation		CH_4	
Improved nitrogen efficiency	M10.1; M11	Management of inputs incl. integrated production (reduction of mineral fertilizers, reduction of pesticides); OI_M11_area_11.2/ OI_M11_area_11.1	Nitrification and denitrification pathways in soil and manure (inc from leaching)		N_2O	Urea application also emits CO_2 but that we cannot quantify the impact CAP measures has on this. This measure can overlap with improved N fixation. We assume that 100% of land in uptake area is carrying out this measure.
Biological N fixation in rotations and in grass mixes	M10.1; M11	Management of inputs incl. integrated production (reduction of mineral fertilizers, reduction of pesticides); OI_M11_area_11.2/ OI_M11_area_11.1	Nitrification and denitrification pathways in soil and manure (including from leaching)		N_2O	This measure can overlap with improved nitrogen efficiency but to avoid over-reporting we apply a 5% factor to uptake (i.e. assume that only 5% of land in uptake area is carrying out this measure).
Manure storage	M04	OI_M04_lu	Methanogenesis under anaerobic conditions in soils and manures		CH_4	

Note: Table explanation:

- Mitigation action: corresponds to emission factors.
- CAP measure: Includes P2 and P1

- Uptake indicator: As reported against in the annual implementation reports for P2 and the greening report data supplied by DG Agri for P1
- Emission/ removal: Relates to the emission pathway. Source may be positive or negative (i.e. emission and reductions), while sink refers to actions that remove CO_2.

5.3.2.1 Mitigation potential

We have reviewed published information on the effects of measures on GHG emissions and removals. Activities on farms, which result from implementation of measures, were identified and mapped onto GHG emission reporting categories used in national GHG inventories. This gives linkages between measures and mitigation potential, with disaggregation by GHG and by reporting category. The reporting categories (e.g. manure management, enteric fermentation, agricultural soils) give an indication of the farming system that the mitigation has relevance to. We have used indicators of uptake, by Member State, to allow mitigation potential estimates (e.g. in units of t/ha/y CO_2eq) to be scaled up to Member State Level and EU level. Table 21 provides details of the mitigation action and Table 22 maps CAP measures to mitigation actions and provides detail of the uptake. Uptake has been generated from two sources. For Pillar II, the 2014 – 2020 RDP output indicators report was used and for Pillar I we used the greening report data (March 2017).

CAP measures with the greatest mitigation potential could be broadly divided into three categories – relating to crop production, land use or nutrient and soil management. Under the first category, retaining crop residues and ceasing to burn crop residues and vegetation are the two practices estimated to have the largest mitigation potential. Although zero tillage has overall low mitigation capacity, its potential is significantly higher in semi-arid areas such as Spain, Portugal, Greece and Cyprus. Efficient land use practices include conversion of arable land to grassland, new agroforestry, woodland planting, preventing deforestation and the management of existing woodland, hedgerows, woody buffer strips and trees on agricultural land. Regarding nutrient and soil management, biological N fixation and the use of nitrification inhibitors were estimated to have the greatest potential. It is worth noting that carbon auditing – an energy measure with overall high mitigation capacity – was not included in the simulation on the grounds that it is unquantifiable.

Table 21: Mitigation actions and their potential effects for the CAP measures included in the GHG simulation only

Mitigation Action	Mitigation potential (net)	CAP measures supporting the mitigation action	Source(s)
Reduced tillage	0.0059 to 0.0180 t/ha/y CO_2eq	M10.1 Agri-environment climate commitments	Defra Project EC0103, 2010 Nix, 2013
Zero tillage	0.0121 to 0.0359 t/ha/y CO_2eq	M10.1 Agri-environment climate commitments EFA buffer strips	McVittie, 2014 Defra Project EC0103, 2010 Nix, 2013
Retaining crop residues	0.11 to 2.2 t/ha/y CO_2eq	Cross-compliance GAEC6 – may also be required under GAEC4 or 5	Frelih-Larsen et al., 2014 Posthumus et al., 2013
Conversion of arable land to grassland	0.87 to 7.3 t/ha/y CO_2eq	M4.4 non-productive investments linked to the achievement of agri-environment-climate objectives M10.1 Agri-environment climate commitments M11.1 payment to convert to organic farming practices and methods M11.2 payment to maintain organic farming practices and methods Cross compliance GAEC4 or 5 (if specified by Member States EFA buffer strips	Ammann et al. 2007 Lugato et al. 2014
New agroforestry	0.15 to 0.88 t/ha/y CO_2eq	M08.2 establishment and maintenance of agro-forestry systems	Frelih-Larsen et al., 2014

		EFA	
Wetland/peatland conservation/restoration	0.40 to 8.2 t/ha/y CO_2eq *but* applicable to limited areas	M10.1 Agri-environment climate commitments M12.1 compensation payment for Natura 2000 farmland areas Greening - ESPG	Frelih-Larsen et al., 2014 Artz et al., 2012; cited in Feliciano et al., 2013 Bain et al., 2011 cited in Bonn et al., 2014
Woodland planting	1.47 to 1.83 t/ha/y CO_2eq	M08.1 afforestation/creation of woodland	Wiltshire et al., 2014
Preventing deforestation and removal of farmland trees	0.73 to 7.3 t/ha/y CO_2eq	Cross-compliance Greening payment	McVittie, 2014
Management of existing woodland, hedgerows, woody buffer strips and trees on agricultural land	0.37 t/ha/y CO_2eq	M08.2 establishment and maintenance of agro-forestry systems EFA	Wiltshire et al., 2014
Ceasing burning vegetation and crop residues	0.2 - 0.7t/ha/year increase in soil SOC	GAEC6	Reijnders, (2008)
Use of nitrification inhibitors	0 - 0.017 t CO_2eq/ha/y	M10.1 Agri-environment climate commitments	Misselbrook et al., (2014) Lam et al (2017)
Improved nitrogen efficiency	0.033 - 0.159 t/ha/y CO_2eq	M10.1 Agri-environment climate commitments M11 Organic farming	Martineau et al. (2016)
Biological N fixation in rotations and in grass mixes	0.006-2.2 t/ha/y CO_2eq	M10.1 Agri-environment climate commitments	Feliciano et al., (2013) Martineau et al. (2016)

The results of the simulation are generated using the mitigation potential for each of the mitigation actions detailed in Table 21 in combination with the uptake detailed in Table 22 below.

Table 22: Measures linked to mitigation activity and uptake factors

Measure	Sub	Description	Mitigation Action (MA)	Allocation to MA	Unit of activity	EU Activity 2016
M04	LU	Investment in livestock management in view of reducing GHG and ammonia emissions	Improved manure storage	100%	Livestock unit (no.)	97,221
M08	8.1	Afforestation/creation of woodland establishment;	Woodland planting	100%	Area (ha)	209,346
M08	8.2	Agro-forestry systems planted and retained per ha	New agroforestry	100%	Area (ha)	119,257
M11	11.1	Payment to convert to organic farming practices and methods;	Improved nitrogen efficiency	95%	Area (ha)	2,513,750
			Biological N fixation	5%		
M11	11.2	Payment to maintain organic farming practices	Improved nitrogen	95%	Area (ha)	9,428,881

		and methods	efficiency			
			Biological N fixation	5%		
M12	12.1	Compensation payment for Natura 2000 agricultural areas	Wetland/peat land conservation/ restoration	100%	Area (ha)	902,536
M10	10.1	Soil cover, ploughing techniques, low tillage, Conservation agriculture	Reduced tillage	89%	Area (ha)	8,142,550
			Zero tillage	11%		
M10	10.1	Animal feed regimes, manure management	Optimised feeding strategies	35%	Livestock unit (no.)	2,766,531
			Feed additives for ruminant diets	65%		
M10	10.1	Management of inputs incl. integrated production (reduction of mineral fertilizers, reduction of pesticides)	Improved nitrogen efficiency	95%	Area (ha)	15,377,659
			Biological N fixation in rotations and in grass mixes	5%		
Greening	PG	Area of ESPG designated and declared	Wetland/peat land conservation/ restoration	100%	Area (ha)	5,100,148
Greening	EFA	EFA area for buffer strips	No cultivation	100%	Area (ha)	42,606
Greening	EFA	EFA area for strips along forest	No cultivation	100%	Area (ha)	8,053
Greening	EFA	EFA area for agroforestry	New Agroforestry	100%	Area (ha)	35
Greening	EFA	EFA area for afforested areas	Management of existing woodland on agricultural land	100%	Area (ha)	50,805
Greening	EFA	EFA area for catch crops	Improved nitrogen efficiency	100%	Area (ha)	2,925,036
Greening	EFA	EFA area for nitrogen fixing crops	Biological N fixation in rotations and in grass mixes	100%	Area (ha)	3,344,375
Greening	EFA	EFA area for short rotation coppice	Short rotation coppice	100%	Area (ha)	18,910

5.3.3 SIMULATION RESULTS

Based on the GHG simulation described above, the following results have been generated. Discussion as to their relevance in the evaluation is set out in sections 6 to 9.

The results are presented as follows:

- Simulated GHG emissions at EU28 level, by measure and by GHG, presented as separate tables for Pillar I and Pillar II and in a chart;
- Simulated GHG emissions by region for each of the CAP measures included in the simulation for net GHG emissions.

Table 23: Simulated GHG emissions impact by the simulated Pillar I CAP measures according to EU28 uptake (2016) (kt CO_2 eq/ year)

CAP measure	Scenario	Emitted as CO_2	Emitted as N_2O
EFA	Low	19	152
	Medium	20	4005
	High	21	7858
Permanent grassland ESPG	Low	1466	0.000
	Medium	15764	0.000
	High	30061	0.000
Total P1	Low	1486	152
	Medium	15784	4005
	High	30082	7858

Source: Alliance Environnement simulation results

The scenarios reflect the ranges for the emission factors shown in Table 21. The low scenario assumes that the mitigation potential of each mitigation activity which is associated with the relevant CAP measure is at the low end of the range, the high scenario assumes the opposite and the medium scenario is the average of the two.

Table 24: Simulated GHG emissions impact of some Pillar II CAP measures according to EU28 uptake (2016) (kt CO_2 eq/ year)

CAP measure	Scenario	CH_4	CO_2	N_2O	% reduction compared to the baseline (net CO_2 eq.)
GAINS	Baseline	287394	38677	240201	
M04	Low	6	0.000	0.000	0.0011%
	Medium	13	0.000	0.000	0.0023%
	High	20	0.000	0.000	0.0035%
M08.1	Low	0.000	308	0.000	0.0543%
	Medium	0.000	345	0.000	0.0610%
	High	0.000	383	0.000	0.0677%
M08.2	Low	0.000	22	0.000	0.0039%
	Medium	0.000	22	0.000	0.0039%
	High	0.000	22	0.000	0.0039%
M10.1	Low	0.05	121	243	0.0644%
	Medium	0.13	170	1125	0.2287%
	High	0.22	218	2007	0.3930%
M11	Low	0.000	0.000	189	0.0334%
	Medium	0.000	0.000	874	0.1543%
	High	0.000	0.000	1559	0.2753%

M12.1	Low	0.000	361	0.000	0.0638%
	Medium	0.000	3881	0.000	0.6853%
	High	0.000	7401	0.000	1.3069%
Total P2	Low	6	812	432	0.2209%
	Medium	13	4418	1999	1.1356%
	High	20	8024	3566	2.0503%

Source: Alliance Environnement simulation results

The % reduction is calculated by measuring the reduction in all three gases against the GAINS baseline shown in row 2 (grey).

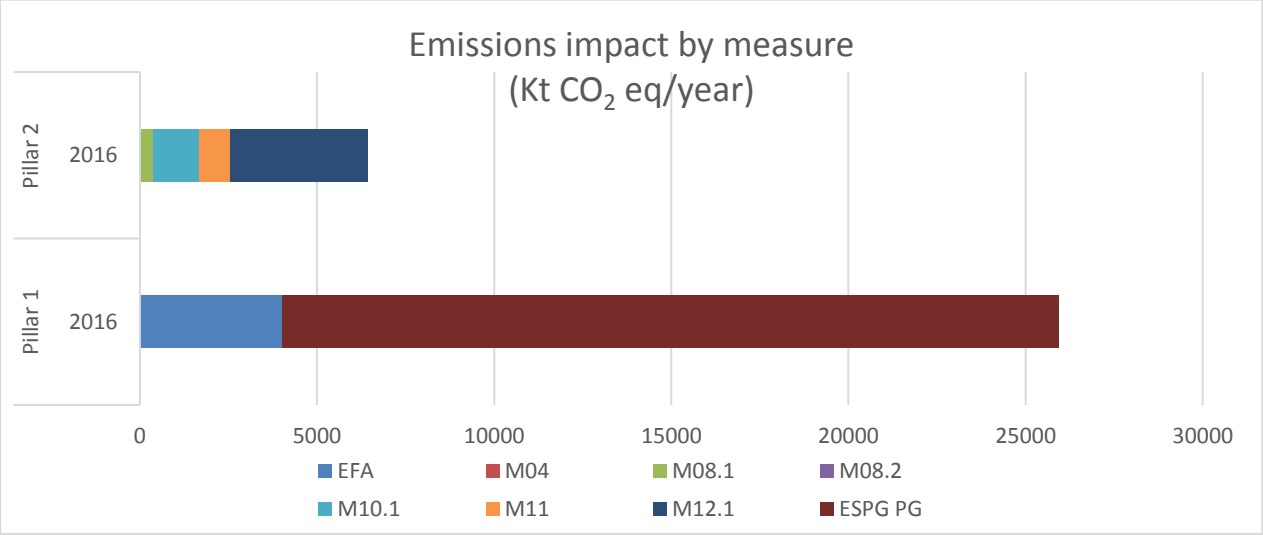
The Pillar II measure with the highest simulated impact on GHG emissions is M12.1 payments to farmers in Natura 2000 areas. This is a function of the emission factor allocated to such payments, which is based on an assumption that they help to support plans which protect carbon-rich soils. Such payments are offered in respect of a large number of hectares in Member States, so the combined effect is a large simulated reduction in emissions.

The simulation result almost certainly exaggerates the impact of this measure. This is because payments compensate farmers for the cost of complying with restrictions which are already in place. They do not buy new mitigation actions. It is reasonable to associate some mitigation impact with the payment, because in its absence protection might have been more difficult to put in place due to farmer opposition, and management plans once in place might have been less well complied with. The simulation cannot, however, account for such factors and the whole impact on GHGs associated with Natura 2000 protection has thus been attributed to M12.1.

There is also a strong likelihood of double counting between M12.1 and the greening permanent grassland measure for ESPG, whose impact is simulated based on the benefits of protecting environmentally sensitive permanent grassland, most of which is in Natura 2000 areas. Such overlaps are foreseen by Regulation 1306/2013 which requires Member States to deduct from the M12.1 payments any amount associated with restrictions which a farmer is already required to comply with as a result of the greening measure. The simulation – which is driven measure by measure – cannot account for such overlaps but they must be borne in mind when considering what the simulation tells us about the CAP's overall impact.

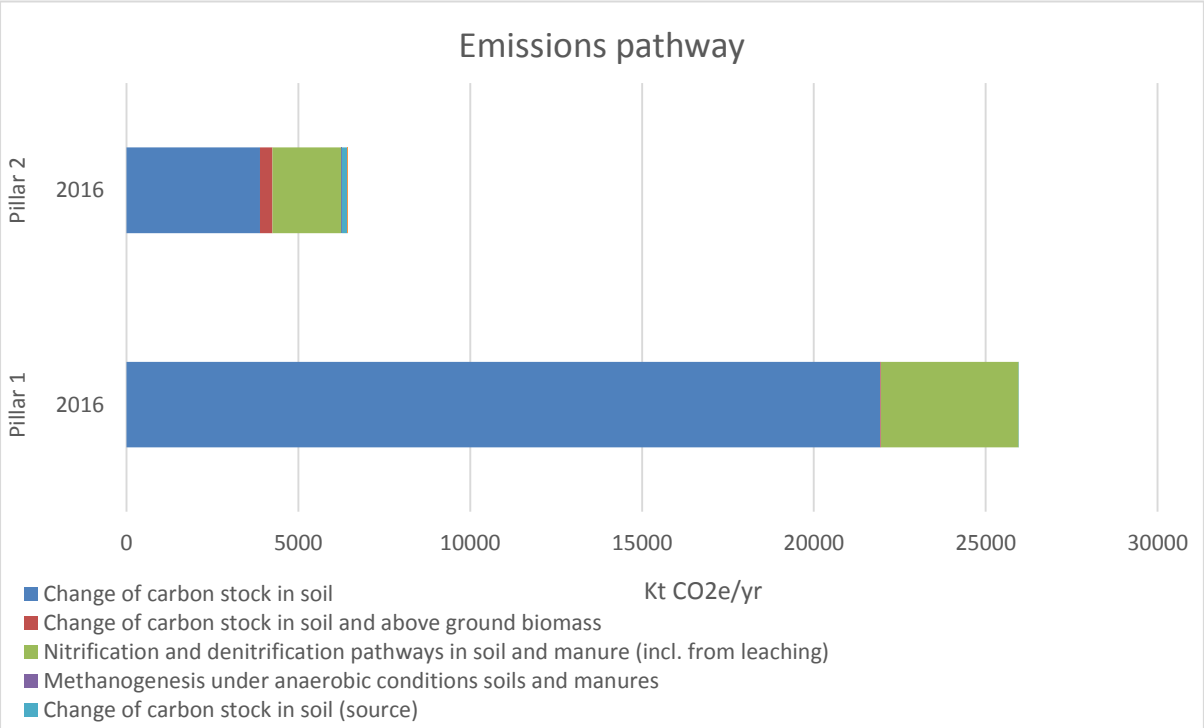
Figure 7 and Figure 8 demonstrate how the emissions impact can be represented in two ways. Figure 7 shows the emissions impact of each individual Pillar I and Pillar II measure within the simulation. Figure 8 shows the emissions impact of the simulated Pillar I and Pillar II measures by pathway. This is generated by understanding the impacts of the measure on the GHG affected and function of that effect. The absolute emission impact is the same in both graphs.

Figure 7: Simulated emissions impact by measure



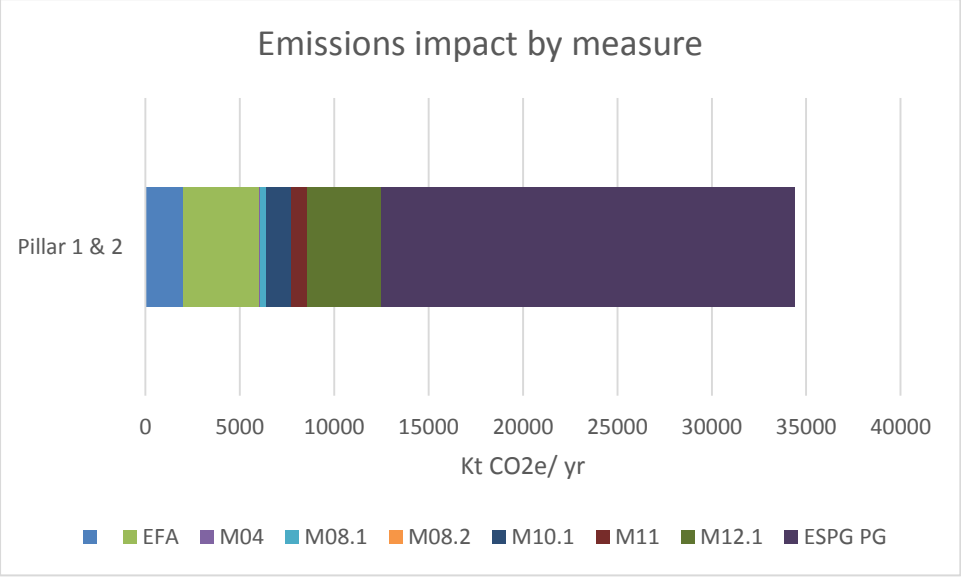
Source: Alliance Environnement simulation results

Figure 8: Graph showing emissions impact of CAP measures by pathway



Source: Alliance Environnement simulation results

Figure 9: Combined emissions impact of Pillar I &2*



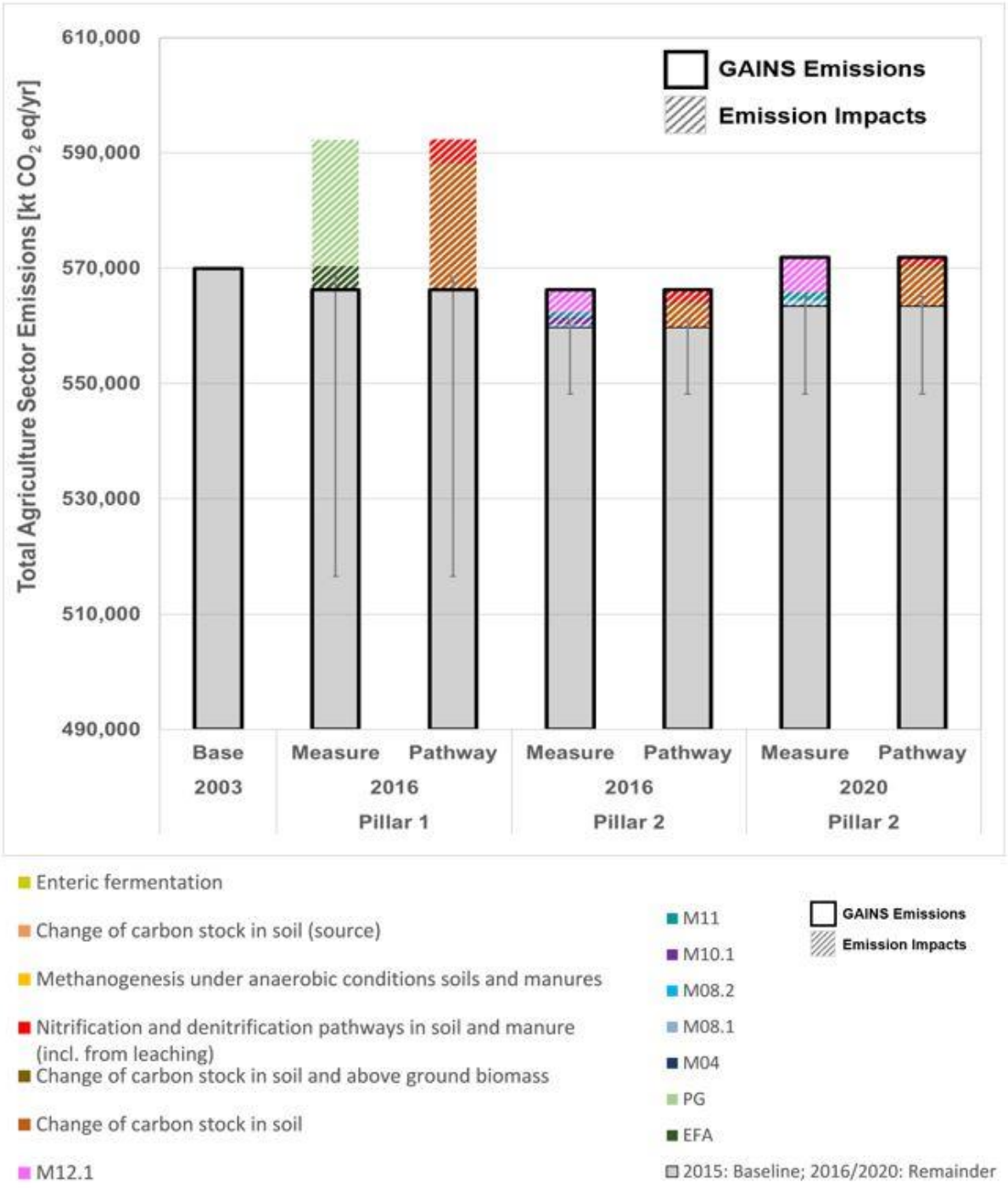
Source: Alliance Environnement simulation results

* Figure 9 shows the combined simulated impact of the simulated Pillar I and Pillar II measures. It does not allow for any overlap between the effect of the ESPG measure and M12.1, which is discussed in section 6 below.

Figure 10 shows the simulated emission reductions from both Pillar I and Pillar II measures in relation to the baseline emissions modelled by GAINS for 2016. Because the results for Pillar II may in some cases reflect low uptake of measures early in the programming period, for Pillar II a result for 2020 is also calculated based on the assumption that uptake targets programmed for that year by Member States will have been met. In each case, the shaded area represents the simulated reductions in emissions. For Pillar I, the graph shows that emissions would have been significantly higher than the

GAINS baseline in the absence of the measures whose impact has been simulated. The light and dark green shading shows the contributions of the ESPG and EFA measures. The red and brown shading shows the contributions from reduced nitrification and changes to soil carbon stock. For Pillar II the purple shading shows the significant contribution of M12.1, and the brown shading again illustrates the extent to which the result reflects changes in the soil carbon stock.

Figure 10: Simulated net GHG emissions resulting from the simulated CAP measures and their emission pathway, based on EU28 uptake data



Source: Alliance Environnement simulation results

Note: Coloured bars indicate the emissions from CAP measures and emission pathways (for 2016 and 2020) calculated from the central mitigation potentials applied to uptakes. Error bars indicate

the "remainder" emissions (grey bar) if the high (top bar) or low (bottom bar) mitigation potentials were applied.

The GAINS baseline is the area outlined in black. GAINS models Pillar I but not Pillar II impacts. Impacts for the two pillars are therefore presented in different ways. Coloured areas above the baseline for Pillar I represent additional emissions which might have occurred (according to the simulation for this study) in the absence of P1 measures. For Pillar II, the coloured area below the baseline represents emission reductions simulated by this study which are not contained in the GAINS baseline.

Simulation results for individual Member States are presented in Annex 3. They are discussed in section 7.

The information in this evidence base has been used to inform the answers to ESQs 1-4 provided in the following section.

6 EXTENT OF SUCCESS OF CAP MEASURES IN RELATION TO CLIMATE ACTION (ESQ1)

ESQ1: To what extent were the CAP measures adopted in the EU adopted for climate action successful or unsuccessful?

In answering this question greenhouse gas emissions should include those from energy and transportation used in farm operations, land use and land use change etc. Furthermore, the answer to this question should distinguish between decoupled Direct Payments, coupled Direct Payments (Voluntary Coupled Support) and EAFRD support.

The simulation exercise described in section 5.3 identified quantifiable reductions in emissions from the Pillar I measures for ESPG and EFA (Table 23) and from a range of Pillar II measures (Table 24). For those measures which could not be quantified using the simulation (see section 5.2.2), available evidence about their impact from modelling work by others as well as qualitative evidence is presented. To avoid repetition, the response to ESQ1 considers success at the level of the policy as a whole and largely avoids discussion of the details of the contributions made by individual CAP measures, which are set out in ESQ4. The CAP's success in stimulating appropriate adaptation to the risks of climate change is assessed in ESQ5.

6.1.1 PILLAR I

It was not possible to simulate the GHG impact of decoupled payments (Basic Direct Payments and SAPS, the redistributive payment, the small farmers' payment and payments to areas facing natural constraints) using our model but the literature shows there to be no definitive overall impact either through changed land use or changes in production (which might give rise to emissions directly and/or through indirect land use change). The relevant evidence is reviewed in section 5.2.2. Collectively these payments do increase the extent to which land is used for agriculture but the GHG effects can occur in ways which are either positive (e.g. greater biomass production after abandonment) or negative (e.g. worsening soil erosion after abandonment). Such effects are highly dependent on site specific factors and there is as a result no counterfactual against which the extent to which either positive or negative effects are more prevalent could be assessed.

Voluntary Coupled Support was redesigned in 2014 with the intention of supporting production only up to historic levels. However maintaining production at these levels still results in higher production, compared to a no CAP counterfactual if production would otherwise have fallen below historic levels in the absence of VCS support. The impact assessment carried out by the European Commission to support its 2018 legislative proposals (European Commission, 2018) used modelling by the JRC to estimate that removal of coupled support would reduce production in the beef sector by 2.5%, the dairy sector by 0.7% and the sugar sector by 4.9%. Reductions in ruminant herds on this scale would be expected to have a significant and positive impact on emissions of GHGs although a reduction in direct emissions from livestock might be accompanied by changes in land use whose

impact is difficult to predict. Case studies for this evaluation found some evidence that some farmers in Aquitaine were able to switch from grassland to arable systems when ANC support was withdrawn whereas case studies for the evaluation of the greening measure (Alliance Environnement and Thünen-Institut, 2017) identified farmers who felt that they were constrained by the permanent grassland ratio from converting or ploughing grassland. These findings indicate that changes from livestock to arable systems could occur in some circumstances were VCS support to livestock to be withdrawn, but their extent would be constrained by other CAP measures and in particular the permanent grassland ratio. This would limit the extent to which reductions in GHG emissions due to fewer livestock animals were offset by increased emissions arising from land use change such as the conversion or ploughing of grassland.

Support for the continuation of extensive livestock farming on carbon rich soils can in certain circumstances yield mitigation benefits. However Member States have made VCS available with little use of selective criteria, particularly in the dairy industry. 72% of the VCS budget supports the production of ruminant livestock, and more than half of the entire EU dairy herd is supported. Moreover only two of the nine case study Member States who offer VCS to ruminants have set any eligibility rules to restrict the number of animals for which a farmer may claim support, and neither has sought to influence stocking density through such rules.

A smaller proportion (10%) of Member States' VCS budgets has been set aside for protein crops. These can reduce GHG emissions but production at EU level is currently taking place on just 1.7 million hectares. Martineau et al (2016) report that reductions in direct GHG emissions from improved nitrogen efficiency of between 0.033 and 0.159 tonnes/hectare/year are achievable via nitrogen management measures including the planting of protein crops. On this basis, the protein crops currently grown in the EU may be contributing some 56.1 to 270.3 kilotons'/year CO_2eq in reduced emissions. However, not all of this reduction can be attributed to VCS. As well as market factors, the eligibility of protein crops for EFA and the crop diversification measure are known to have had an impact (Alliance Environnement and Thünen-Institut, 2017).

Overall, it is judged that the extra direct emissions from additional ruminant livestock which are kept because of VCS outweigh any reduction in emissions attributable to VCS support for protein crops. The removal of VCS might lead to changes in land use in some circumstances, with both conversion to arable farming and abandonment followed by natural succession being possible results. The former would increase emissions whilst the latter may reduce them. However there are policy constraints – notably the greening permanent grassland measure – on arable conversion. There is therefore no reason to conclude that reduced emissions from a reduction in livestock numbers would automatically be offset by increased emissions from ploughing.

Two studies using modelled data have estimated the net impact of greening to be a 0.2% GHG annual reduction by 2025 in total agriculture non-CO_2 emissions compared with the baseline scenario (2013) (with the EFA component understood to be delivering a slightly greater GHG reduction compared to permanent grassland, and the impact of crop diversification being negligible) (Gocht et al, 2017). The European Court of Auditors (European Court of Auditors, 2017) concluded that "greening is unlikely to provide significant benefits for the environment and climate, mainly because of the significant deadweight which affects the policy". The results of the GHG simulation carried out for this study show a more optimistic view of the mitigation realised through greening which is the result of differences in methodology. The simulation approach used for this study assesses changes in emissions based on the uptake of individual CAP measures. It considers emissions to be reduced when a farmer chooses an EFA option which has been identified as capable of reducing them. This differs from the Auditors' approach which is to credit the greening measure with a benefit only when a farmer changes his practice. Both approaches have drawbacks since neither can fully account for how farmers would have behaved in the absence of the greening measure. The degree to which deadweight may distort the simulation results in respect of ESPG is discussed further below. With this caveat, the simulation results for this study - for the ESPG component of the permanent grassland measure and for EFA - suggest that emissions from agriculture would have been 3.5% (19.8 Mt CO_2eq) higher in 2016 in the absence of these two measures. This is 3.5% of agricultural emissions as modelled by GAINS. As illustrated in Figure 9, the majority of this result is attributable to the permanent grassland ESPG component.

These quantified results need to be treated with considerable caution. Those for the permanent grassland measure in particular are based on modelling of the ESPG measure which assumes that all

the benefit of protecting ESPG can be attributed to the greening measure, and which uses an emissions factor established from literature which relates to the GHG removal benefits arising from restoring wetlands and peatlands. The literature makes clear that such large removals are achievable in a limited range of circumstances, so that the "medium" simulation result[25] is very likely to be an overestimate. Additionally is also a concern since 96% of ESPG designated by Member States was already protected through designation under the Natura 2000 Directives. Where the N2000 management plans put in place to implement such existing protection already banned ploughing, the effect of greening would be to increase the potential cost (via a greening penalty) to the farmer of not complying with the existing rules. Any reductions in the ploughing of sensitive grassland which are achieved by the Nature Directives cannot also be attributed to the greening measure The ECA notes that grassland within Natura 2000 sites are at comparatively low risk of conversion or ploughing.

The permanent grassland ratio is the greening measure most directly aimed at the reduction of net emissions as well as the one which applies to the greatest area of land. Its effect on LULUCF emissions is significant but was not quantified in this study due to the significant uncertainty relating to the management of permanent grassland. Unlike ESPG, where ploughing is banned and designation (should) guarantee that soil carbon is locked in and sequestration can continue, various types of management with very different consequences for mitigation are possible in the case of land which is not ESPG and which is only protected through the Permanent Grassland ratio. The European Court of Justice in 2013[26] made clear that land classed as permanent grassland can be ploughed and re-seeded without it losing its Permanent Grassland status. Due to this, we do not have sufficient confidence to attempt to quantify the impact of the ratio as we have done with ESPG. Alternative calculations were carried out using carbon stock change factors for grassland remaining grassland. Two separate analyses have been carried out to demonstrate the impact on different soil types and with different climates. The results are presented in the tables below.

The six scenarios are (S1) grassland cultivated and re-seeded to grassland, (S2) grassland becoming cropland, and (S3) grassland remaining grassland (no cultivation for re-seeding). S4, S5 and S6 then repeat the three scenarios for a different soil type. For North Western Europe S1-S3 assume a high activity clay soil and S4-6 a sandy one. For Southern Europe S1-3 assumes a low activity clay soil and S4-6 a volcanic one. In each case the emissions change during land use was estimated using IPCC factors for management (F_{MG}), land use (F_{LU}), and inputs (F_I). For land use change (LUC) we used IPCC good practice guidance to estimate the soil carbon stock loss for (2) grassland becoming cropland. In practice, this soil carbon loss is a consequence of soil cultivation where previously cultivation did not occur. For scenario (S1) grassland cultivated and re-seeded to grassland, we have applied the same LUC method, as for S2 to estimate the soil carbon stock loss, in this case, as a consequence of soil cultivation and re-seeding. We make the caveat that, although we have applied a LUC adjustment for S1, in national inventory compilation this would not be a situation where LUC is recognised and soil carbon loss as a consequence of cultivation would not be estimated using Tier 1 methods in the IPCC 2006 guidelines.

[25] This corresponds to the mid-point of the range of potential improvements in emissions per hectare

[26] The Court judgment of 2 October 2014 in the case C-47/13 clarifies the succession of forage species in the grassland and thus clarifies the definition of permanent pasture: permanent grassland must be interpreted as agricultural land which has been for five years or more, used to grow grass and other herbaceous forage, even though that land has been ploughed up and seeded with another variety of herbaceous forage other than that which was previously grown on it during that period.

The result for each scenario is shown in column Delta C, which shows the change in soil carbon stock after 20 years as an annualised figure.

Table 25: Example of carbon stock change in grassland – North-West Europe

Scenario	SOC (0-T) t/ha C (0-30 cm)	F LU	t/ha C (0-100 cm)	F MG	F I	Area (hectares)	SOC 0 t/ha C (0-30 cm)	Delta C t/ha C (0-30 cm)
1	95	1	-1.15	1.0045	1	1	94.3	-0.7
2	95	0.985	-1.15	1	1	1	92.4	-2.6
3	95	1	0	1.007	1	1	95.7	0.7
4	71	1	-1.15	1.0045	1	1	70.2	-0.8
5	71	0.985	-1.15	1	1	1	68.7	-2.3
6	71	1	0	1.007	1	1	71.5	0.5

Table 26 Example of carbon stock change in grassland – Southern Europe

Scenario	Baseline C stock SOC(0-T) t/ha C (0-30 cm)	F LU	LU adjustment t/ha C (0-100 cm)	F MG	F I	Area ha	SOC 0 t/ha C (0-30 cm)	Delta C t/ha C (0-30 cm)
1	24	1	-0.5	1.007	1	1	23.7	-0.3
2	24	0.99	-0.5	1	1	1	23.3	-0.7
3	24	1	0	1.007	1	1	24.2	0.2
4	70	1	-0.8	1.007	1	1	69.7	-0.3
5	70	0.99	-0.8	1	1	1	68.5	-1.5
6	70	1	0	1.007	1	1	70.5	0.5

These calculations are for indicative purposes only. There is high (unquantified) uncertainty, because in practice carbon stock change is site-specific. The age of the grassland concerned and the extent to which its carbon stock has reached equilibrium are important variables. The adjustment for initial ploughing uses data for 0-100 cm, whereas other factors relate to 0-30 cm depth interval. We have assumed that most of the stock change for the 0-100 cm depth at ploughing occurs within 0-30 cm because ploughing is usually to a depth of less than 30 cm, and most soil carbon is in the top 30 cm of the soil. Therefore we have not corrected for this difference in input data.

The results show the variation in potential carbon stock change between scenarios in which cultivation takes place and those in which it doesn't. In order to use this information to calculate a simulated impact on emissions for the permanent grassland ratio we would need much more information on the soil types and the length of time they had been under grass as well as a clear view of any counterfactual land use. 36.1 million hectares of permanent grassland was under the ratio obligation in 2016 (3.8 million hectares having ceased in 2015 to be declared by farmers as permanent grassland following changes to the definitions of that term). The ratio allows up to 5% of this total to be converted to arable use, and potentially all of the remainder to be ploughed and reseeded as grassland although in practice a significant proportion of it is unsuitable for cultivation. Compared to our counterfactual scenario in which there are no CAP measures, therefore, the ratio is preventing up to 95% of the 36.1 million hectares of permanent grassland from being ploughed without reseeding as grassland. The greening evaluation presents case study evidence indicating that the measure is preventing some grassland from being ploughed at all. For instance some French dairy farmers are deterred from responding to low milk prices through diversification into arable.

In order to illustrate the potential scale of the impacts on soil carbon arising from the permanent grassland ratio, Table 27 shows calculations of the effect of a one percent change in the area of declared permanent grassland (361,000 hectares) managed according to each of the scenarios.

Table 27: Soil carbon loss associated with a 1% change in the area of permanent grassland converted or ploughed, ploughed and reseeded or maintained without ploughing

Soil type and climate	Annualised loss/gain of soil C over 20 years				
	A. No plough (t/ha)	B. Plough and reseed (t/ha)	C. Convert or plough for arable (t/ha)	Difference A-B per % permanent grassland (kt CO_2eq)	Difference A-C per % permanent grassland (kt CO_2eq)
High activity clay (NW Europe)	0.7	- 0.7	-2.6	1853	4504
Sandy (NW Europe)	0.5	-0.8	-2.3	1721	3710
Low activity clay (Southern Europe)	0.2	-0.3	-0.7	664	1193
Volcanic (Southern Europe)	0.5	-0.3	-1.5	1061	2650

6.1.2 PILLAR II

In quantitative terms, the simulation carried out for this study indicates that in 2016, the Pillar II CAP measures for which impact was quantifiable[27] were responsible for a 1.1% emission reduction compared to the baseline. For certain measures, this reflects particularly low uptake (e.g. between 1-3% of planned expenditure for investments in physical assets (M4) had been committed by 2016). If all uptake targets set by Member States were met by 2020, the simulation indicates that the simulated Pillar II measures would reduce emissions by 1.5%.

The extent of success should be considered alongside wider sectoral trends (section 5.2.1), as follows:

- Livestock production: CH_4 emission reductions may be achieved by certain operations under the agri-environment-climate measure (M10.1) with respect to manure management and feed, and investments in physical assets (M04) with respect to manure storage and livestock housing.
- Fertiliser use: N_2O and CO_2 emission reductions are only reported for agri-environment-climate commitments (M10.1) with respect to management of inputs.
- Preserving carbon sinks and enhancing carbon sequestration: CO_2 reductions and removals may arise from practices supported by all CAP measures included in the simulation but are small in relation to wider reductions and removals in the sector

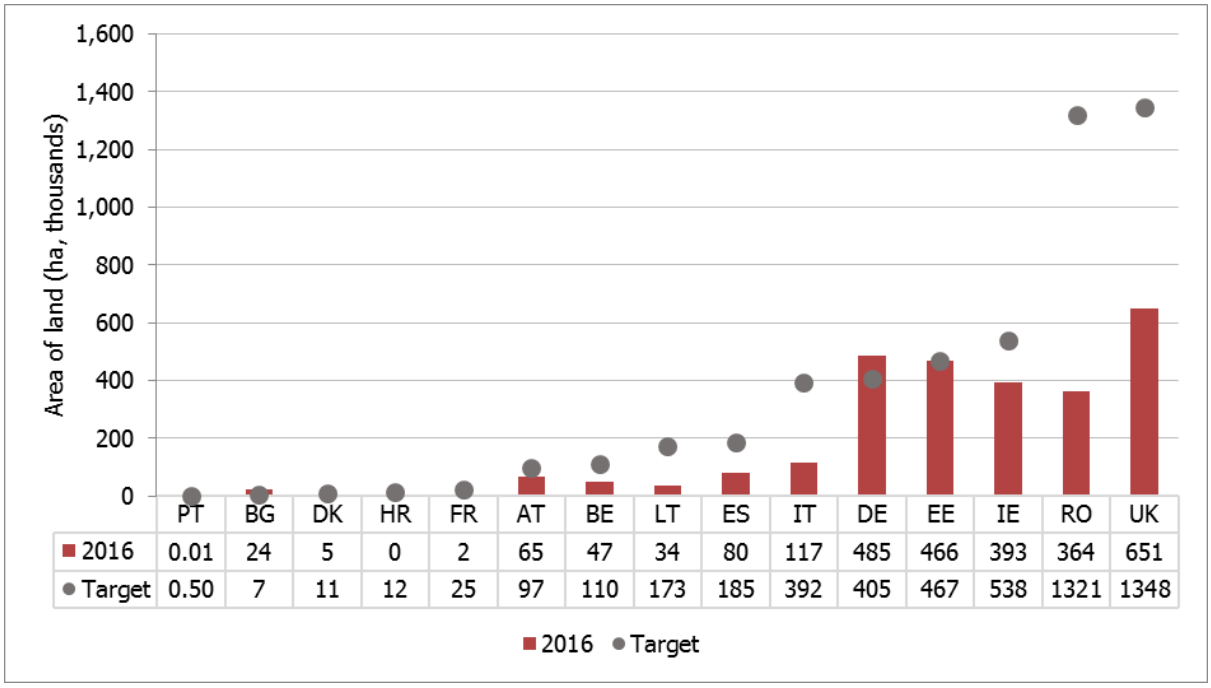
The extent of mitigation achieved by individual Pillar II measures is set out in response to ESQ4.

A comparison between the RDPs of those Member States which did set GHG reduction targets and the simulation results indicates that there is a positive correlation between whether Member States set targets in their RDPs and the extent of mitigation actions realised and planned. However, because it was not possible to simulate the GHG impact of all CAP measures, simulation results are not necessarily a reliable guide to the overall mitigation performance of CAP instruments in the

[27] These are: M4, 8.1, 8.2, 10.1, 11 and 12.1. See section 1 for more detail.

different Member States. By 2016, according to the simulated GHG emissions, GHG savings from CAP measures greater than the EU28 average were achieved by seven Member States (Austria, Estonia, Finland, Ireland, Portugal, Slovenia and the UK). Of these Member States, only Finland and Slovenia had not set targets in their respective RDPs.

Figure 11: Uptake of mitigation measures in 2016 compared to RDP target level for Member States, which set themselves a GHG mitigation target



	PT	BG	DK	HR	FR	AT	BE	LT	ES	IT	DE	EE	IE	RO	UK
2016	0.01	24	5	0	2	65	47	34	80	117	485	466	393	364	651
Target	0.50	7	11	12	25	97	110	173	185	392	405	467	538	1321	1348

Source: own analysis of 2017 AIRs

6.1.3 CROSS-COMPLIANCE

It was not possible to quantify the impact of cross-compliance overall in the absence of uptake data. Member States set their own rules for almost all GAECs and there are serious methodological difficulties in determining the area of land affected by those rules and thus the potential for emissions to be reduced. Cross-compliance supports a number of GHG-mitigating actions of which those with the highest potential (in terms of reductions in CO_2eq/ha) are preventing crop residues from being burned, and the incorporation of such residues into soil to build organic matter. Stubble burning is banned by the compulsory GAEC 6, whilst Member States have a choice as to whether or not to require the incorporation of residues through cross-compliance. The choices made by the case study Member States are discussed further in the answer to ESQ4, but an assessment of the overall impact of cross-compliance on GHG emissions cannot be made.

6.1.4 CONCLUSIONS

Literature including the results of other modelling studies suggests that the impact of direct payments (other than the greening measure and VCS) on GHG mitigation is likely to be low. The greening measures for permanent grassland (both the ratio and ESPG) and EFA were identified from a screening exercise as likely to result in GHG reductions, but only the impact of ESPG and EFA could be simulated. The results of this simulation suggest that ESPG and EFA may have reduced agricultural GHG emissions by 3.5% in 2016 compared to the counterfactual with ESPG accounting for most of the saving. However, the simulation model cannot adjust for the various types of soils designated as ESPG nor for the confounding effect of other policy measures.

The permanent grassland ratio was specifically designed to protect soil carbon. Scenarios developed to show the impact of converting soils to arable, ploughing them then reseeding as grassland or not ploughing at all show that for each percentage point (361,000 hectares) of declared permanent grassland which remains unploughed there will be an estimated reduction in net CO_2 emissions from soil of between 0.7 and 1.8 Mt CO_2 eq (depending on soil type and climate) if the soil would

otherwise have been ploughed followed by reseeding. A greater estimated reduction (1.2 – 4.5 Mt CO_2 eq) is achieved if grassland would otherwise have been converted to arable use. Despite these large potential impacts, the actual impact of the ratio cannot be estimated in the absence of data identifying the changes in land use it has caused, the soil types concerned and the age of the grassland.

We conclude that additional emissions associated with additional ruminant production supported by VCS are not outweighed by reductions in emissions associated with VCS support for protein crops. There is also no reason to conclude that a reduction in emissions from ruminants were VCS to be withdrawn would be fully offset by an increase in emissions from ploughing.

Based on 2016 uptake data, RDP measures are helping to reduce GHG emissions by ~6.4 Mt CO_2eq/year which is 1.1% of total emissions from agriculture as modelled by GAINS. Full uptake (by 2020) of the measures Member States have programmed would yield reductions equivalent to 1.5%.

It is not possible to attribute any aggregate quantified impact on emissions to soft measures such as the provision of advice or to cross-compliance.

7 EXTENT OF IMPACT BY ACTIVITY, REGION AND FARM TYPE (ESQ2)

ESQ2: To what extent and in what way have the combined CAP measures affected climate change and greenhouse gas emissions and reductions?

a) by activity

b) by region,

c) by farm type, such as COP farms

The answer to this question should point out which CAP measures can directly or indirectly be identified as affecting climate objectives.

An answer to this question is possible in respect of simulated emissions only. This answer does not therefore consider cross-compliance or soft measures. The answer to this question is supported by evidence presented in Figure 9 and in Annex 3, where we present total emissions (net and by GHG source) (in kt CO_2eq) for the agriculture sector for each Member State, for 2003, 2016 and 2020 from GAINS. Coloured bars are used to indicate the emissions changes resulting from CAP measures by measure (M) and emission pathways (P). Pillar I results are shown for 2016 and Pillar II results for both 2016 and 2020, to show the effect of further uptake. Also there is data in Table 23 and Table 24, showing simulated GHG emissions by Pillar I and Pillar II CAP measures at EU level.

We have made estimates using:

- relationships between inventory reporting, farm activities and measures,
- estimates of uptake of measures,
- published information on the effects of agricultural practices on GHG emissions and removals, and
- net GHG emissions data from inventory reporting.

The mitigating effect revealed by the simulation is dominated by the effects of CAP measures on change in soil C stocks (the balance of emissions mitigation and increased removal of C from the atmosphere) and change in N_2O emissions from soil and manure. It is estimated that 15.8 Mt of the 19.8 Mt reduction in emissions of CO_2eq in the simulation result for Pillar I measures comes from changes in soil and biomass C stocks, whilst the corresponding figure for the simulated Pillar II measures is 4.4 Mt CO_2eq out of a total emission reduction of 6.4 Mt.

For N_2O emissions from soil and manures, across the EU28, it is estimated that, for the Pillar I CAP measures (ESPG and EFA), simulated emissions would have been 4 Mt CO_2eq/y greater in 2016 in the absence of the relevant measures (0.71% of baseline emissions).

For the Pillar II CAP measures, it is estimated that emissions of N_2O from soil and manures are lower with these measures in place, by 2 Mt CO_2eq/y (2016) (0.35% of total baseline emissions from agriculture). Measures M10.1 and M11 (organic farming support) accounted for all of this result.

Table 28: Simulated GHG emissions impact by some Pillar II CAP measures according to EU28 uptake, 2016, medium scenario, by gas

CAP measure (ranked by percentage reduction)	CH_4	CO_2	N_2O	% reduction compared to the baseline (net CO_2 eq.)
GAINS baseline	287394	38677	240201	
M12.1	0.000	3881	0.000	0.6853%
M10.1	0.13	170	1125	0.2287%
M11	0.000	0.000	874	0.1543%
M08.1	0.000	345	0.000	0.0610%
M08.2	0.000	22	0.000	0.0039%
M04	13	0.000	0.000	0.0023%
Total P2	13	4418	1999	1.1356%

Note: See Table 24 for all scenarios

In our analysis, the positive effect from the ESPG greening requirement is simulated using emission factors for the conservation and restoration of peatland or wetlands. It is our judgement that wetland/peatland conservation and restoration activities represent a large part of the net GHG mitigation associated with C stock change in grassland. However, as discussed in ESQ1 it is likely that the simulation result – which relates to environmentally sensitive permanent grassland specifically – is an overestimate.

As discussed above this simulation result does not include avoided emissions resulting from the permanent grassland ratio.

Bearing these caveats in mind, the results of our simulation of the effects of emission pathways and those of policy measures show that the greatest mitigation effects occurred on farm types that implemented greening and especially the protection of permanent grassland designated as environmentally sensitive grassland. The Pillar II measures with the greatest mitigation effects (M12.1 and M10.1 - see above) include sub-measures which could be relevant to any farm type, but both measures are land-based and so will be less relevant on poultry and pig meat farms, which tend to have limited land area, than on other farms.

Given that CH_4 emissions from agriculture are known to be high (around 54% of total net EU28 GHG emissions for agriculture, excluding LULUCF), it is of note that pathways for CH_4 emission - enteric fermentation and manure management - do not feature highly in our analysis results. Other work to estimate the mitigation potential of agricultural measures in the EU (Martineau et al, 2016) has shown that livestock mitigation measures have low potential, due to the technical difficulty in mitigating emissions in this sector. Methane emissions from enteric fermentation and manure management are closely linked to livestock populations, and mitigation measures that decrease livestock populations would be subject to higher carbon leakage effects than other measures (see section 3.2).

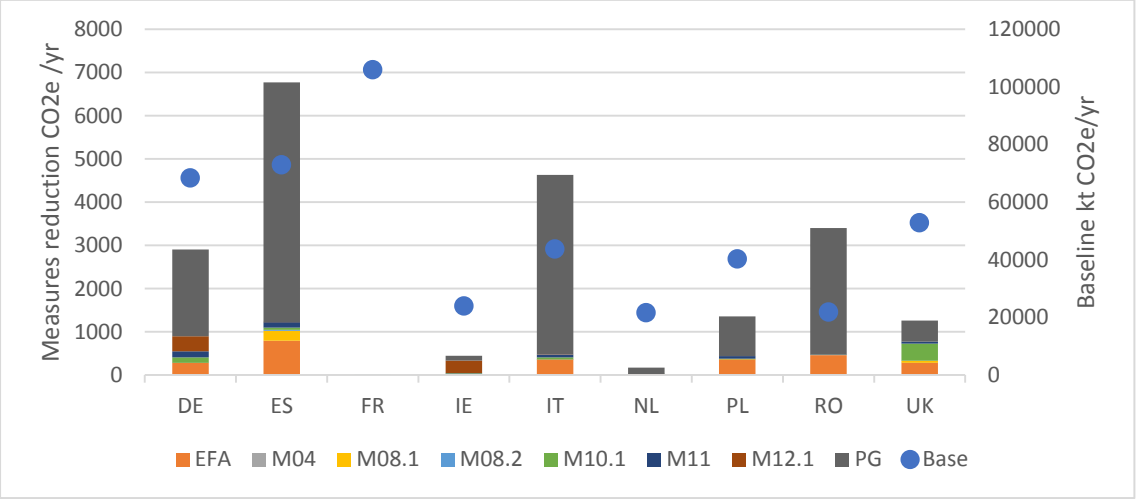
In a similar way, we may consider CO_2 emissions associated with energy consumption, which also do not feature strongly in our analysis results. Carbon dioxide accounts for around 2% of total net EU28 GHG emissions for agriculture, excluding LULUCF. This percentage is higher in some sectors (especially horticultural farms, and also specialised dairy farms, and poultry and pig meat farms), but the relevant mitigation actions are site specific and not simulated.

The way that the combined CAP measures have, or have not, affected climate change and GHG emissions and reductions by region emerges from analysis of net mitigation effects for each individual Member State (see Annex 3). For the majority of Member States (AT, BE, BG, CZ, DE, DK, ES, HR, HU, IT, LT, LU, NL, PL, PT, RO, SE, SI, SK and UK) CAP measures have had a similar mitigating effect on climate change, to that for the EU28 as a whole. The Member States with differing effects of CAP measures on GHG mitigation (both higher and lower) are CY, EE, FI, FR, GR, IE, LV and MT. There is no clear regional pattern. For example, Member States in the latter group include both those with little grassland (e.g. MT, CY with little opportunity to establish or protect permanent grassland), as well as MSs with a large area of permanent grassland (e.g. IE).

Figure 12 and Figure 13 below provide a more detailed representation of the emissions impact of CAP measures by Member State and in comparison to baseline emissions data. Figure 12 shows the data for all Member States with baseline emissions over 20 Mt CO_2eq/yr and Figure 13 provides data for Member States with baseline emissions below 20 Mt CO_2eq/yr.

Figure 13 demonstrates[28] the importance of the contribution of ESPG in protecting C stock in some countries. As described earlier this result should be treated with some caution as without the measure, it is unlikely that the benefit would be fully lost.

Figure 12: MS emissions impact vs baseline (MS over 2000 kt CO_2eq baseline)



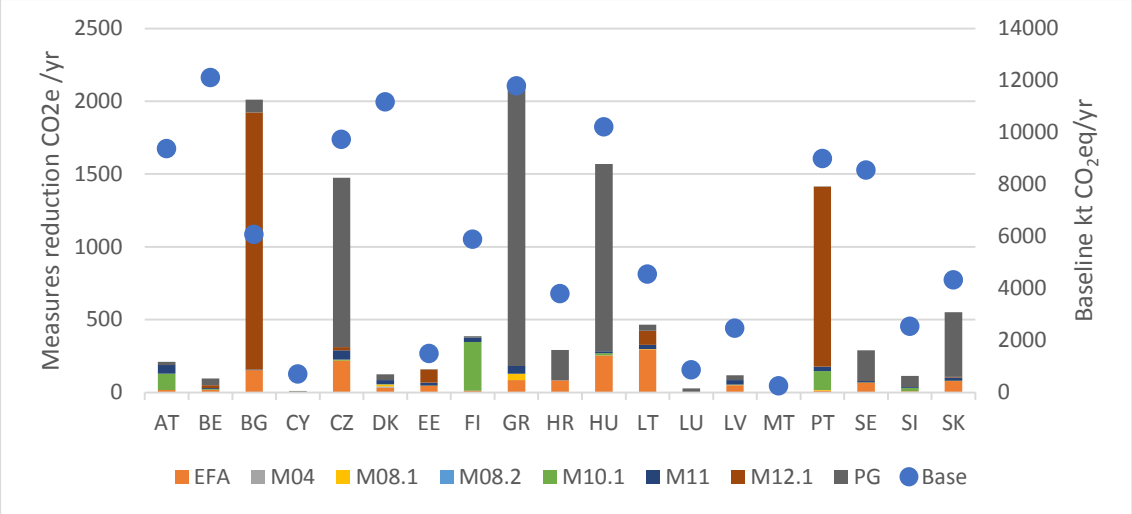
Source: Alliance Environnement simulation results

[28] When reviewing the graph data, please note:

- The axis scale for measures on the left is different from the baseline axis on the right.
- The analysis does not include the data for greening in France as the data set provided did not include this.

Figure 13 below provides a similar picture for the Member States with lower baseline emissions with ESPG and measure 12.1 providing the majority of the emissions benefit. This is a function of the large areas of land designated within these Member States and the potentially high benefit resulting from the protection of these carbon stores. This analysis does not suggest that the other activities associated with measures are not beneficial but farm practices such as N efficiency measures, feeding regimes and GHG efficiency measures are very difficult to gather accurate activity data for and the emissions reductions are small in comparison to the benefits brought though changing land use and protecting existing C stocks.

Figure 13: MS emissions impact vs baseline (MS under 2000 kt CO_2eq baseline)



Source: Alliance Environnement simulation results

Conclusions

In conclusion the reductions in emissions we have been able to ascribe to certain CAP measures through simulation have largely been achieved through change in soil C stock (the balance of C stock loss mitigation and increased removal of C from the atmosphere) and change in N_2O emissions from soil and manures. These changes have been effected predominantly by Pillar I greening measures (protection of environmentally sensitive permanent grassland, and ecological focus area), and by Pillar II measures for environmental protection, that will have influenced land management practices and N_2O emissions as a consequence of a possibly reduced nitrogen fertilisation. There is no clear regional pattern to the pathways leading to net GHG emissions changes and their policy drivers, but there are differences between Member States depending on their geography, farming systems and policy implementation choices. In the case of other CAP measures it has not been possible to quantify their impact through simulation and so the quantified reporting of pathways, farm types and regions affected is an incomplete picture.

Figure 12 and Figure 13 show that the contribution of measures affecting land use has the greatest impact with the protection of ESPG and other high carbon soils from cultivation providing the greatest impact on GHG emissions. On this basis the conclusion can be drawn that these impacts will mainly be achieved from extensive livestock systems. The contribution from more intensively farmed grassland and arable systems is less clear as the amount of land designated as ESPG or eligible for payments through Measure 12.1 will be much smaller. The main contribution from arable systems comes through EFA with 92% of emissions reductions coming from N fixing crops and a further 7% from catch and cover crops. EFA contributes a total of just over 4Mt CO_2eq reduction.

8 CHANGES IN AGRICULTURAL EMISSIONS AND REMOVALS (ESQ3)

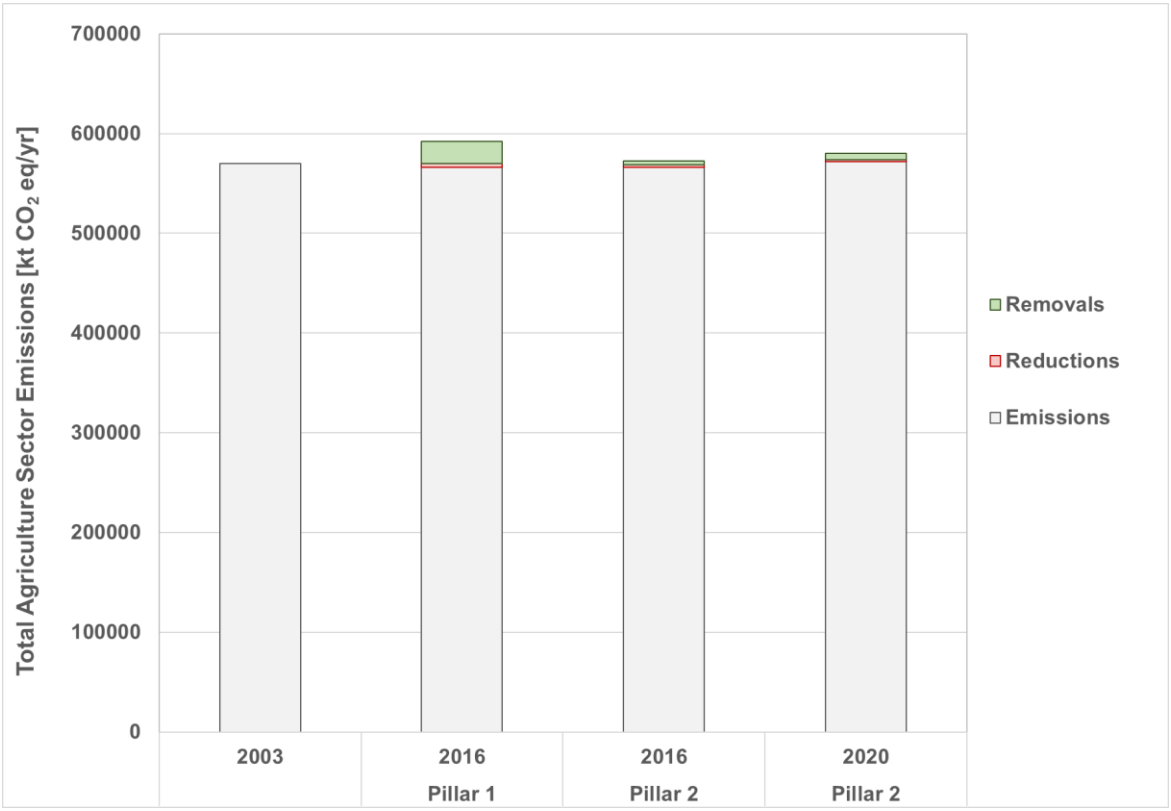
ESQ3: To what extent has there been a change in agricultural emissions and removals in the form of CO_2 related and non-CO_2 related ones as a result of CAP measures?

The way in which emissions in our simulation are split between the different GHGs is considered in ESQ2 above. For ESQ3 we supplement that analysis with a more detailed look at CO_2.

Carbon dioxide accounts for 79% of EU28 total net GHG emissions for 2015, including LULUCF (EEA data). However, for agriculture (not including LULUCF, which is a net CO_2 sink), CO_2 accounts for only 2.2% of the EU28 total net GHG emissions. Despite the low level of net CO_2 emissions in the agriculture sector relative to other GHGs, CO_2 is of great importance in the agriculture sector GHG balance. This is because of the very large pool of C in soil, which is greater than the atmospheric pool of C (as CO_2 and other GHGs). Soils can be a net source or sink for atmospheric C depending on land use and management: the soil C pool is not static, but there is exchange with the atmosphere, and therefore there is potential for large emissions of CO_2 through a soil to atmosphere pathway. Conversely, there is also large potential for CO_2 removal into the soil C pool.

The answer to this question considers the effect of CAP measures on CO_2 removals, how this contributes to net GHG emissions by the agriculture sector, and the extent of these removals relative to other emissions. Supporting evidence is presented in Figure 14 showing total net emissions (in kt CO_2eq/yr) for the agriculture sector at EU level for 2003, 2016 and 2020 from GAINS. Coloured bar sections indicate removals (C sequestration) and reductions (decreased emissions) from the total (represented by the height of all sections of the bars).

Figure 14: Total agriculture sector emissions (kt CO_2eq/yr) for the EU28 for 2003, 2015, 2016 and 2020 from GAINS



Source: Alliance Environnement simulation results

Note: Coloured bar sections indicate removals (C sequestration) and reductions (decreased emissions) from the total (represented by the height of all sections of the bars). The grey parts of the bars represent the remaining emissions after mitigation.

Figure 14 shows Pillar I and Pillar II in 2016 and Pillar II also in 2020. Pillar II results for 2020 were simulated in order to assess the impact of measures once target levels of uptake have been reached. The removals in the green bar sections are CO_2 removals from change in C stock in soil and above ground biomass, arising from the following CAP measures:

- M12.1 (compensation payment for Natura 2000 agricultural areas);
- M08.1 (woodland planting);
- M08.2 (management of existing woodland on agricultural land);
- M10.1 (reduced and zero tillage);
- Greening requirements for ESPG and
- Greening requirements for EFA.

The results relate to the measures we were able to simulate through the quantitative model. Other measures with an impact on CO_2 in soils and biomass, such as cross compliance GAEC and the permanent grassland ratio, were not simulated and are not therefore part of this numerical analysis.

The reductions in the red bar sections are net GHG emissions mitigation from the following emissions pathways:

- Nitrification and denitrification pathways in soil and manure, including from leaching (N_2O),
- Methanogenesis under anaerobic conditions in soils and manures (CH_4),
- Change of C stock in soil (emission only, CO_2),
- Enteric fermentation (CH_4).

2.2% of agriculture sector net GHG emissions are CO_2 emissions, and are predominantly from arable soils (estimated at 10–40 Mt/yr; see section 5.2; (Frelih-Larsen et al, 2016)).

Removals as a result of CAP measures in 2016 (Pillar I only) were 2.8% of total agriculture sector net GHG emissions. For Pillar II (2016 and 2020) removals as a result of CAP measures were 0.75% and 1.2% of total agriculture sector net GHG emissions, respectively. For comparison, net GHG emissions reductions as a result of CAP measures were smaller, at 0.71% (2016, Pillar I), 0.39% (2016, Pillar II), and 0.28% (2020, Pillar II).

There is potential for CO_2 emission through loss of soil C to be mitigated, and potential for greater CO_2 removal as sequestered soil C. Decreases in soil organic carbon through cultivation of soils have been well documented (e.g. Conant et al (2007)). This loss can be mitigated by reducing tillage, or by increasing the return of non-harvested C to soil (Rees et al, 2005). Cross-compliance contains relevant requirements and GAECs although the extent of their impact is not quantifiable.

Removal of CO_2 into soils, without changing land use, depends on the balance between C additions (crop residues and organic matter additions) and C losses, mainly through organic matter decomposition. The most effective means of CO_2 removal is change of land use from annual crop production to perennial grassland and/or woodland, although CO_2 removal will not continue indefinitely (Smith, 2014). As well as land use change, appropriate management of woodland and grassland may facilitate CO_2 removal. Soussana and Lemaire (2013) reported a meta-analysis of 115 studies in grassland and found that soil C levels increased with improved management in 74% of studies. The management actions to remove CO_2 found in these studies included: reducing N fertiliser inputs in highly intensive grass leys; increasing the duration of grass leys; converting grass leys to grass-legume mixtures or to permanent grasslands; and moderately intensifying nutrient-poor permanent grassland. However, the intensification of nutrient-poor grasslands on organic soils may lead to large C losses. The complexity of management required to optimise soil C levels illustrates the relevance to GHG mitigation of "soft" measures such as advice.

The Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States reported that on average, soils in Europe are accumulating carbon: soils under grassland and forests are, on average, a carbon sink estimated to grow by 80 million tonnes every year (see section 5.2; (Frelih-Larsen et al, 2016)). This amounts to approximately 0.1% of all EU soil C stocks (75 billion tonnes), so a small increase relative to existing stocks would have a large effect on net GHG emissions from the agriculture sector. However, looking at agricultural land across the EU the combination of grassland and cropland had a net emission of 72.23 Mt in 2016 according to GHG inventory reporting (EEA data).

Conclusions

Looking specifically at CO_2 the simulated quantification of the impact of some Pillar I and Pillar II measures shows that removals of CO_2 attributable to those measures in 2016 amounted to 2.8% of total agriculture sector net GHG emissions for the Pillar I measures and 1.2% for the Pillar II ones.

Significant emissions contributions and reductions/removals are to be expected from other activities supported by the CAP that have not been quantified through the simulation due to limited details relating to activity data (permanent grassland ratio and cross-compliance GAEC) or the absence of a counterfactual baseline (VCS).

This demonstrates that the CAP has been most successful in achieving benefits relating to CO_2 based on the simulation with the CO_2 impacts accounting for 80% of Pillar I and 69% of Pillar II. N_2O emissions reductions from Pillar I account for 15% of the total and Pillar II is 8%. The simulation was able to quantify only negligible reductions in CH_4.

This finding illustrates the challenges in accounting for and verifying emissions impacts as a result of changes in management practices that may affect efficiency of production and resultant GHG impacts. Having accurate activity data to support this is very challenging when considering that inventories and other baseline data look at absolute emissions rather than intensity measures.

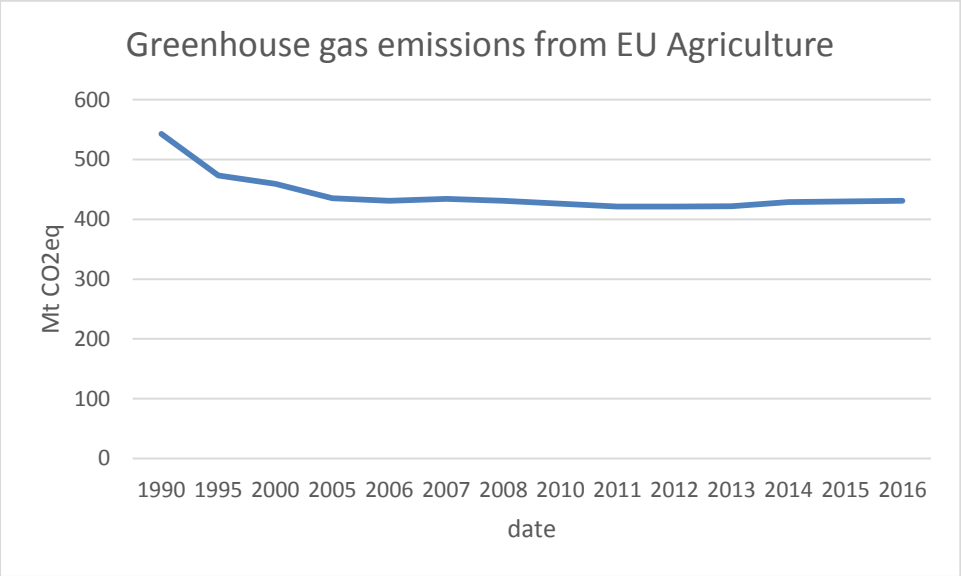
9 THE IMPACT OF INDIVIDUAL CAP MEASURES INCLUDING ON PROGRESS TOWARDS THE EU'S 2020 GHG REDUCTION TARGET (ESQ4)

ESQ4: Which specific CAP measures or other actions brought about the change mentioned above and how much does this contribute to meet the -20% target of the European Union, also in view of the reductions in other sectors?

To respond to this question, the chain of causality between CAP measures and their impact on GHG emissions must be established. The extent to which agriculture is contributing to efforts at an EU level to reduce GHG emissions by 20% by 2020 compared with 1990 levels is first assessed. The 20% target applies to EU emissions as a whole – there is no requirement at EU level to reduce agricultural emissions by this or any other amount. Agriculture's contribution to the wider sectoral effort is therefore addressed by this ESQ. The contribution from the emissions reductions associated with certain CAP measures which we have simulated is calculated. The assessment then evaluates the extent to which these and other CAP measures are supporting mitigation actions.

The EU's total emissions of GHGs in 1990 were 5716.4 million tonnes of CO_2eq. The Kyoto Protocol requires a reduction in annual emissions of 20% by 2020 which is 1,143.2 million tonnes. Whether this target has been achieved clearly cannot be established until 2020 but agriculture's trajectory can be examined. As described in section 5.2.1, in 2016, the EU agriculture sector emitted about 13% of total GHG emissions (including 10% reported for agricultural activities and 2.8% for energy consumption by the sector). Direct emissions from agriculture in the form of CH_4 and N_2O were in 2016 20.7% lower (430 Mt CO_2eq) than in 1990 (542 Mt)(EEA). However, as shown the bulk of the reduction occurred before 2010 with agricultural emissions flat lining thereafter before rising slightly from 2013.

Figure 15: EU GHG emissions from agriculture



Source: EU UNFCCC emissions inventory

Emissions from croplands and grasslands management (accounted as LULUCF) have fallen further in percentage terms, by 29%, but less in absolute terms from 103.5 Mt CO_2eq in 1990 to 73.5 Mt CO_2eq in 2016. In terms of the overall contribution from farming activities, to date, the agriculture sector is contributing more than its share of the emissions reduction needed to meet the EU's 20% reduction target, assuming that each sector should play a proportionate role. Proportional contributions by individual sectors are not however required by the ESR framework and it must be borne in mind that agricultural emissions are now rising.

Our analysis suggests that emissions could have been 26.2 million tonnes higher without the impact of those CAP measures for which we have simulated a quantified result. 20.2 Mt CO_2eq of the avoided emissions are covered under LULUCF reporting and attributable to cropland and grazing land management with the remaining 6 Mt CO_2eq accounted for by reductions in emissions of N_2O and CH_4. On this basis, the simulated CAP measures account for over two thirds of the difference between LULUCF emissions from cropland and grassland in 2016 compared with 1990 (20.2 Mt CO_2eq out of the total difference of 30 Mt CO_2eq) and 5.4% (6 Mt CO_2eq out of 112 Mt CO_2eq) of the change in non-CO_2 emissions from agriculture over the same period. It must be borne in mind that the impact of the simulated measures does not represent the full impact of the CAP, as discussed above.

The extent to which the individual CAP measures are contributing to EU climate mitigation efforts is assessed below by category.

9.1.1 Income support and Production payments

For the purposes of this evaluation, "production payments" include direct payments; support in areas facing natural constraint under Pillar I and Pillar II; and voluntary coupled support. This assessment uses agricultural production as a proxy indicator for GHG emissions, whereby an increase in production will lead to additional GHG emissions (owing to the unavoidable nature of GHG emissions from agricultural production). As discussed in the literature review, it is not possible to attribute an overall change in GHG emissions to the land use changes associated with these payments.

Efforts to model the impact of direct payments on production using the CAPRI model show that direct payments are maintaining agricultural production to a significant degree across the EU and that up to 2025, they are directly responsible for increases in GHG emissions, nutrient surpluses and pesticide inputs by 2.3 to 2.5% (Brady et al, 2017). However, this impact is derived from modelled data for regions in Sweden which have been aggregated to an EU level and is recognised as only being relevant to regions sharing the same characteristics. Modelling work by the JRC examines a broad scenario which does not offer a counterfactual for direct payments alone.

As shown by the evidence in section 5.2.2, at an EU level, particularly since the shift to decoupled payments, direct payments help to ensure that land stays in agricultural production which would otherwise be used for other purposes or abandoned. However, no specific impact on GHG emissions can be established at the EU level. The same is true of the redistributive payment, which transfers income from larger to smaller farms, and the small farmers' scheme. The latter simply replaces entitlements with a small commuted payment. No impact on production is likely as a result of the administrative saving involved. The impact of the SFS is that it disapplies greening requirements and cross-compliance sanctions from farmers who participate. The simulated reduction in emissions from the greening measure would therefore have been larger had this exemption not been in existence. Just under six million hectares of land managed by participants in the small farmers' scheme was exempted from greening in 2015. Since the impact of cross-compliance itself cannot be quantified, neither can the impact of disapplying its sanctions from certain farms.

An additional consideration when determining the potential impact of the Small Farmers Scheme on GHG emissions is the fact that holdings under this scheme are exempt from greening obligations and from cross-compliance penalties. Thus, depending of the effectiveness of these obligations, there is a risk of missed opportunity to mitigate GHG emissions. This will be discussed in relation to the mitigation potential of greening and cross compliance in the subsequent section (it is also discussed in relation to coherence; see ESQ8).

The impact of coupled support is described in ESQ1.

Based on the findings reported for coupled support in relation to disadvantaged areas, it is concluded here that the measures supporting areas of natural constraint will have no to little impact on production levels in the livestock sector; and therefore no impact driving GHG emissions.

9.1.2 Land management contracts

Requirements specifying land management practices include the following CAP measures: greening; standards for GAEC; payments for afforestation/creation of woodland, establishment and

maintenance of agro-forestry systems, prevention of damage to forests from forest fires and natural disasters and catastrophic events, and forest-environmental and climate commitments; agri-environment-climate commitments; payments for organic farming; compensation payments for Natura 2000 agricultural areas.

It is not possible to quantify the impact of cross-compliance on GHG emissions owing to the difficulty in determining the specific areas of land to which the bespoke rules set by Member States apply in practice. Different Member States set often widely different rules, as illustrated by Table 29 which summarises the GAEC rules adopted in 2018 by the ten case study Member States.

Table 29: Rules set by the case study Member States for GAECs 4, 5 and 6 in 2018

	Soil cover requirements (GAEC 4)	Measures to prevent soil erosion in vulnerable places (GAEC 5)	Requirements for maintenance of soil organic matter (in addition to the compulsory stubble burning ban) (GAEC 6)
CZ	After arable crops, a winter crop or catch crop must be planted. Alternatively stubble must be retained or the land not ploughed.	Certain crops such as sunflower which are judged to cause soil erosion may not be grown on land vulnerable to erosion by water. Other grains and oilseed rape must be grown using conservation techniques or undersown.	Either a minimum amount of manure must be incorporated per hectare or N-fixing species planted.
DE	Ground cover required on non-productive EFA and fallow land. Ploughing restrictions.	Soil cover required on arable land if and when exposed to erosion risk.	None
ES	Tillage restrictions on winter crops. Unless terraced, soil cover required when permanent row crops on slopes of >15% spaced more than 1m apart and also restrictions on uprooting permanent crops on slopes. Fallow must be cultivated traditionally, subject to minimum tillage or have soil cover.	No inversion tillage on slope > 15% unless terraced.	No plate, fan spray or spreader gun systems to be used for slurry application. Solid manure to be buried as soon as possible after spreading.
FR (based on information from 2017)	Cover required on fallow and area where plants have been grubbed up.	Ban on working waterlogged soil.	None
HR	Fallow, grubbed up areas. Autumn and winter cover required in NVZs. Ground cover required during the vegetative period and in Autumn.	Ploughing only perpendicular to the slope on land with >15% slope. Grass cover required between permanent crops if slope >15% and rows run parallel.	None
HU	After summer and autumn crops through sowing of further or catch crop or retention of stubble.	Ban on growing certain erosion-causing crops on sloping land. Vineyards must be terraced.	Minimum rotation length requirements for certain crops e.g. sunflower may not be

			grown in consecutive years on the same land.
IE	Green cover required on all arable land in Autumn. Restrictions on ploughing grassland in Autumn.	Grass- and duneland must not be overgrazed and steps (such as moving feeding stations around) must be taken to avoid poaching.	None
LT	Soil cover required on all land apart from protective black fallow strips in organic systems.	No root or tuberous crops if slope > 12%.	None
NL	Green manure required after maize or cereals.	Anti-compaction measures such as tillage required. Land with slope > 18% must be grassland.	None
RO	20% of arable land must be covered by winter or perennial crops in winter.	Row crops must be aligned with contour if on land sloping by more than 12%. Maintain terraces.	Sunflowers must not be grown more than twice in a row.

Source: JRC Mars Wiki from Member State notifications

Depending on the nature of the rule set by a Member State, an attempt can be made to quantify its impact using data for the area to which it applies and a suitable emission factor. It is potentially feasible in the case of some types of rule – such as those which require a land management practice such as green cover on a defined area such as all arable land (IE). However the incidence and hence impact of other types of rule including those targeted at the management of sloping land is extremely difficult to estimate. Box 4 illustrates some of the difficulties.

Box 4: Analysis of the proportion of land subject to the requirements of GAEC 4 and 5 using slope criteria defined by the Member States

In cross-compliance, Member States are required to define rules for minimum soil cover under GAEC 4 and to limit soil erosion under GAEC5. They are given complete discretion as to the specific rules they set and which sites they consider to be vulnerable. A widely used criterion is slope, with 9 and 13 Member States targeting respectively their GAEC 4 and 5 rules according to slope. Five Member States – Cyprus, Greece, Malta, Poland and Slovakia – use slope as a criterion for both GAEC 4 and 5.

We identified the proportion of arable land within a Member State that corresponds to a specific slope category[29] and compared this to the Member State defined slope criteria for implementing GAECs 4 and 5. This allows us to establish the proportion of arable land in those Member States which is not protected from erosion by either GAEC 4, GAEC 5 or both (see Annex 3.2). The analysis shows that while many MS defined GAEC slope criteria that are consistent with the topography of their arable land (e.g. BE-Wallonia, CZ, EE, EL, LT, LU, LV, NL, SK), a number of Member States (e.g. ES, FR, HR, PL, RO, SE) appear to have set a slope criterion which excludes a large part of their arable land. For example, with a GAEC 5 slope criterion of >15%, only 3% of agricultural land in Spain is estimated to be subject to the GAEC 5 requirements. Using Poland as an example, a spatial illustration of the areas that would be covered by either or both of Poland's rules for GAECs 4 and 5 is presented in Annex 3.2. The graphs in Annex 3.2 suggest that a very small proportion of land could be subject to the GAEC 4 & 5 requirements in Poland (restricted by a slope criteria of >20%). In addition, when overlaid with soil organic matter information as mapped through LUCAS, it suggests that Poland's GAEC soil protection rules may not be well targeted at the protection of its high carbon soils.

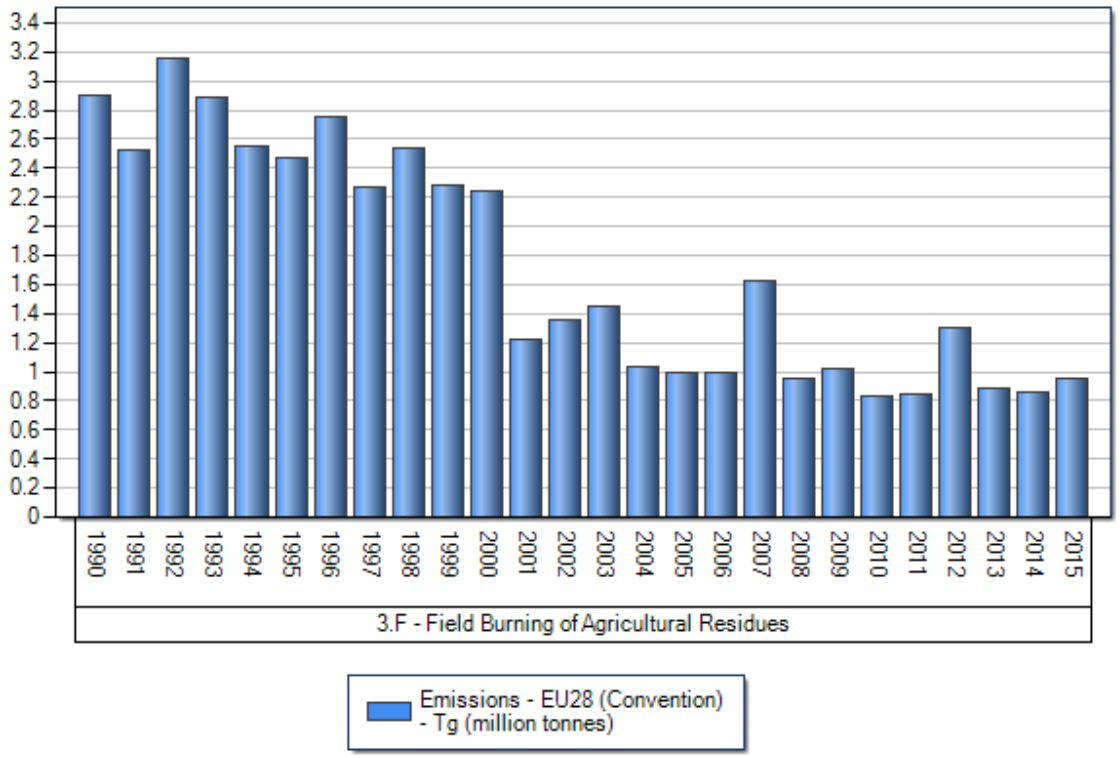
There are important caveats in this analysis to be borne in mind as the proportion of land under different slope categories in our calculation is based on the averaged slope within a soil mapping unit, and this can hide significant variation in gradient at the field scale, where the GAEC standards would be applied. This means the area of land to which the GAEC requirements could be applicable could be larger than identified here.

Source: own analysis

[29] Level (0-8%); sloping (8-15%); moderate steep (15-25%) and steep (>25%)

Deadweight is also a significant issue when estimating the impact of cross-compliance, since Member States have tended to set rules based on existing good practice which limits the additionality achievable. This is illustrated by the example of the introduction of a stubble burning ban (now part of GAEC 6) in 2003. Figure 16 shows that the most significant decline in CO_2 emissions from stubble burning took place before the introduction of the GAEC standard. This suggests that the standard was a codification of existing practice rather than a driver of it.

Figure 16: CO_2 emissions from field burning of agricultural residues in the EU28



Source: EEA GHG data viewer

GAEC 6 is intended as a measure to protect and improve soil organic matter and can also be used to support a variety of actions with high mitigation potential, including:

- vegetative cover and cover crops;
- rotation (with or without legumes);
- minimum and no tillage regimes;
- incorporation of crop residues;
- maintenance of over-winter stubble and addition of organic matter (compost, manure etc.);
- avoiding overgrazing in grasslands

9.1.3 CAPITAL INVESTMENTS

As shown in section 5.2.2, capital investments offer considerable mitigation potential – namely in relation to manure management, support for renewable energies and energy efficiency improvements.

However, there is limited information available to estimate the extent to which CAP measures are (i) supporting these investments, and (ii) the impact the investments are having on GHG emissions.

As a first step to quantifying their impact, the extent of uptake is assessed. At measure level (i.e. discounting the nature of the projects funded), it becomes apparent that the CAP measures supporting investments in physical assets are the most widely accessed across the EU (with total investments supporting €580 million of investments by 2016). In contrast, total investments in rural economy (relating to the creation, improvement or expansion of all types of small scale infrastructure, including investments in renewable energy and energy saving) were €64 million by 2016. In all

cases, implemented expenditure is considerably lower than the planned expenditure (between 1-3% of planned expenditure had been implemented by 2016). Although uptake data was only available up to 2016, Figure 10 shows also a scenario in which all uptake targets for 2020 are assumed to have been met in that year. By theme, implemented CAP measures are expected to contribute to a total (EU expenditure and co-financing) of €282 million for energy efficiency objectives and €59 million for renewable energy production. In relation to the total expenditure allocated to contribute towards achieving a "Low-Carbon Economy" across all European Structural and Investments Funds (€64 billion)[30], CAP measures supporting capital investments only amounted to 0.5% of the total.

Using the volume of expenditure as a proxy indicator, it can be inferred that capital investments mobilised via CAP measures will have a low impact relative to other investments at EU level and that physical assets is the CAP investment measure currently contributing to the largest extent when compared to other CAP investment measures. Some examples of the types of investment which were funded using capital measures during the previous programming period are in Table 17.

A very crude estimate of the mitigation achieved by this CAP measure for the current programming period was undertaken by looking at the number of livestock units affected by the implemented expenditure and applying a mitigation potential factor based on changes to livestock housing and manure storage.

Table 30: Mitigation potential estimated for investments in physical assets, based on uptake data for the year 2016 (kt CO_2 eq.)

CAP measure	Year	Low	Central	High
M04	2016	6.19	13.05	19.90

Source: Alliance Environnement simulation results

9.1.4 SOFT MEASURES

As shown by the evidence presented in section 5.2.2, soft measures are generally accepted as playing an important role in changing behaviours and improving capacity. It is understood therefore that targeting soft measures to support climate mitigation actions will indirectly contribute to GHG reductions. The focus of this section is to assess the extent to which these CAP measures target climate mitigation.

The most common CAP measures used to improve capacity and uptake are the measures supporting knowledge transfer (Measure 1; with 258,108 participants attending training across the EU by 2016) and advisory services (Measure 2; with 42,439 farm holders registered) under Pillar II and the Farm Advisory System.

The CAP measure supporting knowledge sharing networks via the establishment and operation of operational groups of the EIP for agricultural productivity and sustainability (M16) is recognised in section 5.2.2 as leading to a number of initiatives which are intended to support capacity in relation to climate mitigation at farm level (see Table 19).

Additional soft measures are identified in the literature review as having the potential to contribute to GHG reductions. These measures include the use of business plans to support energy efficiency mitigation actions on farms and in rural businesses (via the farm and business development measure, M06); and support for implementation of operations (including community energy efficiency operations) under the CLLD strategy (LEADER, M19).

Examples of how LEADER has been used for the 2007-2013 programming period are set out below.

Table 31: Examples of LEADER projects funded in 2007-2013

Project title	MS	Mitigation activity	Outcome related to mitigation
ClimEEC - Climate Eco Expert Cluster	LU	Cooperative biogas plant (with 200 buildings connected)	80% energy savings
VIRERE – Promoting renewable energy through diversified rural	ES	Introductory courses on renewable energy	-

[30] https://cohesiondata.ec.europa.eu/themes/4

tourism			
Improving energy efficiency of communal buildings in a LAG area	HU	Reduce energy consumption of local government buildings across 16 municipalities	CO_2 emissions were reduced
Setting up a renewable energy visitor centre in Feldheim - Germany	DE	Information and training about innovative renewable energy	3,500 visitors/ year
Setting up a centre to upgrade, produce and maintain electric vehicles and charging stations	BG	Support to establish 5 charging stations for electric vehicles	Awareness raising; infrastructure to encourage uptake of electric vehicles

Source: own compilation

9.1.5 CONCLUSIONS

In the EU the GHG emissions that are attributable to agriculture are currently (2016) 20.7% below their level in 1990 whilst emissions accounted for as LULUCF from croplands and grasslands have fallen by 29%. If the sector maintains these levels of emission reduction and removals to 2020 it will deliver a contribution to the Kyoto Protocol target which is proportional to that from other sectors.

The quantified reductions we have simulated from CAP measures are equal to over two thirds of the reduction in LULUCF emissions from cropland and grazing land management and 5.35% of the reduction in non-CO_2 emissions. However, the quantified result gives an incomplete picture of the CAP's overall impact.

Based on a combination of evidence from literature and modelled impact, the table below gives a high level indication of the impact of CAP measures on GHG emissions.

Table 32: High-level ranking of CAP measures according to their impact on GHG emissions

CAP measures	Impact on GHG emissions
Income support	A significant impact on the extent of agricultural area. This can have both positive and negative consequences for emissions and quantification of the overall net impact is not possible.
VCS	Negative impact when used to support ruminant livestock but not quantifiable. Positive impact when used to support leguminous crops but the measure is used to a much greater extent to support ruminant production.
Land management practices	Positive impact with potential to deliver more
Capital investments	Positive impact with potential to deliver more
Soft measures	Usually indirect impact but fundamental to delivery of mitigation actions

Source: own compilation

10 THE CAP MEASURES' CONTRIBUTION TO CLIMATE ADAPTATION AND RESILIENCE (ESQ5)

ESQ5: To what extent have CAP measures addressing climate action contributed to climate adaptation and/or climate resilience of the agricultural sector and of society more in general? (e.g. ecosystem-based adaptation for flood control etc.)?

10.1 UNDERSTANDING THE QUESTION

EU agriculture must adapt its production systems to the changing climatic conditions and their consequences, to ensure the sustainability of EU food security and to maintain the ecosystem services necessary for the resilience of European society. The EC developed and adopted in 2013 the EU adaptation strategy (*COM(2013) 216*), which has three main objectives:

- promoting action by Member States;
- climate-proofing action at EU level in the form of mainstreaming adaptation into policies affecting the most vulnerable sectors such as agriculture, fisheries and cohesion; and
- climate-proofing action at EU level by bridging knowledge gaps e.g. supporting research and modelling of climate impacts, development of the Climate-Adapt knowledge platform.

The EU institutions agreed in 2013 that at least 20% of the €960 billion EU budget for 2014-2020 should be spent on climate mitigation and adaptation, three times the previous level. The EU adaptation strategy does not set binding adaptation targets for Member States as exist for mitigation. This is partly because of the less quantifiable nature of adaptation actions (Hart et al, 2017) but also because there are no binding requirements in the international agreements concerning adaptation, other than planning and reporting requirements. The CAP plays a key role in improving the resilience of the agricultural and forest sectors and also more broadly the resilience of EU society.

Adaptation is defined by the IPCC as 'the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities'. To analyse the effect of the CAP on adaptation, the evaluators assessed the extent to which CAP measures contribute to: reducing the vulnerability of the agricultural and forest sectors; improving their capacity to benefit from positive outcomes of climate change; and allowing the agricultural sector to play its role in reducing vulnerability to climate change at higher levels (territorial level, EU society), in the context that adaptation is considered to be a public good.

Monitoring and evaluation of adaptation also requires careful consideration of examples and risks of maladaptation. Maladaptation is defined by the IPCC as 'any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead'. Five main types of maladaptation practices can be identified, they are actions that: increase emissions of GHGs; or disproportionately burden the most vulnerable; or have high opportunity costs; or reduce incentives and capacity to adapt; or set a path that limits future choices (Barnett and O'Neill, 2010). These aspects have been considered in answering this ESQ.

Prior to 2007, action against climate change was not a formal priority of agricultural or rural development policy in the EU. For the 2007-2013 period, rural development policy was revised and reoriented around four Axes, corresponding to the objectives of the new European Agricultural Fund for Rural Development (EAFRD)[31]. Climate change was highlighted for the first time explicitly, and it was stated that 'the resources devoted to axis 2 should contribute to three EU level priority areas: biodiversity and preservation of high nature value farming and forestry systems, water, and climate change'. For the EAFRD 2014-2020, climate change mitigation and adaptation was defined as a cross-cutting objective[32] and within one of the six EU priorities for rural development, in Priority 5(e) for 'supporting the shift towards a low carbon and climate resilient economy in agriculture, food and

[31] As set out in Council Regulation (EC) No 1698/2005

[32] Regulation (EU) No 1305/2013

forestry sectors'. Therefore, the analysis of this ESQ mostly focuses on the programming period 2014-2020.

Concerning climate adaptation more specifically, it has been considered as an overarching objective of the overall framework of the five European Structural and Investment (ESI) Funds for 2014-2020 (EC, 2013), including the European Agricultural Fund for Rural Development (EAFRD), co-financing the CAP second pillar. Climate action including adaptation is a cross-cutting objective of the whole CAP 2014-2020. However, it must be underlined that there are no legally binding or concrete, quantified objectives for adaptation; and the only budget requirements are that at least 20% of all EU spending should be on climate mitigation and adaptation, and at least 30% of the EAFRD contribution to each RDP should be spent on measures addressing mitigation and adaptation, as well as environmental issues.

Very few CAP measures make explicit reference to climate adaptation (see Table 1). For other measures there is no clear intervention logic that can be defined based on the review of CAP Regulations. However, this study's initial assessment of all CAP measures concluded that more measures had effects on adaptation, including crop diversification (under Pillar I greening requirements) and support for knowledge transfer, preventive/restoration actions, forests, co-operation and risk management under EAFRD. Therefore, the main challenge in answering this ESQ is to assess the contribution of CAP measures to climate adaptation and/or resilience, when the main objective (for most of the measures) is not adaptation to climate change. This requires mapping the outcome of CAP measures by assessing qualitatively the intended and unintended, direct and indirect effects of the CAP on adaptation to climate change of the agriculture and forest sectors and of EU society. It has been done firstly through a literature review, identifying the main factors of vulnerability and/or capacity to grasp opportunities linked to climate change, that can be affected positively or negatively by the CAP; and, secondly, through detailed case studies of 10 RDPs.

When analysing adaptation processes, there are different time frames and levels of actions to consider. Planned adaptation[33] implies a long-term anticipation of climate change effects. But many actions considered as adaptive are 'autonomous[34]' or reactive, driven by farmers' short-term choices of land use and management practices, when facing challenges linked to climate change (Mendelsohn, 2012). Hence the analysis also assessed the extent to which the CAP 2014-2020 has promoted planned adaptation at MS, MA and farm level, and how the CAP measures have or have not constrained farmers' choices in ways unfavourable to adaptation (level of flexibility, etc.). Other factors limiting or promoting the adaptation of the agricultural sector have been also assessed.

10.2 Process and methodological approach

The methodology to answer this ESQ has been based on the following steps. First, a literature review enabled evaluators to assess the main factors affecting 1) the vulnerability to climate change of farm or forest holdings and of EU society; and 2) their capacity to grasp positive opportunities provided by climate change. Second, evaluators assessed the extent to which MSs and MAs had used the CAP as an instrument for the implementation of their own adaptation plans and strategies. This was considered to be a strong indicator of the CAP's capacity to promote and support planned adaptation at MS and MA level. The assessment was based on information found on Climate-ADAPT[35] , a literature review at EU 28 level, and on interviewing key stakeholders for the 10 case study Member States. Third, the integration of adaptation within CAP policies has been assessed through interviews with key informants in the case study Member States, and through the literature review. Fourth, linkages between factors of vulnerability (assessed in the first step) and CAP measures have been identified through case study interviews, surveys of advisors and farmers, in-depth analysis of the case study RDPs, and the literature review. These steps allowed the evaluators to map the main outcomes of CAP policies on adaptation of the agricultural and forest sectors. Finally, a quantitative assessment of RDP effects was made, based on RDP implementation data from the AIR (2017 Annual Implementation Reports).

[33] Adaptation motivated by policies and institutional drivers.
[34] Adaptation undertaken by farmers without subsidies or incentives, e.g. adjusting sowing or harvesting dates.
[35] http://climate-adapt.eea.europa.eu/

The main limitation encountered in the assessment of CAP effects on adaptation was the impossibility of performing any quantitative analysis, because adaptation choices and effects are very dependent on the context and location, and there are few indicators relevant to adaptation at EU-28 scale.

10.3 IDENTIFICATION OF MAIN DETERMINANTS OF THE AGRICULTURE AND FOREST SECTORS' VULNERABILITY TO CLIMATE CHANGE

The IPCC defines vulnerability to climate change as '… a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2014). In answering the evaluation question, it is considered that the vulnerability of EU farms (and EU societies) is determined mainly by: their exposure in terms of the pedo-climatic location of the farms/plots; the sensitivity to climate change of the farming systems and farm structures, and their level of specialisation, etc.; and their adaptive capacity in terms of the level of skills, knowledge, financial and physical assets, institutional environment, etc. Systems' exposure and sensitivity to climate change are the main determinants of the impacts of climate change, while the adaptive capacity of the system is 'the ability of a system to adjust successfully to climate change'.

The main risks arising from climate change are biophysical changes in long-term trends such as rising temperatures, changes in rainfall, and increased incidence of extreme climatic events such as storms, droughts, hail, longer vegetative periods, increased incidence of pests and diseases, but there are also socio-economic risks such as expected higher price volatility.

The main general findings from the literature review on the assessment of vulnerability of EU farming and forest holdings and EU society (see Annex 4) are the following:

- Determinants of vulnerability are highly dependent on location and context, and consequently the significance and relevance of particular indicators can vary from region to region, especially in relation to the specific socio-economic context. Hence comparison of vulnerability levels across regions and countries (for example across the EU), or across whole sectors, through common indicators to allocate resources for example, does not appear to be relevant (Fellmann, 2012). Vulnerability assessments are useful grids of analysis but the relevant vulnerability indicators have to be defined for a sector or a region.
- The literature also emphasizes the importance of the socio-economic aspects of adaptive capacity, such as the role of institutions and of governance (Williamson, Hesseln and Johnston, 2012);
- The first step in assessing policies' effectiveness in supporting adaptation is screening policy measures for possible adverse effects (Barnett and O'Neill, 2010);
- Other main issues with assessing vulnerability to climate change and designing policies supporting adaptation are the time-frame and the uncertainties: the CAP operates mostly on a short time-frame whereas adaptation require long-term decisions (e.g. for permanent crops), but the long-term horizon is actually unclear.

The main factors determining the vulnerability for farming and forest holdings are summarised below and presented in Annex 4:

- at holding level: characteristics of holding such as the location of farms/fields, soil properties, geographic accessibility, farmers' and foresters' knowledge and technical capacity but also personal attitudes; type of management and land use, including economic size of holdings, income, farming system, type and diversity of crops/trees/livestock; and farming practices such as cropping intensity, precision farming, agroforestry, organic farming, soil management practices improving SOC, and other practices favouring on-farm biodiversity such as EFA maintenance/creation);

- at territorial or national level: the provision of advisory services to farmers (financed by private, public or other funds); the availability of risk management tools for farmers; the policy framework, including the capacity to plan adaptation and the coherence, stability, flexibility, and supportiveness of policy instruments; and the provision of incentives for resilient practices, and promotion of sustainable investment and innovation.

For territories or countries, the main factors of vulnerability and the capacity to make use of climate opportunities that can be influenced by farming activities, are mainly linked to land use issues

(maintenance of grassland, protection of wetlands), water usage, farming practices such as those limiting erosion, biodiversity losses and excessive water use, and food security[36].

Although the majority of climate change impacts are likely to be negative, one should not forget that there are opportunities too (improved vegetation growth, northward expansion of the range of some species, etc.). Overall, in making adaptation decisions, it appears necessary to consider the multifunctional role of agriculture and to strike a variable balance between economic, environmental and economic functions in different European regions (Olesen and Bindi, 2002).

10.4 THE CAP AND PLANNED ADAPTATION AT MS AND MA LEVEL

Assessing the expected impacts of climate change, elaborating a strategy and a plan for action, and mainstreaming adaptation in all policies are the first steps toward adaptation at public policy level.

Concerning vulnerability and/or risk assessments at EU-28 level, these are in development or implemented in all Member States (except LU, for which there is no information), according to the platform developed by Climate-ADAPT, even though in some Member States the assessment has been made for only some of the climate change impacts in that Member State (floods in the NL Delta Programme, or water scarcity and droughts in CY, MT and PT), or is a preliminary version which will be completed later (ES, FI, HU).

Concerning adaptation strategies and plans, according to the draft versions of the country fiches for climate change adaptation[37] and case study interviews, adaptation strategies have been elaborated by 25 Member States within EU-28 (all except BG, HR and LV, where adaptation strategies are currently in development). All 25 national strategies include plans for adaptation of the agriculture and forestry sectors, while some Member States have developed adaptation strategies and/or plans (which include the agricultural and forestry sectors) at sub-national level (UK, France, Germany, Sweden, and Portugal[38]). On the other hand, institutions from several countries in the Baltic region (DE, DK, LT, LV, EE, FI and SE) have together prepared an adaptation strategy and action plan at supra-national level (Baltadapt project[39]). The Baltadapt study states also that in terms of funding, most Member States have not dedicated funds to these strategies and therefore adaptive actions are supposed to be financed through sectoral policies, such as the CAP for agriculture. An exception is the budget for the NL Delta Programme. As the main EU policy concerning the agriculture sector, which is among the sectors most impacted by climate change, the CAP has the potential to be an essential instrument for the implementation of Member States' adaptation plans. The CAP policy as set in the regulations[40] offered Member States a number of potential levers for adaptation of their agriculture and forest sectors, and of society. Some instruments are compulsory for Member States, with flexibilities on how they are designed at local level (cross-compliance GAEC standards, Farm Advisory Systems, Pillar I Greening measures, Pillar II measures). Many are optional (all RDP measures except agri-environment-climate and LEADER) and their programming relies on choices by Managing Authorities and Member States (Hart et al, 2017). New RDP measures relevant to adaptation were introduced in the 2014-2020 CAP compared to the previous period. For instance, the new M16 cooperation measure is far broader, fostering innovation, collective action and linking the CAP with the European Partnership for Innovation (EIP). The risk management measure M17 is also new. There is more flexibility available to RDP MAs, which has the potential to be positive for adaptation because climate change vulnerabilities and adaptive solutions are very context and location specific. Hence Regions and Member States had the opportunity to tailor their RDP to their specific issues (Henseler and Dechow, 2014).

Integration of adaptation at MS and MA level has been analysed through 1) the assessment of the level of consideration given to adaptation when designing CAP measures for the period 2014-2020 at EU level, and 2) by assessing the Member States/Managing Authorities' choices concerning CAP measures.

[36] The provision of sufficient, healthy, and diversified food to all the population.
[37] Draft versions of the country fiches which outline the climate change adaptation preparedness of each EU Member State (the fiches will be finalised in the second half of 2018), available at: https://ec.europa.eu/clima/consultations/evaluation-eus-strategy-adaptation-climate-change_en
[38] Madeira and Azores regions only.
[39] More information at: http://www.baltadapt.eu/index.php
[40] Regulations (EU) No 1305/2013, 1306/2016 and 1307/2013

10.4.1 CONSIDERATION OF NATIONAL IMPACTS ASSESSMENTS, STRATEGIES AND ADAPTATION PLANS IN CAP DECISIONS

The case studies have shown that the existence (or not) of climate risk assessments, adaptation strategies and plans at MS and regional, and their level of detail are important external factors that favour the integration of adaptation in RDPs, and potentially more broadly in the CAP. Member States are at different stages of preparing, developing and implementing national vulnerability assessments, adaptation strategies and plans. The EU's Climate ADAPT web platform provides a summary of the status of adaptation plans across the EU based on the MMR[41] reporting requirements and updates from EEA countries.

The process of preparing adaptation plans and strategies varies across the EU, being more or less top-down. Participatory processes favour the involvement of all stakeholders, for example, policy makers at regional level, in the risk assessment and planning of adaptation (see Box 5).

Box 5: Inclusion of stakeholders in the preparation of adaptation strategies or plans in France and Austria

After evaluating the first National Adaptation Plan for Climate Change (PNACC 2011-2015), the French government launched a consultation process in order to prepare the second PNACC[42]. This national consultation included nearly 300 participants from various backgrounds and sectors between summer 2016 and summer 2017. They collectively developed recommendations and objectives for the adaptation of France to climate change (including agriculture and forestry sectors). In order to do so, six working groups gathered around six axes: governance, prevention of risks, resilience of the territories, preservation of the environment, economic sectors and the improvement of knowledge, awareness and international action. Similar consultation approaches have been used during the preparation of Austrian NAS (National Adaptation Strategy) with the participation of 100 different organisations (federal and provincial ministries or related institutions such as Railway Austria; interest groups such as the Chamber of Agriculture; and social/environmental NGOs) from summer 2008 until summer 2011 (EC and EEA, 2017).

Source: Case studies in France and CLIMATE-ADAPT platform

Concerning the integration of risk and impacts assessments, the review of RDPs done by COWI in 2017 showed that adaptation has been considered and found to be a relevant challenge in almost all RDPs (based on screening of section 5.1 of the RDPs). Indeed, according to the COWI analysis, only eight RDPs (of 118 RDPs in total) do not identify any adaptation-relevant points in their list of challenges to be addressed; on the other hand, just eight RDPs explicitly cite climate adaptation as a challenge. Overall, the use of the risk assessments when elaborating the RDPs is unclear and difficult to check, and the identified challenges are often generic (improving soil management, increasing efficiency in water use, etc.), seldom reflecting adaptation explicitly, with a clear logic of intervention (COWI, 2017). Yet, clearer linking of ex-ante conditionality (risk assessment for the ESI[43]) with Focus Area 3b (risk-prevention) programming of relevant measures is needed. Overall, the ex-ante conditionality is useful, but its effect is unclear since the document has rarely been referred to and used for programming.

Concerning the consideration of adaptation strategies and plans in CAP choices at MS and MA level, in several Member States or regions (CZ, IE[44], Saxony-Anhalt in DE[45], NL, HU[46], HR and RO) the adaptation strategy and/or plan had not yet been published at the time when the CAP 2014-2020 implementation choices for both pillars were made, and therefore could not be taken into account. However, in some cases, the same policy officers were involved in both processes and therefore the ongoing strategy or plan could be partly taken into consideration (Saxony-Anhalt in DE).

[41] Monitoring Measures Regulation (Regulation (EU) No 525/2013)

[42] Due for the end of 2017, but not yet available on the French Ministry of Ecologic Transition at a time when this evaluation was done (latest check: 06/06/2018).

[43] Annex XI of the Common Provisions Regulation

[44] When defining CAP 2014-2020 implementation, the only relevant document published was the Irish National Climate Adaptation Framework which did not provide sufficient detail regarding agriculture and forests to be of use to this study (according to case study interviews).

[45] The Regional adaptation strategy was published late in 2013 which was too late to be integrated in the RDP.

[46] Hungary's adaptation strategy and the National Adaptation Geo-information System (NAGiS) were developed at the same time as the RDP planning.

For other Member States (ES and FR), several strategies and plans did exist both at national and regional level when the 2014-2020 CAP measures were designed but, according to CS interviewees involved in the policy-making, these were barely taken into consideration . According to interviews, this situation may be due to insufficient collaboration between administration services working on climate action and the sectorial policy makers who tend to work in silos (in Spain). In France also, the adaptation strategy and action plan were rarely (if ever) taken into consideration in CAP implementation choices. The officials interviewed pointed out that in negotiations climate adaptation challenges were less significant than economic and other environmental challenges such as biodiversity (which might indirectly support climate change adaptation).

In Lithuania, the Strategy on Climate Change Management Policy had been elaborated on time and the RDP programme for Lithuania 2014-2020 refers to it.

More specifically, in RDPs documents very little reference is made to the risks assessments, and even less to adaptation strategies and plans. Some programmes are very specific on this issue (several French regional programmes), but the risk assessment and adaptation strategies and plans appear to have played a limited role, if any, in the SWOT elaboration. Overall, it seems that little attention has been given to adaptation strategies and plans and vulnerability assessments when designing the RDPs (COWI, 2017).

10.4.2 Integration of adaptation in CAP by Member States and Management Authorities

Broadly, interviews in most case study Member States[47] pointed out that overall the CAP measures were not primarily designed to achieve climate outcomes. Some measures might have had climate outcomes assumed by their nature (greening, etc.), but in most cases the implementation choices were not explicitly designed for this purpose[48]. In most cases adaptation has been pursued through environmental management purposes but much more rarely through dedicated adaptation measures (COWI, 2017). For example, some Member States tended to address climate change adaptation indirectly through wider environmental management such as biodiversity protection (France), which to some extent makes sense since support for biodiversity often also contributes to climate change adaptation (Altieri et al, 2015a) but is not sufficient to address adaptation needs. Another example is measures tackling water management efficiency in Spain's RDP, without necessarily reducing overall water demand by agriculture in areas with limited water availability.

In order to analyse more precisely to what extent adaptation challenges have been integrated in the implementation of the CAP, specific measures have been further analysed in this section.

Among greening measures, the crop diversification requirement could have potentially positive effects on holdings' and territorial adaptation. Indeed, increased crop diversity (and crop rotation which might indirectly be promoted by the measure), can limit pest outbreaks (if the crops grown are sufficiently different) and sensitivity to particular weather events and the effects of price volatility. The main aspects of this measure were defined at EU level; the fact that it promotes diversification rather than rotation limits its relevance for adaptation. MS had the option to propose an equivalent scheme. France has used such a scheme to offer its maize farmers the option to continue mono-cropping, which has been identified as an example of possible maladaptation at farm and territorial level in the literature review.

The two other greening requirements, for permanent grassland and EFA, may have had unintended positive effects on adaptation through their effect on land management for biodiversity and soil protection. The maintenance or creation of EFA is aimed at safeguarding and improving biodiversity but may also reduce soil erosion by promoting catch and cover crops. The maintenance of permanent grassland favours resilience to floods, erosion, and protection of soil organic carbon, the latter being beneficial for water retention in soils (Price, Balshaw and Chambers, 2014). At Member-State level,

[47] One exception is Saxony-Anhalt, where climate adaptation concerns were a central consideration when designing the RDP 2014-2020, due to floods and intense rainfall which occurred in 2011. This was an important driver for inclusion of adaptation measures in the RDP (in particular for M5 Prevention and restoration after extreme climate events).

[48] Other objectives outweighed climate objectives, such as economic objectives (e.g. farm profitability) and other environmental objectives (e.g. biodiversity).

the evaluation of greening payments showed that the position of the Member States during CAP negotiations and their implementation choices were driven by administrative concerns (administrative burden, mapping errors and risks of disallowance) rather than environmental considerations (including climate change adaptation) (Alliance Environnement and Thünen-Institut, 2017). The environment was mentioned as a significant driver of decisions about greening requirements in only few Member States. As a result, undemanding implementation choices were made by many Member States. The remaining options left to Member States in defining greening requirements concern EFA choices, where biodiversity is the objective defined in the Regulation. In Member States for environmental purpose, they mainly favoured biodiversity (and therefore climate change adaptation but only indirectly) (see Box 6). Case studies interviews carried out for ten Member States confirmed that greening measures were never designed intentionally for climate adaptation purpose, but in some cases did have indirect benefits for adaptation, as illustrated in Box 6.

Box 6: Examples of Member States where the implementation of greening measures is likely to encourage climate change adaptation

Two examples of Member States where the implementation of greening measures is likely to encourage climate change adaptation are:

Crop diversification measure:

- Poland allowed as an equivalent practice an AECM which requires a minimum four-crop requirement (compared to the two or three-crop requirement under the measure), a 65 % maximum for the main crop and all cereals, and a 10 % minimum for all crops. This equivalent practice is likely to further enhance crop diversification and therefore reduce crop farms vulnerability to climate change.

Permanent grassland measure:

- In the Czech Republic, in addition to Natura 2000 permanent grasslands, other lands have been included in the protected area, especially land on soils which are sensitive to erosion (designated as highly endangered in LPIS) and land within 12m of water bodies (which can mitigate flood risk). Erosion is expected to increase with climate change.

Source: (Alliance Environnement and Thünen-Institut, 2017)

For the second pillar, the ESI planning process (including RDPs) involves Partnership Agreements that set binding terms between Member States and the Commission for the RDPs, providing an opportunity to lock-in climate change considerations. One of the ex-ante conditionalities for the 2014-2020 ESI requires national or regional risk assessments for disaster management, taking into account climate change adaptation[49]. Guidelines for the integration of adaptation in RDPs also stipulate that RDP spending should be driven by strategies in place, including the adaptation strategies developed at national (or regional) level that are presented in the Climate-ADAPT platform[50]. The planning of RDPs also requires a SWOT analysis (strengths, weaknesses, opportunities and threats) that must identify needs, including adaptation needs. This analysis must in turn drive choices of measure and budget allocation in RDPs. Eligibility criteria can help prioritize resilient systems or avoid funding actions leading potentially to maladaptation. RDPs are then finally submitted to ex-ante evaluations assessing their overall consistency and coherence. All these planning tools require Member States and Managing Authorities to gather appropriate information, develop strategies and make political choices about the adaptation of the agriculture and forest sectors. Guidelines are provided to facilitate the integration of adaptation in the RDPs, presenting the planning process and giving examples of potential actions that could be supported. The more concrete aspects of adaptation integration are supposed to be addressed by climate experts and information and knowledge should be gathered during the implementation of RDPs. Hence, the challenge for the development of adaptation policies is that adaptation is an emerging issue for which the knowledge base is currently being built. The European Network for Rural Development (ENRD) promotes the exchange of experience among stakeholders but the subject is relatively new, and challenges are many. According to the case studies, the level of climate expertise available and the extent to which the RDP planning process made use of it varied widely across MS and MA. This planning process of RDPs did however require Member States and Managing Authorities to integrate adaptation of the agriculture and forest sector

[49] Annex XI of CRP (Common Provisions Regulation)

[50] Communication 2013 Principles and recommendations for integrating climate change adaptation considerations under the 2014-2020 rural development programs.

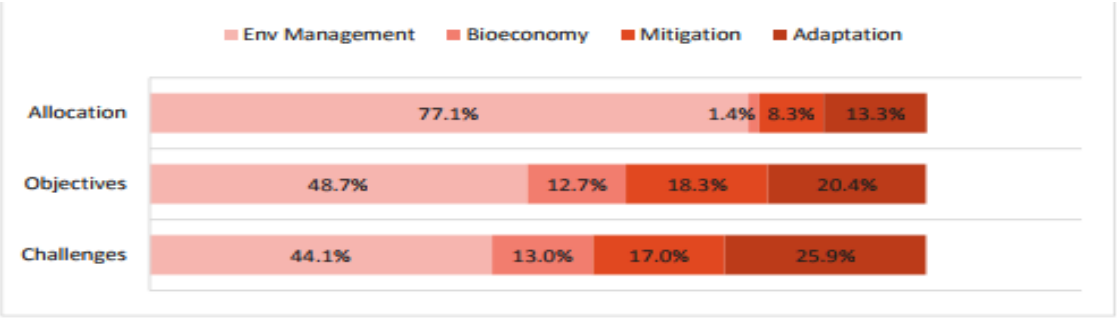
into their policy. There were no such requirements for the Direct Payments and Horizontal Regulations.

Hence, as explained above (see 10.4.1), climate change needs have been identified in most programmes (all except 8 of the 118 RDPs). But the level of integration varies greatly with the perception and impacts to date of climate change. In Member States which recently have been severely impacted by climate change, the challenges of adaptation have been considered as a priority and some effects of the measure can already be observed (Saxony Anhalt in DE and Aquitaine in France for forest measures). On the contrary, in some northerly Member States/Managing Authorities which are less impacted or where climate change provides new opportunities, adaptation is not (for the moment) a real priority and only limited effects on adaptation can be expected (IE, NL and LT). The implementation of specific measures depends also on the Member State's context. For example, risk management measures have not been planned in LT and had low uptake in HU. In these Member States farmers are used to being supported through State Aid when they are stricken by harsh climatic events, and therefore they are not yet ready to pay a premium for such a protection. Such reactive State support may hinder the incentive for them to change their practices to adapt.

However, overall, according to case study interviews and the literature review, adaptation has been more visible and integrated thanks to the 20% budget target and the tracking methodology, even though much still depends on Member States' uptake of adaptation at programme and implementation level. Indeed, the tracking methodology left the possibility for Member States to tackle climate actions through different objectives that are sometimes indirectly linked to adaptation (see ESQ7). There is no RDP Focus Area (FA) dedicated specifically to climate change adaptation, which makes it difficult to tracking expenditure allocated to adaptation, and one must consider several FAs which can address adaptation as well as other environmental challenges. Also, some measures target several FAs (M4, M10, M11 and M13), which makes the assessment of adaptation action even more challenging. As a consequence, the majority of adaptation-related CAP support occurs within measures that also address also other objectives. This makes it difficult to discern to what extent a measure's budget allocation is targeted specifically at adaptation. Because of these difficulties encountered with the tracking methodology, most Management Authorities and Member States fulfilled the requirement on climate action through measures tackling traditional environmental management related to management of resources, conservation and protection of resources, habitats, biodiversity, etc. (COWI, 2017) (see ESQ7).

Even if climate change adaptation is mentioned as a need in the RDP ex-ante assessments, in the measures it is mostly tackled indirectly through measures supporting environmental management (biodiversity), mitigation, or the bio-economy. Especially, when analysing how climate change adaptation needs have been addressed specifically in RDP objectives and budget allocations to measures, one can observe a gap between its weight in identified climate relevant challenges and the allocation of funds to measures clearly dedicated to (and designed for) adaptation. Indeed, adaptation is identified in more than 25% of challenges found across all RDPs and more than 20% of objectives, but only 13% of the EAFRD budget is allocated to this area (COWI, 2017). On the other hand, environmental management challenges have much more importance in terms of budget allocations than in terms of identified challenges (see Figure 17).

Figure 17: Consistency between allocation, challenges, and objectives (as %distribution of total number of climate relevant challenges and objectives) relevant to each of the four types of climate action



Source: (COWI, 2017)

Overall, at EU-level, 7.5 billion Euros have been allocated to dedicated adaptation, to support actions explicitly dedicated to preventing or minimising the damage that climate change can cause, corresponding to 13.3% of the total climate change allocation under EAFRD (COWI, 2017).

The mainstreaming of adaptation depends very much on Member States' choices concerning the use of measures with potential to have dedicated effects on adaptation, and on the budget allocated to these measures. Managing Authorities are obliged to implement the agri-environment-climate measure and the LEADER approach but are free to decide how to design and use these and any other RDP measures to meet their national or regional needs.

Based on in-depth analysis of RDPs the measures and sub-measures that have been used to address climate change adaptation challenges have been identified. They can be categorised in four groups: 1) soft measures such as measures M1 knowledge transfer and information actions, M2 advisory services and M16 cooperation, as they are essential for capacity building and innovation; 2) investment measures such as M4 investment in physical assets when it is used to fund adaptive equipment (e.g. crop protection against hail); 3) land management measures such as M10 agri-environment-climate (when it supports adaptive practices such as soil cover) and M13 payments to areas facing natural and other specific constraints (e.g. by supporting extensive livestock grazing of open areas that would otherwise be a fire risk); 4) risk management measures such as M5 for restoring agricultural production damaged by natural disasters, and introduction of appropriate prevention, and M17 risk management can also be directly beneficial for adaptation. For example, FA3b in combination with measures M5 and M17 is quite clearly explained in the case study RDPs and receives substantial funding and addresses a number of the key climate hazards such as drought, forests fires, pest, invasive species, mudslides, flooding and heavy rainfall.

However, the description of measures and RDP texts provide very little information on the considerations taken by the managing authority in doing so. In the absence of clear criteria for this in the guidelines and in the Regulations, and the lack of a Focus Area dedicated to adaptation, the assessment of adaptation integration in RDPs is open to interpretation (see ESQ7).

Beyond choosing which measures are implemented or not and deciding budget allocations, targeting of RDP measures can also be used to improve mainstreaming of adaptation. Some Member States or regions have implemented specific eligibility or selection criteria targeting vulnerable areas or farming systems or favouring resilient ones. An example is the Aquitaine region in France that developed an environmental label, promoting practices and farming systems favouring a sustainable environment management and which includes some adaptive practices. This label is used as an eligibility criterion for some RDP measures (see Box 7).

Box 7: Selection criteria AREA in Aquitaine (FR)

In Aquitaine RDP, in order to favour environmentally-friendly actions, the region has implemented an environment certification scheme used as an eligibility criterion for several RDP measures: the AREA certification (Environmentally Friendly Agriculture in Aquitaine). This includes one measure targeting water saving through improved management of irrigation. Under this applicants are required, for instance, to subscribe to technical advice on irrigation and to adhere to a collective approach to managing the local water resource. The certification scheme also has some requirements aimed at limiting GHG emissions (improved manure management for livestock farmers, and energy use) which also limit the risk of maladaptation. This certification is compulsory for farmers under M4 and makes it possible for farmers to have an increased support under M6.

Source: case study interviews in France

Other examples of factors favouring the integration of adaptation have been identified. In France, the agro-ecology[51] project was launched in 2014 at national level, integrating several actions which benefit climate change adaptation (see Box 8). The literature review showed that agro-ecology practices are highly beneficial for adaptation: they reduce vulnerabilities to climate change (e.g. crop diversification, maintaining local genetic diversity, animal integration, soil organic management, water

[51] According to the French Ministry of Agriculture, agro-ecology is a production system based on ecosystem services and on the use of technical solutions which consider the whole farm as a system and allows to maintain economic and technical results at a same or higher level (compared to conventional farming practices) while improving the environmental performances of the system (see http://agriculture.gouv.fr/quest-ce-que-lagro-ecologie).

conservation and harvesting) (Altieri et al, 2015b). They are also beneficial to mitigation (e.g. reduced use of inputs).

Box 8: The Agro-ecology project in France

The 'Loi d'Avenir pour l'Agriculture, l'Agroalimentaire et la Forêt' (Law for the future of Agriculture, Agroindustry and Forest) is the legal framework of the agro-ecology project in France. It is based on the law 2014-1170 of 13 October 2014[52]**.** This regulation provides tools to respond to the main environmental challenges of agriculture (pesticide use, water pollution, pollination, soil erosion, etc.) and the main objective of the project is to promote a transition of a majority of French farms towards greater sustainability. It is based on 73 measures organized in seven categories: economic and environmental performance of the agricultural sector (14 measures); protection of natural, agricultural and forest areas and renewal of generations (18 measures); food and sanitary performance (11 measures), education, training and research (7 measures); forest (10 measures); overseas departments and regions (9 measures); and provisional and diverse measures (4 measures).

These are examples of actions promoted under two categories, which can favour adaptation of farm holdings to climate change.

In the category 'Economic and environmental performance of the agricultural sector', the main action is setting up 'Groupements d'Intéret Economiques et Environmentaux' (GIEE) which are groups of farmers working together on common projects to increase their environmental, economic and social performance (article 3). GIEE aims at favouring exchanges of experience and knowledge between farmers and promoting changes towards more sustainable practices. In 2017, 407 GIEE had already been created. In some regions the creation of GIEE can be supported through the RDP. They are often considered as Operational Groups to be supported under Measure 16 (in Aquitaine), and belonging to a GIEE has been an eligibility or selection criterion or a mark-up factor for a higher rate of funding in many RDPs.

In the category 'Protection of natural, agricultural and forest areas', the main measure regarding environment is Article 24, which gives the regions a bigger role in the management of agricultural policies. Indeed, the regions (which are also the Managing Authorities for the RDPs) are required to integrate agro-ecology into their public policies through their Regional Plan for Sustainable Agriculture ('Plan Régional de l'Agriculture Durable', PRAD). This document presents the main agricultural policies at regional level. Each region had to publish its Regional Plan for Sustainable Agriculture in 2015.

Concerning the integration of the Agro-ecology project with RDPs, an evaluation by Oréade-Breche concluded that the level of integration, and with it the integration of adaptive actions, varied greatly among regions, depending on: 1) their pedo-climatic conditions; 2) their exposure to extreme climatic events; and 3) the farming systems prevailing in the region (areas with mainly highly specialized, exporting value-chains were less likely to promote agro-ecology). Other conclusions were that the integration of the Agro-ecology Project has been done mainly through selection criteria for projects and differential rates of support (AREA criteria in Aquitaine), much less through a specific focus of the support mechanisms, and that the range of measures contributing to agro-ecology varied widely according to the RDPs.

Source: French Ministry of Agriculture[53] and (Oréade-Brèche, 2017).

The implementation of the Agro-ecology project has been based on CAP measures as well as on national and regional policies. Case study interviews showed that it has driven also the mainstreaming of adaptive actions in the RDPs designed by MAs (Regions), with national coordination. Therefore, it favoured an integration to some extent of CAP and national measures towards a common objective, the improved sustainability of French farms, although the level of integration varied a lot among regions. This French example shows the CAP measures can be used flexibly towards the objective of climate adaptation (if there is political willingness to do so).

10.4.3 INTEGRATION OF ADAPTATION IN CAP HORIZONTAL REGULATIONS

Farmers receiving direct payments under Pillar I and area-based payments under Pillar II have to comply with basic cross-compliance standards comprising Good Agricultural and Environmental Conditions (GAEC) and Statutory Management Requirements (SMR). The framework is defined at EU level but Member States define farm-level requirements applicable to their context and needs. In the intervention logic elaborated for this evaluation, cross-compliance GAEC standards are considered as

[52] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029573022&categorieLien=id

[53] http://agriculture.gouv.fr/le-projet-agro-ecologique-pour-la-france

having unintended positive effects on adaptation (see Box 9). They could also be used to avoid cases of maladaptation.

Box 9: Main potential effects of 2014-2020 GAEC on climate change adaptation (according to the intervention logic)

- GAEC 1 and 5 could have an impact on adaptation by limiting soil erosion, protecting water courses and improving resilience against floods, limiting the presence of cultivated parcels close to water courses and improving water retention.
- GAEC 2 could have an impact on adaption to climate change by regulating the use of water for irrigation.
- GAEC 3 could support adaptation through the improved protection of a key-resource for adaptation.
- GAEC 4 could support adaptation through the improved content of organic matter which is essential to maintain soil moisture, and through limiting erosion.
- GAEC 6 could support adaptation by maintaining soil moisture which is an important factor to improve the resilience to drought (but in 15 Member States it consists only of the ban on residue burning).

GAEC 7 could support adaptation by maintaining ecosystem services such as erosion protection (and conservation of stored carbon), and resilience to floods and droughts.

Source: own analysis

The literature review showed that the provision of training and advisory services is essential to promote adaptation of forest and farming holdings. Hence measures supporting the set-up and access to these services are of paramount importance for adaptation at farm and territorial level.

The introduction of cross-compliance in 2003 was accompanied by an obligation for Member States to set up a Farm Advisory System (FAS) in order to help farmers to better understand and meet the EU rules for the SMRs and GAECs (with the obligation to be able to offer advice to farmers by 2007). This horizontal measure does not have a budget *per se*, but RDP M2 can be used to support Managing Authorities in setting up new farm advisory services where needed, and to support farmers making use of them. However, before 2014, climate change was not covered by the scope of FAS, and it is important to note that although it has been included in the scope of FAS from 2014, climate change is an optional rather than a compulsory topic. It has not been possible to assess accurately to what extent climate change has been included in advice to farmers. Case study interviews hint that the situation varies across MS and that the integration of climate action related issues has been low. It should also be noted that advisers also reported on the high complexity in advising on adaptation given 1) the uncertainty of climate change impacts, 2) the fact that knowledge of adaptation issues is still developing, and finally 3) the fact that vulnerability of a given farming system is very dependent on its context and location.

To conclude on the level of integration of adaptation in CAP measures, it can be said that:

- The planning of climate adaptation of the agriculture and forest sector through risk assessments and adaptation plans has largely improved in the last decade at EU-28 scale but links between CAP measures and risk assessments and adaptation plans are lacking, despite the fact that this would allow better integration of planned adaptation in the CAP;
- The planning process of ESI-Funds, including the EAFRD, did require MS and MA to gather appropriate information, elaborate strategies and actions toward adaptation; this helped to some extent with the improved integration of adaptation as a cross-cutting objective. There were however no requirements to integrate adaptation in Pillar1 or the horizontal measures, although the GAEC framework and greening measures (as defined at EU level) had potential to promote adaptation;
- For many Member States most CAP measures have mainly been designed to tackle economic drivers, and at best, more general environmental drivers; adaptation has mostly been tackled indirectly through broader environmental management issues such as biodiversity and soil.

10.5 Assessment of CAP effects on adaptation

After identifying the main factors of vulnerability/opportunity linked to climate change, this section aims at identifying positive/negative, intended/non-intended effects of CAP measures on those factors, through case studies and the literature review. As has already been stated, there is no clear

intervention logic for adaptation set out in the CAP regulations. Hence the evaluators have elaborated a potential intervention logic, considering both measures with intended and non-intended effects.

10.5.1 EFFECTS OF THE FIRST PILLAR'S MEASURES ON ADAPTATION

The major part of Pillar I decoupled direct payments after the 2003 reform replaced earlier Pillar I support coupled to numbers of livestock and area of crops, initially mostly on a like-for-like basis at holding level, but the disparity of support per hectare became more and more difficult to justify. To respond to these concerns and adapt the support to its evolving objectives, the 2013 CAP reform introduced several schemes and principles, including the voluntary redistributive payment and a simplified scheme for small farmers, plus the internal and external convergence, capping and degressivity principles, that are supposed to generate redistributive effects and lead to a fairer distribution of direct payments between Member States, between regions and between farmers (DG Agriculture, 2017). In practice the extent of this redistribution depends very much on the choices made by Member States concerning those schemes, and since the 2013 reform they have enjoyed more flexibility in implementation of the direct payments regime.

The direct payments in the CAP 2014-2020 comprise seven components of which three are compulsory – basic payment, greening and young farmers' payments, and four are voluntary - redistributive, natural constraint support, coupled support, and the small farmers scheme. Overall, direct payments accounted for around 72% of the CAP budget for the 2013-2015 period. Based on FADN data over the period 2004-2013, the contribution of direct payments to farm net income was 47%, with other public transfers contributing 15% and market income 38%. The average share of direct payments ranges from 7% in horticultural farms to 101% in 'other grazing livestock' farms over this period (Matthews, 2016).

10.5.1.1 Effects of the greening requirements

There are three greening measures: crop diversification, maintenance of permanent grassland and maintenance/creation of Ecological Focus Area (EFA).

The **crop diversification measure** is meant to promote crop diversification in agricultural systems, as opposed to monoculture. Hence it is beneficial for adaptation since crop diversification improves farms' resilience to climate events such as droughts, as well as to economic shocks from price volatility. Crop rotation allows additionally the improvement of resilience to pests and of soil quality. Also, the diversification into non- or less water-demanding crops may lead to a decreased dependence on water resources in traditionally irrigated areas. Mono-cropping is a dominant practice in a number of countries and regions in the EU (Italy, Romania, Spain, Poland, north-western Germany and south-western France) and is associated with the cultivation of wheat, maize, barley and oats mainly. In reality the crop diversification measure required changes of crop on less than 1% of EU arable land due to measure's design and to the level of exemptions. However, the impact was higher locally in areas with high levels of mono-cropping (2.8% of UAA had to diversify in Spain). Most farmers that had to diversify mainly planted leguminous plants instead of cereals, and they mainly did it in rotation, both practices being identified as positive for adaptation by favouring resilience to pests, droughts, and improving soils structure (Alliance Environnement and Thünen-Institut, 2017).

The **permanent grassland measure** aims at maintaining permanent grasslands and is divided in two sub-measures: PG (Permanent Grassland) ratio and ESPG (Environmentally Sensitive Permanent grasslands) designation. The **PG ratio** can improve adaptation of EU society since permanent grass cover limits soil erosion and improves resilience to floods, both phenomena being expected to increase with climate change. At territorial level it allows maintenance of a level of diversity in the farming system, which has been identified as crucial for adaptation (see literature review). The designation and resulting protection of ESPG have the potential to maintain services provided by these ecosystems (flood regulation) which are important in a context of climate change. The evaluation of greening measures has shown that effects on permanent grassland area are challenging to assess accurately due to the change of permanent grassland definition and lack of data. However, it notes that clear pressures on permanent grassland were already evident in 2015-2016 in 12 Member States, of which six are over the 5% threshold (CY, EE, FR-Haut-de-France, EL, RO, UK-En). All but four Member States (BE, DE, FR and UK) chose to apply the PG ratio rules at a national level,

hence allowing higher levels of ploughing at NUTS 3 level. Germany implemented a pre-authorisation system which does appear to be a disincentive to ploughing permanent grassland. The way in which some Member States or regions define permanent grassland has had other effects. For example, in Andalucía (Spain), the criteria for eligibility for direct payments and the definition of permanent grassland as implemented in Spain has led to a decrease in the area of wooded grasslands (dehesa) declared as eligible for Pillar I support and may lead to their abandonment. This might increase the risk of forest fire in the region (since open, grazed grasslands limit fire spread) and therefore might lead to maladaptation (see literature review).

ESPG also allows maintenance of a level of diversity at territorial level and is beneficial for the protection of biodiversity. Hence it can have indirectly positive effects for adaptation. 51% of permanent grassland in Natura 2000 areas has been designated by Member States (7.7 million ha), but only 61% of that area has been declared by farmers (4.7 million ha). Although seven Member States declared all permanent grassland in Natura 2000 sites as ESPG, most others designated a low proportion of habitat types that could qualify as ESPG. Five Member States designated ESPG outside Natura 2000 areas in 2016 (BE-Fl, CZ, LV, LU and UK (Wales)), covering around 2% of total permanent grassland subject to the greening measures in all countries except the Czech Republic where 49% of the area was designated. The evidence suggests the ESPG measure reinforces the application of existing legislation both within the Natura 2000 network outside it, although Member States have designated little land outside.

The **EFA measure** requires that an area of the farm equivalent to at least 5% of arable area is declared as Ecological Focus Area (EFA). It can promote the adoption of farming practices (catch and cover crops, N-fixing crops (NFC), fallow, agro-forestry, afforestation) and/or the creation of additional landscape features or other ecological areas, all being practices identified as beneficial for the adaptation at farm and higher level. Indeed, EFAs have the potential to be beneficial to adaptation to climate change by maintaining or increasing ecosystem services to agriculture (maintaining biodiversity, limiting soil erosion and inputs needed, improving resilience to droughts and floods), mainly thanks to the maintenance of a vegetation cover.

As a consequence of EFA, farmers have defined areas equivalent to more than 5% of their eligible arable area as EFA, amounting to an area equivalent to 14% of EU arable land. The main types of EFA declared by farmers at EU level are linked to productive or potentially productive areas: nitrogen fixing crops and catch/cover crops, together accounting for 73% of the total EFA area in 2016, followed by fallow area (24%). Catch and cover crops are practices favourable to adaptation since they improve SOC content and maintain soil moisture, which is good for resilience to droughts, while also limiting the risk of soil erosion. Nitrogen-fixing crops can play a role in adaptation by improving self-sufficiency of livestock holders, reducing their vulnerability to price volatility. Landscape features comes fourth with 1.4% of the total EFA area in 2016. In terms of effects, the data suggests that the EFA measure is one of a range of factors driving an increase in the area cultivated with nitrogen-fixing crops, such as pulses, soybean and green fodder (alongside Voluntary Coupled Support, the greening crop diversification measure and market developments). It has also helped spread the use of catch and cover crops in some regions (FR, DE, CZ, UK-En), although this is also influenced by the existence of requirements under the Nitrate Action Plan (in NL) or under cross-compliance. For land lying fallow, the negative trend in EU fallow area stabilised in 2015 in many of the Member States where fallow was used by farmers to meet their EFA obligations, suggesting the EFA measure is one of the drivers of this change, although in practice only 30% of the EU fallow area is used to meet the EFA requirements. The maintenance of fallow land is beneficial for broader ecosystem services such as resilience to floods, biodiversity, soil erosion (hence SOC in soils), supporting adaptation of the territory and the farms. The impact of the EFA measure on the maintenance of landscape features is likely to be small, given their limited uptake and the fact that most are already subject to some degree of protection under national law, or through cross-compliance, although the EFA measure may have helped improve enforcement (Alliance Environnement and Thünen-Institut, 2017). However, effects of the EFA measure are expected be different since a ban on pesticides on productive (on catch and cover crops) EFA has been imposed from 2018 onwards[54].

10.5.1.2 Unintended effects of direct decoupled payments

[54] Delegated Reg. amending delegated Reg. 639/2014

The literature review emphasized that socio-economic aspects are a main determinant of the sensitivity and adaptive capacity of holdings. Hence, as far as climate action is considered, direct payment schemes can: 1) improve farmers' adaptive capacity by facilitating investments deemed necessary to adapt to new climate conditions, hence facilitating a transition toward more resilient systems; and 2) decrease their sensitivity to shocks that may be directly or indirectly due to climate changes (climate events, but also indirectly price volatility), by improving income stability.

The fairer distribution of direct payments among Member States and within Member States that is made possible by the CAP 2014-2020 (through the voluntary redistributive payment, internal and external convergence principles) appear to be a potential positive change for the adaptation of EU farms (Mendelsohn, 2012). It can also support adaptation at a higher level (EU society) by supporting farm diversity through higher levels of support for smaller farms (through the redistributive payment increasing the payment on the first hectares, and the Small Farmers Scheme). According to the literature review, diversity of farming systems is a key-element for adaptation at farm and regional levels. For instance Reidsma and Ewert (Reidsma and Ewert, 2008) showed that diversity in farm size and intensiveness reduces vulnerability of regional wheat yields to climate change, especially in the Mediterranean region. Overall, their conclusion points out the importance of considering adaptation at a regional level and of maintaining the diversity of farming systems rather than focusing on one type of farming system, which is often large, intensive and specialized systems. And Scenar 2030 (M'barek et al, 2017) shows that a 'no CAP' scenario (with current trade policy) would lead to simpler systems, implemented on a smaller agriculture area, located in the most favourable places. But in reality, the level of DP distribution depends on Member States' choices concerning the implementation of direct payments schemes, given the high level of flexibility available to the Member States.

The maintenance of a minimal geographic distribution of diversified farming systems is essential for food security concerns but also for the better environmental management that is deemed necessary for adaptation. For example, the increased concentration of intensive livestock farms that is currently on-going in the EU contributes to the degradation of water sources by nitrate pollution in areas specialized in livestock production, and to a sub-optimal use of chemical fertilizers in areas specialized in crop production.

Concerning the implementation of decoupled payments, equity of distribution among regions and farmers has been an important criterion in some Member States (DE, AT, LV, MT, PL RO, etc.). For other Member States, the major concern when implementing CAP reform in 2014 was to minimise the changes in support provided to the agricultural sector compared to the previous CAP, and therefore maintain its competitiveness (Ecorys, IEEP and Wageningen University & Research, 2016). Indeed, in many cases, the main objectives pursued by the Member States were to limit the impact of the changes on farmers' income and to maintain the balance between agricultural sectors or between regions (see Box 10). In less developed Member States, the objective was to favour economic development in agriculture and forestry sectors (LT).

As a consequence, environmental challenges, including climate change adaptation, were secondary drivers, especially when designing the direct payment schemes (basic payments, greening requirements, redistributive payments, small farmers' schemes, etc.).

In terms of direct payments distribution, Member States applying the SAPS had already implemented a system of flat-rate payments per hectare before 2015. Other Member States/regions applied a flat-rate payment from 2015 (FR-Corsica) or before 2015 (Germany and UK-England[55], Malta). The other Member States chose between progressively reaching a uniform value by 2019 (Netherland, Austria, Finland, UK-Scotland and UK-Wales) or a partial convergence ('tunnel' model). Member States that have opted for the partial convergence have maintained the link with historical levels of coupled production support (ES, FR, BE, etc.). Also, nine Member States implemented the redistributive payment: BE (Wallonia only), BG, DE, FR, HR, LT, PL, RO and UK (Wales only). Amongst these, six have decided not to apply the reduction of payments mechanism. PL, BG and UK (Wales) will grant the redistributive payment while applying the reduction of payments mechanism. However, the funds allocated to the redistributive payment are significantly lower than those potentially available for the

[55] Under the Single Payment Scheme (2005/2014), Germany and England selected a regionalised dynamic hybrid model, which had evolved to a regional flat-rate by 2013 and 2012 respectively. Other MS/regions (Finland, Denmark, Sweden, Luxembourg, Slovenia, UK-Northern Ireland) applied a hybrid model (part-historical and part-flat rate).

scheme in accordance with the regulation (30%), with Member States having allocated between 0.5% and 15% of their national envelope to the scheme. Hence small farms benefit more than large farms from the new policy, but in small proportions. Degressivity/capping principles have had very little impact on the distribution of payments between farms (Matthews et al, 2016). The external convergence did allow an unprecedented redistribution among Member States, although this was also small.

Hence, overall there has been a redistribution, but with small effects, and direct payments still show important differences among Member States and within some Member States (those that chose partial convergence). Since DP are made per hectare, at EU-28 scale, in 2015 the largest 20% of farms receive 82% of the direct payments, and they have around 82% of the land (DGAgri, 2017). The redistribution is generally a positive change for adaptation at farm, national and EU level because it supports farm diversity, but Member States could have made much greater use of this measure and redistributed larger sums. In the past, a general effect of direct payments that had been identified was to draw EU farms and territories toward specialisation (Agrosynergie EEIG, 2013), which has clearly been identified as a factor of vulnerability to climate change both at farm and territorial level. Hence measures counterbalancing these effects and supporting diversity of crops, of agricultural activities, and mixed systems are deemed crucial for adaptation at farm and regional levels.

The evaluation study of the CAP measures' impact on the general objective "viable food production" has shown that direct payments make a positive contribution to the stability of farm income. In the absence of CAP support, income instability would have increased in all EU Member States. It thus contributes to improving the resilience of EU farms to climate change since climate change is expected to increase commodity price volatility as well as the incidence of extreme events affecting production. However, the income stabilising effect of direct payments depends on their relative importance as a share of average farm income and therefore it differs in magnitude among EU countries (Agrosynergy, 2018).

Also, it has been shown that direct payments have ensured the survival of many family farms that would have otherwise gone out of business. Furthermore, the targeting has been slightly improved in favour of family-owned farms for the CAP 2014-2020 (with the Active Farmer clause, redistributive payments, etc.) (Hennessy, 2014). The type of organization, corporate farms versus family-owned farms, appears also to be a factor of holdings' vulnerability to climate change. Indeed, it appears that sustainable practices and transformational changes will be better adopted by farmers owning their farms, since they are more inclined to valorise the long-term positive effects of these changes. Also, family-owned farms can be more resilient to shocks since they rely at least partially on family labour rather than salaried labour, the latter being less flexible than family-labour (Scherer, Verburg and Schulp, 2017).

However, it has to be underlined that direct payments can also have unintended negative effects on adaptation. They may support the maintenance of vulnerable farms, slowing some structural changes that could be necessary for adaptation in some cases, or supporting risk-prone behaviour, or eventually supporting systems that are not favourable for the adaptation of the territory as a whole (Bardají et al, 2016); hence they can lead to cases of maladaptation. But in the same way they may support the transition of farmers that want to improve the resilience of their systems since all changes have implicit risks. Both cases have been cited during case study interviews. As the evidence is anecdotal no assessment can be made of whether the former or the latter is more common.

Some situations that may lead to cases of maladaptation have been reported during the case study interviews. In Spain, for example, interviewees pointed out that the Basic Payment was still strongly linked to historical payments (See Box 10).

Box 10: Implementation choices for Basic Payments in Spain and impact on climate change adaptation

In the framework of the 2014-2020 CAP, in Spain, the Basic Payment is still mainly based on historical references, as the mode of calculation allows minimal internal convergence. Also, the Basic Payments have been regionalized and the level of payments can be very different between regions. The level of support for Basic Payment is based on farmers' productive potential calculated by Agricultural District Offices ('Oficinas Comarcales Agrarias) via criteria such as the area cultivated, the type of crops etc. (MAPAMA, 2015-2020). The productive potential is calculated on the basis of the productive orientation declared in the 2013 information paper completed by the farmer for the Ministry. The level of support under the new basic payment model is very similar to the level of support farmers received from the historical reference. One major consequence is that, due to the

historic model used, the farms which are more productive or intensive and with higher yields continue to receive higher levels of CAP payments. This is the case, for example, for farmers working on irrigated systems located in arid zones, as they have higher yields. However, these systems are going to be increasingly vulnerable to the effects of climate change and they may lead to higher vulnerability of the whole territory through their use of ground water from aquifers that already quite depleted. If the criteria of the level of aquifer exploitation is not taken into account when defining support such a situation can push a territory toward maladaptation.

Source: Interviews with the Ministry of Agriculture and WWF in Spain

Hence, as a result of insufficient understanding of adaptation issues and lack of screening for maladaptation, direct payments may in some cases be leaving farms more vulnerable. All cases of maladaptation are very context-dependant and cannot be generalized. The screening requires considering socio-economic indicators in conjunction with natural resource indicators (e.g. availability of water resources and their possible change with the climate change).

The Young Farmers scheme, which is mandatory, provides relatively higher levels of direct payments to young farmers. Case study interviewees indicated that older farmers are more often reluctant to make necessary changes in their practices or system as they do not perceive the risks in the same way as young farmers. They can plan to have left the agricultural business (through retirement) before experiencing substantial impacts. Although at EU level 14 Member States chose to allocate the maximum level of support (2% of their DP envelope), the total payments for young farmers amount approximately to 317 million EUR, only 0.79% of the DP envelope, well below the initial estimates of around 1.3%. However, people younger than 25 years accounted for 0.6% of the total number of farm managers across all types of farms in 2013, while those younger than 35 years represented 6.0% of all managers[56]. The low budget share allocated to the Young Farmers Scheme is regrettable, because ensuring efficient generational renewal appears to be important for adaptation**.**

10.5.1.3 Unintended effects of coupled support

Voluntary coupled support (VCS) is meant to provide income support to certain sectors or regions that are 'particularly important for economic, social or environmental reasons undergo certain difficulties'. By targeting certain sectors, VCS could provide support for sectors that are economically vulnerable but important for the adaptation at territorial level.

Interviews carried out during the case studies confirmed that main drivers in Member States' choices concerning VCS were predominantly economic criteria. The main sectors supported were beef and calves (41% of the amounts earmarked for VCS from 2015), milk (20%), sheep and goats (12%). However, in several Member States, some choices regarding supported sectors do have potential to enhance the adaptation of farms to climate change. For instance, 16 Member States[57] have granted support to the protein crop sector with potential benefits of crop diversity and feed self-sufficiency of livestock farmers (see Table 33). Support was granted to the protein sector for a total equivalent to 10.6% of the amounts earmarked to VCS, from 2015. Especially, several Member States have specified rules to support N-fixing crops only in cases where this supports protein self-sufficiency of livestock farmers, either at farm or territorial level (FR, RO, HU, EL, HR and CZ) (see Box 11 which describes VCS implementation in France and Table 33 which summarises MS choices on VCS for protein crops.

Box 11: Implementation choices for VCS in France and potential for climate change adaptation

In France, one of the objectives of coupled support for protein crops is to support farmers' feed-self-sufficiency[58]. Indeed, coupled support for leguminous forage is provided only to livestock producers (to encourage farmers to produce their own forage) and crop producers producing under contract to livestock producers. Therefore, indirectly the VCS can support better integration between crop and livestock farming systems. The support for forage seed production is also related to this need for more forage production and is thus positive in terms of adaptation and mitigation to climate change. Overall, improved feed-self-sufficiency is beneficial to climate change adaptation since it favours a better resilience to crop price volatility, which is expected to increase with the increased incidence of climatic events (see literature review) (Bernués et al, 2011) (Herrero et al, 2010).

[56]http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agriculture_statistics_family_farming_in_the_EU

[57] But Slovenia stopped it in 2017 (according to the 2016 notification).

[58] Décret n° 2016-330 du 17 mars 2016 relatif aux régimes de soutien couplé du domaine végétal dans le cadre de la politique agricole commune et modifiant le code rural et de la pêche maritime.

Besides, livestock production is also eligible for VCS, but a digressive payment depending on farm size and/or number of cattle has been implemented in order to avoid encouraging more intensive systems, that could lead to erosion issues which are unfavourable for the resilience of farms and territories.

Source: Interviews in France

The table below presents the main choices of MS concerning VCS for protein crops.

Table 33: Main implementation choices for VCS for protein crops in Member States that chose to provide support to this sector (based on 2014 implementation choices, updated with 2016 changes)

MS	Support under Article 68	VCS	VCS criteria relevant to feed autonomy
BG		X	No
HR		X	Fodder protein crops only and for soya min of 4LU/ha of soya
CY			
CZ		X	Must be linked to livestock breeding with min 3LU/ha of protein crop
EE			
FI	X	X	NO
FR	X	X	One scheme under which the link with animal production is an obligation
DE			
EL		X	Specific VCS for fodder protein crops
HU		X	Available for dairy farms only
IE		X	No
IT		X	No information
LV		X	No
LT		X	No
LU		X	No
PL	X	X	No
RO		X	Support to alfalfa must be linked with animal production
SK			
SL		X (until 2017 only)	No
ES		X	No

Source: own compilation based on 2014 notifications (VCS) and (Agrosynergie EEIG, 2015)

Also, voluntary coupled support has the potential to favour systems which are economically vulnerable but important for resilience of the territory; and in doing so it promotes more broadly farm diversity at territorial levels, which has been identified as beneficial for adaptation (see literature review). For example, a VCS is focused on nuts in rain-fed areas in Spain, avoiding abandonment of terraces that limit erosion in mountainous areas. Also, in The Netherlands a VCS supports very extensive beef/veal/sheep/goat grazing in natural areas which do not meet the criteria for the basic payment scheme. However, it is regrettable that there are no conditions set up by Member States that ensure that the support is used to improve adaptation of those vulnerable systems.

On the other hand, voluntary coupled support can potential negative effects on adaptation. In Spain, coupled support is available for rice and tomatoes, even though these irrigated crops require high levels of water consumption and are grown in areas facing water scarcity issues (see Box 12).

Box 12: Implementation choices for VCS in Spain and risks for climate change adaptation

The Ministry justifies the support granted to rice in the Guadalquivir basin (VCS of 100 EUR/ha maximum[59]) by the fact that it is beneficial for the environment and biodiversity. The objective of this support is to maintain rice crops in traditional areas. However, rice growing is a cause of GHG emissions and has great need of water and energy. Moreover, there are very few controls on water use in this sector, and water management in Spain is not yet efficient enough to mitigate GHG emissions issues. It should be noted that the Guadalquivir river basin is a highly stressed system and existing water demands exceed available resources even under non-drought conditions. A decrease in overall water availability will have significant climate change impacts on rice farming and biodiversity (Stucker and Lopez-Gunn, 2015). However, it has to be acknowledged that alternative agricultural uses are limited by the high salinity of soil and water. In areas traditionally used for rice farming,

[59] VCS support by unit (per hectare or per head of livestock) depends on the annual number of beneficiaries, MS notified to the EC global envelopes for every VCS.

agricultural alternatives that are environmentally sustainable are very limited, except livestock grazing on wetland grassland. This radically different agricultural activity is certainly difficult for rice producers to adopt. Such transformational changes required for adaptation in the long run need higher levels of support (Stucker and Lopez-Gunn, 2015).

Also, the VCS in the industrial tomato sector (VCS of 254 EUR/ha maximum) is justified by the Ministry by the fact that this form of production maintains significant socio-economic activity in the regions cultivated (mainly in Extremadura and Valencia). The world price and global competitiveness has led to an important reduction in prices and industrial tomato producers in Spain receive support to maintain this agricultural activity that would probably have ceased without support from the CAP. Considering the large amounts of energy and water resources necessary to produce rice and tomatoes, these VCS could be considered as encouraging non-sustainable agricultural practices, when they are supported in areas facing water scarcity issues.

Source: Spain case study

10.5.2 EFFECTS OF HORIZONTAL REGULATIONS

GAEC requirements apply across all farm holdings in EU-28 that claim direct payments under Pillar I or environmental land management payments under Pillar II. All GAEC standards have potential for positive effects on adaptation (see Box 9) but the extent to which this is realised depends on how Member States choose to define the standards. Interviewees in the case study Member States pointed out that climate change adaptation had not been a significant driver of GAEC choices (DE, ES except for GAEC soil in 2018, RO). In most case study Member States GAEC standards did not change significantly between CAP 2007-2013 and CAP 2014-2020 (HU and RO), showing no strong commitment to furthering climate change adaptation in the new programming period through GAEC standards.

Even although in many of the case studies GAEC requirements are considered to be undemanding for most farmers (FR, HU, IE, LT, NL and RO), at EU-level they ensure that minimum standards are applied by most farmers. In some case study Member States (RO) there seems to be a poor understanding amongst farmers of the environmental added value of the measure, which can undermine its environmental benefits.

Considering the GAEC standards most likely to benefit adaptation, an EU wide review of GAEC 6 (maintenance of soil organic matter) definitions revealed that most (15) Member States did not go beyond the EU minimum requirement, a ban on stubble burning. Furthermore, when looking at the evolution of the GAEC requirements over time, there appears to have been a year on year decrease in the number of Member States which defined additional requirements for the maintenance of soil organic matter, such as restrictions on entering land when it is waterlogged or frozen, use of crop rotations, not growing successive crops with a high soil carbon demand, application and/or monitoring of organic matter, soil testing and stubble management (Hart et al, 2017). However, case study interviews showed that there is a growing consensus that soil quality (and especially SOC) is key for both mitigation and adaptation. In France, a political movement called Carbone four[60] has gained momentum and could lead to more ambitious soil management in the next programming period. For GAEC 4 (minimum soil cover) the Member States' definitions are more diverse, applying to all agricultural land, or only to sloping land, or only non-productive areas, and requiring soil cover all year or during winter only (mainly by crops, grass, stubble or spontaneous vegetation).

In the case of GAEC 2, which concerns compliance with authorisation procedures for irrigation water, this is mostly defined by Member States as a requirement to hold a permit for irrigation and, in some Member States, to have a water meter. The EU GAEC framework does not include any requirement to link the quantity of water used to the quantitative state of the water resource in the area, which would have been beneficial to avoid cases of maladaptation.

Overall, Member States have not tailored GAECs for adaptation purposes, so their potential is not fully used. Notably GAEC 2 concerning water management could be better tailored to improve resilience to water scarcity. Better integration of the Flood Directive and Water Framework Directive within GAEC could improve water management and increase resilience to climate change. However, one issue concerning water management and climate change is that the Water Framework Directive (2000) does not integrate climate change challenges and emerging issues on water quantity management.

[60] See http://agriculture.gouv.fr/4-pour-1000-et-si-la-solution-climat-passait-par-les-sols-0

Concerning the EIP, the positive effects in strengthening the AKIS (Agricultural Knowledge and Innovation Systems) in respect of adaptation-related issues has been examined in ESQ6 (Innovation).

Concerning the FAS, although the measure does not have a budget *per se*, but Management Authorities can choose to use M2 in their RDPs to support setting up farm advisory services and also to support farmers making use of them. According to an EC report in 2010[61], 25 Member States decided to contribute to the costs of one-to-one advice (ranging from 20% to 100% of full costs) through RDPs. The measure supporting farmers' use of advisory services was planned in 20 MS, covering 1,123,000 farmers, with a total budget for 2007-2013 amounting to €870.5 million (0.6% of total public expenditure on rural development). The measure supporting the setting-up of management, relief and advisory services was planned by seven Member States, with four Member States (ES, MT, PT, IT) clearly focusing on FAS. The 2007-2013 budget amounts to €172.9 million, 0.1% of total RD public expenditure. For the current programming period, the administrative burden linked to the measures M1 and M2 did affect the uptake of these measures (see Annex 4).

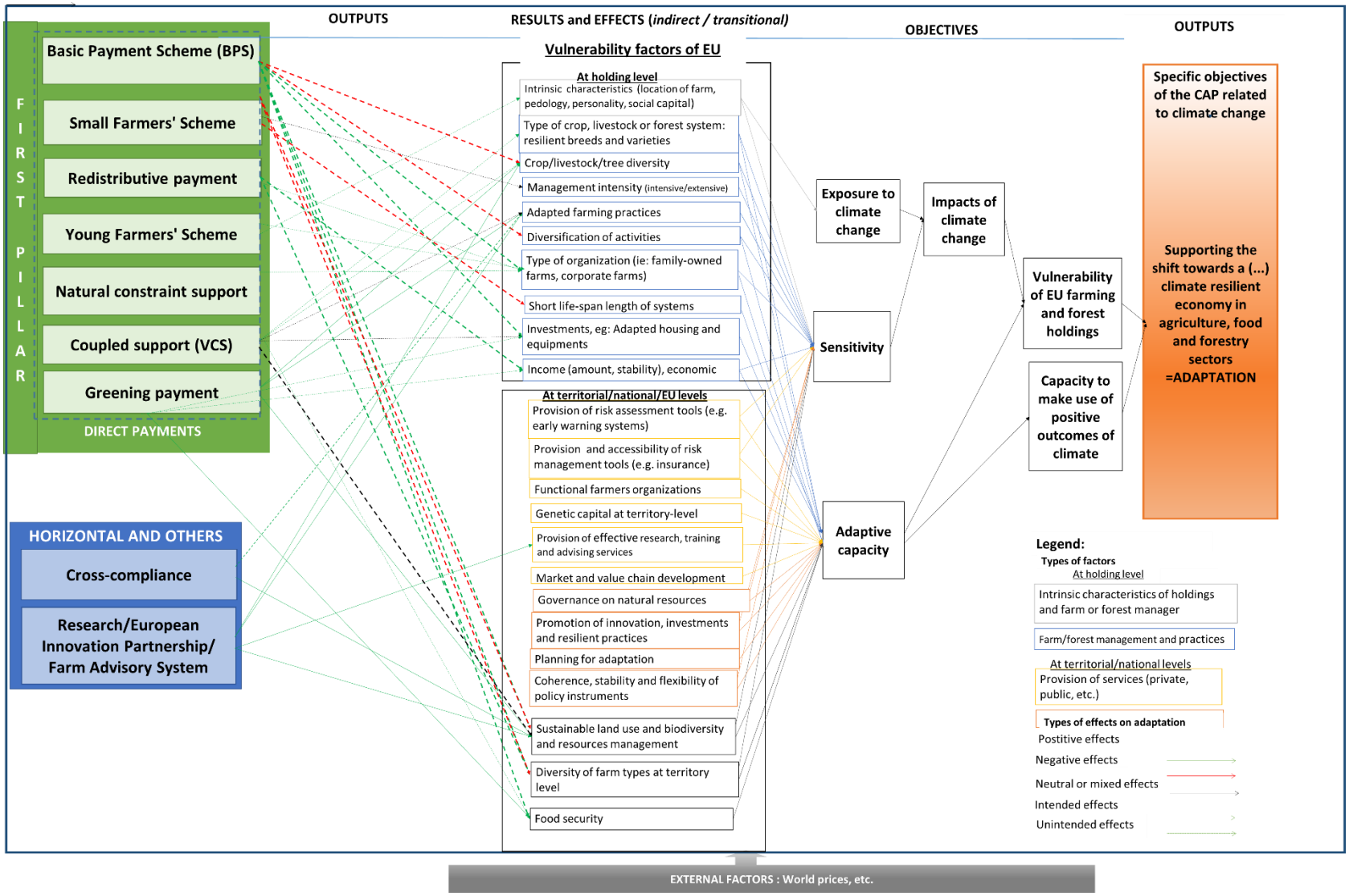
Hence, even though the measure did not target climate change adaptation before 2014, it did support the implementation a Farm Advisory Service in some Member States (ES, MT, PT, IT), which now may enable the development of climate adaptation training and advisory services. However, the consideration of climate change in the topics addressed in advice and training varies among case study Member States (see Annex 4).

In conclusion the main positive and negative, intended and unintended, (qualitative) effects of the CAP first pillar and horizontal measures are presented in the scheme below. These effects and the literature review on which are based these conclusions are also presented in Annex 4. Effects on adaptation could not be quantified in the scope of this evaluation. They can be summarized as follow:

- The First Pillar and Horizontal Regulations have positive effects on the adaptation of EU holdings as well as on territories and EU society as a whole, for example on the strengthening of EU AKIS (EIP, FAS) and on the maintenance of sufficient diversity among farming systems. However, these positive effects on adaptation could be much greater, and achieved more efficiently, if they were designed through an adaptation lens.
- Unintended effects prevail, since none of these CAP measures have explicit climate objectives.
- There may be also cases of CAP measures that may lead to possible cases of maladaptation. However, these are always very specific to a given environmental and socio-economic context and no generalisations can be made concerning maladaptation. These are always formulated as 'possible cases of maladaptation' since this will also depend in the end on the 'real' climate impacts that will affect these areas. Today these effects are estimated in the scientific literature through different scenarios, hence a level of uncertainty.
- Some missed opportunities can be underlined: there have been low budget shares dedicated by MS to the Young Farmers Scheme although the generational renewal is essential for adaptation and overall sustainability of the EU agriculture; the limited level of DP redistribution by MS do limit the relevance of these payments to adaptation (e.g. in limiting the excessive specialization of EU farming systems, driven mainly by competitive pressure).

[61] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0665:FIN:en:PDF

Figure 18: Map of the CAP Pilar I's outcomes on adaptation of EU farms and forest holdings and EU society to climate change



10.5.3 EFFECTS OF THE SECOND PILLAR'S MEASURES ON ADAPTATION

The assessment of RDPs shows that allocations to adaptation were not consistent between RDPs and, since RDPs themselves said little about how it was intended to address adaptation, transparency and comparability was low (COWI, 2017). Therefore, in order to understand to what extent RDPs have been used to address adaptation needs, the RDPs from the ten case study Member States have been scrutinised in order to determine to what extent measure design favours (or not) adaptation. This information has been complemented with case study interviews. Also, the budgets allocated to these measures and the use of this budget during the first years of implementation (2015-2016) have been studied for all Member States. One should note that even if a measure supports practices beneficial for adaptation, it also generally encompasses other practices or actions which are non-relevant, and that information on budget and uptake are not available at the level of different types of operation within a measure (due to the design of the monitoring and evaluation framework). As a result, the budget allocated to the adaptive measures is an overestimation of the budget allocated to adaptation.

The analysis considered RDP measures (in the scope of the evaluation) that had intended and unintended effects on adaptation, hence all the RDP measures except M9 Producers Organisations, M18 Complementary National Direct Payments for Croatia and M20 Technical Assistance. Managing Authorities are obliged to implement the agri-environment-climate measure (M10) and the LEADER approach (M19) but are free to decide how to design and use these and any other RDP measures to meet their national or regional needs.

However, it is important to note that the quantitative analysis of AIR data has been hindered by several data limitations linked to the database structure and its completeness:

- The analysis remains at measure level however the measure can comprise several types of operation that do serve adaptation, or not; hence all quantitative analysis may overestimate the contribution to adaptation;
- When looking at non-financial output indicators other than public expenditure indicators, the same area/beneficiary (or other unit) can be counted under several FAs and Priorities and therefore no additions can be done at measure level (except where the measures or sub-measure has been programmed under only one FA or just under the priority P4, e.g. M5, M10, M17, etc.); hence analysis of non-financial output indicators and result indicators could not be made when they targeted several FAs;
- There are three RDPs missing in both AIR and output target databases;
- There are no AIR data available for the following MA/MS for the year 2016: MT, SK, ES- Islas Baleares, FR-Martinique, FR-Poitou-Charente, FR-Aquitaine, FR-Limousine and HR;
- There are no output indicator data in the AIR database for the following MAs for the year 2015: ES-Madrid and ES-Valencia.
- There was no information in AIR data on output (area) for sub measures 10.2 and 15.2
- Other data for some indicators, Managing Authorities/Member States and year were missing. It was unclear from the database whether empty cells meant a null value or that data was absent.

10.5.3.1 RDP Soft measures (M1, M2, M16, M19)

The measures M1 (Training) and M2 (Advisory services) support the provision of knowledge transfer and capacity building services to farmers, services that are critical to enhance changes in farming practices and farms/forest management. In particular, training and exchange of experience and information between farmers and other stakeholders are deemed to improve the adaptive capacity of holdings (see literature review).

In most of the case study Managing Authorities (MA) climate change is mentioned as an objective of the measures M1 and/or M2 (DE, ES, FR, HR, HU, NL, LT, RO, see Box 13). In Lithuania especially, an order of the Ministry requires that adaptation to climate change and agri-environment issues are tackled in all new or reviewed training programmes. However, even though climate change adaptation is often mentioned as an objective of the knowledge transfer measures, it has been reported that most actions supported focus primarily on economic or other environmental subjects

(explanations regarding CAP environmental measures) rather than specifically on climate change adaptation (FR).

Also, the effects of the measures have been hindered by a low level of programming (ES, FR); also, there have been delays in their implementation (in DE, and RO). Indeed, at EU-28 level, for the measures M1 and M2 only 2.6% and 1.8% respectively of the financial target had been achieved in 2016. No farmers and/or foresters had yet been trained (under M1) in 15 of the 26 Member States where the measure had been opened[62] by 2016. In some Member States or regions there is no funding allocated to training activities beyond the RDP, so the implementation of these measures is of paramount importance to ensure that farmers are informed about climate change impacts and how to adapt to them (see Box 13).

Box 13: Implementation of knowledge transfer and capacity building measures in Romania and consequences for farmers' adaptive capacity

In Romania, the knowledge transfer and capacity building measures (M1 and M2) have been identified as key measures to enhance adaptation by farmers. Indeed, findings from the case study point out that Romania suffers from the lack of a fully functional Farm Advisory System (FAS) with, as a result, a poor understanding of the environmental benefits of measures among farmers. This also limits their awareness of climate change as well as their capacity to adapt. In spite of this well-known need for knowledge transfer and capacity building actions, the implementation of the measures is facing major delays. By January 2018, for measure M1, only one of the two sub-measures had been launched (M1.1) with one round of beneficiaries selected, while measure M2 had not been implemented at all by then. This probably largely limits farmers' adaptive capacity.

Source: Interviews in Romania

The main reason explaining the low level of uptake for the measure M2 is its complexity and the administrative burden its implementation entails, for both beneficiaries and Managing Authorities. It has deterred some managing authorities from opening it (various regions in FR, CZ and DE-Saxony-Anhalt). In CZ, the budget for M2 has been transferred to M1 for this reason. Interviews in these MS or regions pointed out that the measure would need substantial revision in order to make it easier to design and implement (see ESQ7). Indeed, according to EU framework rules, beneficiaries of the measure have to be selected in line with public procurement rules which limits the applicability of the measure. The Omnibus Regulation which came into force at the beginning of 2018 is intended to address these difficulties but, according to case study interviews it appeared too late for Managing Authorities/Member States to trigger significant changes before the next programming period. For instance, interviewees in France have reported that even with the Omnibus Regulation, the M2 measure will not be opened in most regions.

It has to be underlined that the organisation and funding of advisory services and training of farmers (including public/private provision, EU/national/regional sources of funds) is very diverse across Europe. In some Member States or regions, knowledge transfer and capacity building actions are funded from national, regional or private funds (FR and DE). In others, such as Spain or Romania, advisory services are financed mainly through EU funds, and there is no coordination at national level and little at regional level. In this context: 'The responsibility for combining contradictory requirements (competitiveness, environment, rural development) is most often put on the shoulders of individual farmers who are unequipped to deal with such complex issues' (Laurent and Labarthe, 2006). In the case of Germany, in Saxony-Anhalt (DE), the RDP stipulates that the private advisory services are sufficiently well developed and do not require support for service providers via the RDP. The decision not to support these measures is motivated by the wish to avoid dead-weight effects. However, one could argue that environmental issues are generally not given much consideration in the advice provided by sectoral advisers. Hence, in some Member States the lack of support and coordination of advisory services due to little national support and the non-implementation of M2 may be an important barrier to adaptation. The design at EU level of the measures supporting training and advisory services has to take into account the diversity of advisory services in Europe.

Moreover, in several Member States, one can observe a significant knowledge gap among farmers and/or foresters regarding climate change, which hinders the implementation of adaptive actions (for example, RO and LT, see Box 13 and Box 15). In these Member States, interviewees pointed out that farmers are overall not aware of their need to adapt. In Lithuania, it has been reported that farmers mostly rely on the State to help them in case of difficulties. They expect the State to keep paying for

[62] At least in one region in the case of regional implementation of the 2nd pillar.

the damage linked to extreme climate events (as it did in the Soviet Union period). As a consequence, Lithuanian farmers do not show much interest in adaptive actions.

Also, one challenge of these measures is to provide information in a form that will interest farmers. For instance, in Ireland where farmers have access to a strong publicly-funded farm advisory service, interviewees pointed out that they are overloaded with information related to climate mitigation and adaptation, as well as biodiversity and other environmental elements. According to the interviews a major challenge flagged for advisory services is to bring all of this information into a format that is understandable by farmers. The Managing Authority has issued (2017) a call for tenders to improve this.

Also interviews in Spain pointed to a lack of technical information and expertise from authorities in charge of environmental and climate issues.

The measure M16 (Cooperation) has a much broader approach than in the preceding implementing period (Dwyer et al, 2016). It can promote adaptation to climate change thanks to support for the elaboration and diffusion of innovative practices; better planning of resource management; and support for diversification of holdings' activities. M16 has been programmed by most Managing Authorities/Member States but only 2% of the financial target had been achieved by 2016 due to delays in its implementation. Some Member States used it to finance pre-existing structures, others launched specific calls to support partnerships. An example of use of the M16 for adaptation is the funding of the groups of farmers (GIEE) created in the Agro-ecology project in France (see Box 8 above). They promote collective experimentation and knowledge exchange, hence facilitating a transition toward more sustainable practices. M16 has been further studied in ESQ6, focusing on innovation.

Finally, concerning M19 (LEADER), which must be allocated least 5% of the EAFRD contribution in every RDP. Implementation is ongoing in several case study Member States (FR, HU, IE) and it is too early to assess to what extent supported projects can improve the resilience of territories or the agricultural sector to climate change. However, it can be noted that in Romania over 10% (4 out 36) of selected LEADER projects in 2016 addressed water use efficiency (construction, restoration, upgrading of local flood prevention and protection infrastructure). Also, a review of the supported LEADER projects under the previous programming period (2007-2013) across EU-28 showed that overall, climate relevant projects mostly focused on capacity building and energy efficiency, with a limited focus on more explicit adaptation activities (Frelih-Larsen et al, 2014). According to the study, Managing Authorities can further enhance the role of climate action in LEADER projects by providing technical guidance to LAGs and promoting experience sharing and knowledge exchanges. However, the information available does not indicate whether such actions have been undertaken for the present programming period.

10.5.3.2 RDP Investment measures (M4, M7, M8, M14)

Investment measures have a strong potential for climate change adaptation, since investment in equipment and infrastructures can enable vulnerable farms and forest holdings to adapt to climate change (see literature review). The measures that are linked to climate action in the Regulation are M4 and M8. They have both been implemented in most Member States and regions.

Support can be provided for a broad range of investments under M4, which could include those with direct impacts on climate change adaptation such as:

- improved resource efficiency at holding level (water efficiency, reduced soil tillage)
- storage facilities to increase water resource availability at holding level
- modernization of livestock production units (recycling water or improving ventilation of buildings)
- through sub-measure 4.4, promoting the creation of boundary features, woodlands and wetlands, thus improving resilience to climate change (see EFA measure).

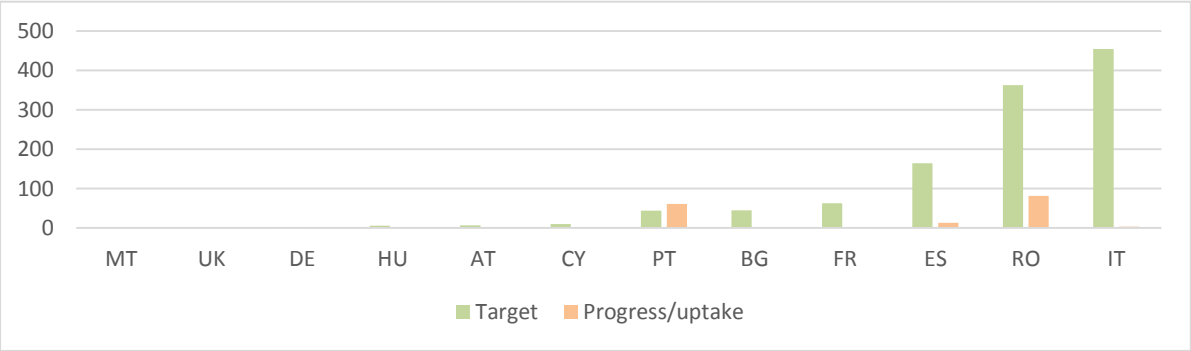
The M4 measure has been opened in most RDPs (111 out of 118) and accounts for more than a fifth of total public expenditure for RDP measures in the EU by 2016. All the case studies Member States or regions include support for adaptive actions under M4. In particular, sub-measure M4.1 (physical or non-physical investments) is the main sub-measure highlighted as relevant to climate change adaptation by case study Managing Authorities. Indeed, under this sub-measure, the following investments can be supported: irrigation systems, water storage infrastructures, hail protection, conservation tillage equipment, pasture management equipment, housing for livestock (for animal

welfare), and improved on-farm roads. The implementation data show that 6% of the financial target had been achieved by 2016 at EU-28 level, but this can include investments relevant to climate change adaptation as well as other investments. The level of implementation (in terms of budget spent compared to the target) is slightly higher for sub-measures 4.1 (investment in physical assets) and 4.3 (investment in equipment and infrastructure) at 7.2% and 7.6% respectively; these sub-measures have considerable potential to support adaptive investment such as efficient irrigation systems and water storage facilities.

In most case study Managing Authorities (9 out of 10), M4 is likely to have had some effects on farmers' adaptive capacity. The only exception is Lithuania where interviewees reported that the investments financed were mostly aimed at improving farm profitability rather than adaptive capacity (e.g. acquisition of tractors, planting machines, fertilizer sprayers, combine harvesters, grain cleaners and dryers, storage towers, etc.).

Water-related issues (water scarcity, droughts, floods) are among the effects of climate change with greatest impact (IPCC, 2014). Regarding water resource management, M4 has a high potential in most case study Member States since it supports some investments which improve efficiency of water use for irrigation (all case study Member States except CZ where problems of governance of water sources have been reported). However, some interviewees reported that, in some cases, the administrative burden and constraints linked to the Water Framework Directive deterred farmers from applying for such investments (in DE-ST and HU). Implementation data (AIR) highlight that in most Member States/Regions where the measure includes specific support for investments which allow saving water (more efficient irrigation systems etc.), the target for such investment is far from being reached (one exception is Portugal where the target of 43,921 hectares has already been overachieved).

Figure 19: Area (1,000 ha) concerned by investments for saving water (target and progress) in 12 Member States[63]



Source: AIR data 2015-2016

However, one issue in the programming of M4 for adaptation is the level of targeting. Interviewees in Spain (Andalusia) pointed out that the modernisation of irrigation systems improves the capacity of farmers to cope with droughts, but it may also lead in some cases, in the long run, to maladaptation in areas where the water resource is already depleted (as a result of increasing water demand with increases in irrigated areas, rather than changes in cropping patterns in these regions).

Indeed, even though irrigation can reduce a farm's sensitivity to climate change in areas with low precipitation, it increases pressure on water resources and therefore increases the sensitivity of the area in which the farm is situated (Reidsma et al, 2009). Therefore, short-term adaptation at farm level may eventually result in maladaptation in the long-term. In some EU regions that are already facing water scarcity, such as southern Europe, increasing the supply for irrigation may not be a viable option since expectations are for a considerable reduction in rainfall and hence reduced replenishment of water supplies (Olesen et al, 2011). For example, the important expansion of irrigated orchards has increased significantly the pressure on water in the upstream Guadalquivir basin (Salmoral et al, 2011).

Also, there is no requirement in the CAP Regulation concerning the subsequent use of the quantity of water saved, and therefore it can still be used by farmers to extend the irrigated area or for double

[63] No target has been set for the other 16 Member States.

harvests rather than securing the resource for well-functioning ecosystems or for other uses. The EAFRD Regulation Article 46 only mentions the need to support more efficient infrastructures but does not detail how to use the water saved. In addition, modern infrastructures and/or equipment (modern irrigation systems) often have a large energy consumption with substantial GHG emissions. This was the case in Andalucía for the CAP 2007-2013 but not in the current period as the MA is now funding only energy-efficient technologies.

Also, some negative effects on adaptation of M4 have been reported. For example, support for high cost investments (heavy machinery) can potentially lead to a high level of specialization of farms (in order to achieve economy of scale) and can lock farmers into specific systems that are more challenging to adapt. Farmers who are financially weakened by heavy investments are also more vulnerable to shocks. In Lithuania, the farmers who obtain support under M4 must achieve indicators from their investment plan even if the market situation has changed (Russian ban on importation of EU food products), which limits farms' flexibility and therefore their capacity to adapt.

Some managing authorities have implemented specific selection criteria in order to favour investments benefiting sustainable land management and/or promoting resource use efficiency (FR-Aquitaine, HR, CZ, HU, DE-ST) (see Box 7 above). Furthermore, in several Member States projects supported under sub-measure M4.3 must comply with the Water Framework Directive to be eligible (DE-ST, FR-Aquitaine, HR, HU and RO).

Furthermore, the measure can be designed in order to support collective investments, which allows spreading of the financial risk among the users, enhances collaboration among farmers and often favours knowledge transfer. For instance, in Andalusia (ES), collective investments are preferred over individual ones for sub-measure M4.4. Furthermore, the measure can support various actions for water resource management (efficient irrigation systems, water storage facilities, etc.). The literature review has highlighted that the collective management of resources favours their sustainable use and therefore favours the adaptive capacity of holdings and territories. Taking into consideration this aspect, French authorities have decided that, starting from 2015, only the catchment areas with a territorial project involving all users of the water resource can obtain funding from the Water Agency for the construction of water storage[64] (see Box 14). Also, in Andalusia (ES), under M4.3 only irrigating communities can be supported.

Box 14: Territorial projects for quantitative management of water resource in France

In river basins affected by a structural deficit of water, territorial projects for quantitative management of water allow stakeholders to act collectively in order to achieve a sustainable management of the resource. These projects must include an assessment of water needs for all the activities of the territory (drinking water, tourism, fisheries, agriculture, energy, industry, etc.) and then define a timetable to achieve quantitative equilibrium of the resource. Territorial projects are based on dialogue between the different stakeholders and users of the territory. Since 2015, only the catchment areas with a territorial project can obtain support from the Water Agency and the Regions (including through RDPs) for the construction of infrastructure for water storage[65]. This limits the risk of maladaptation since the territorial context and the needs and position of the different stakeholders are taken into consideration in the decision process. However, it has to be stated that up to now no water storage project has been approved; there is currently in France a societal blockage of all water storage projects.

Sources: Interviews in France and conferences during the Water Seminar in Toulouse (December 2017)

One exception is in Hungary where support for water retention actions is eligible only in areas officially recognised as having surplus water. Such use of selection and eligibility criteria to target specific areas, farming systems and/or investment type is beneficial and an efficient means of encouraging climate change adaptation and could be further used by managing authorities.

The sub-measure 4.4 supporting non-productive investments linked to the fulfilment of agro-environmental and climate objectives has also been used for climate adaptation. For example, in Andalusia (Spain) it was used in the last programming period to invest in infrastructure to combat erosion (gullies), and for the current period it is used to finance crushing machines for vegetable waste that contribute to an agri-environment-climate scheme to help to prevent soil degradation (green manure), or collection centres for vegetable waste to produce compost.

[64] http://circulaire.legifrance.gouv.fr/pdf/2015/06/cir_39702.pdf

[65] http://circulaire.legifrance.gouv.fr/pdf/2015/06/cir_39702.pdf

The measure M8 (forest management and investment) can support a wide range of actions beneficial for adaptation and covers similar potential climate benefits to M4 and M5, but for forests. More precisely: through afforestation (M8.1) it can provide a sustainable use of former agricultural land that would become marginal because of the effect of climate change: support agroforestry (M8.2): improve forest resilience through improved risk mitigation (pest control, fire prevention, restoration) (M8.3 and M8.4); and improve the resilience of forests to climate change (introduction of adapted species, mixed stands etc.) (M8.5).

As is the case with M4, M8 has been programmed in most RDPs (102 out of 118).

In most case study Member States where the measure has been implemented (7 of the 8), the measure is likely to have had some effect on farmers' adaptive capacity. For instance, in Aquitaine (FR), and in Andalusia (ES) sub-measure 8.3 (promoting fire protection), has been widely used to build infrastructure to mitigate fire risk; it is much less used to promote preventive actions (planting of resilient species, etc.). As a result, today the fire protection infrastructures are quite effective in the region, according to interviewees. Spanish agroforestry systems (which can be supported under M8.2) are mostly agro-silvo-pastoralism systems called dehesas. These extensive systems allow the production of a high-value product (ham), avoiding abandonment and hence improving the resilience of the territory to fires and desertification, which are the main threats from climate change in Andalusia (Moreno and Pulido, 2008) (Garrido et al, 2017).

Concerning **M7 (basic services and village renewal) and M14 (animal welfare)**, these have no intended effects on adaptation according to EC Regulations (see Table 1) but have been used by some Managing Authorities to support some adaptive practices and/or actions. For instance, M7 may support various actions such as the maintenance of pastoral activities[66] (in Aquitaine in France), which are considered resilient to climate change[67], or drawing up or updating strategic and planning documents which address climate adaptation (in Croatia).

M14 can potentially support the improvement of the infrastructure of livestock holdings, taking into account climate change impacts (installation of ventilation systems to reduce the impact of heatwaves on livestock, etc.). However, among the five case study Member States where this measure has been implemented this measure has been found relevant to climate change adaptation only in Ireland.

10.5.3.3 RDP Risk management measures (M5, M6 and M17)

Measures M5 and M17 aim at supporting holdings' resilience to climate change through improved risk reduction and management. M5 supports preventive actions (e.g. the measure 5.1 supports investments in drainage systems in northern regions where more rain is expected in the coming years) as well as restoration after damage in order to improve the resilience of farming systems to climate change (through 5.2). M17 supports risk management, through insurance schemes, mutual funds and an Income Stabilisation Tool (IST), improving resilience to shocks linked to the impact of climate changes (increased incidence of climatic hazards and price volatility, etc.)

Measure M6 supports the diversification of activities on agricultural holdings. Even if it is not a risk management measure *per se*, diversification of activities contributes to reducing risk and can be seen as an option for managing risk at holding level. It has been programmed in 97 RDPs, and specifically supports the development of non-agricultural activities (M6.2 and 6.4) in 79 RDPs.

Despite well-known needs for such actions to adapt to climate change (see literature review), these measures have been opened in a minority of Management Authorities and represent a limited share of total public expenditure at EU-level (with the exception of FR[68]).

Concerning **measure M5**, at EU28-level, only 67 farms and 1052 public entities have been supported under the sub-measure M5.1 (preventive actions). However, for the whole measure (for preventive as well as restoration actions) over €284 million had been spent by 2016, which represents 13.5% of the

[66] To a certain extent, mobility-based farming systems allow the maintenance of farming activities in less productive areas and thereby compensate for climate change effects (Martin et al., 2014).

[67] https://cordis.europa.eu/result/rcn/170946_en.html

[68] In France, €600,750, which represents 97.85% of the national framework RDP budget, has been allocated to the measure. However, one should note that it is one of the only measures implemented at national-level, the other RDP measures being mostly funded under regional RDP budgets (which explains why M17 represents a very large share of budget for the national framework RDP).

programmed expenditure for the whole programming period. According to analysis for the case study Management Authorities, M5 has probably contributed to reducing the vulnerability of some farmers, foresters and/or territories in Saxony-Anhalt (DE) and HR where some adaptation-relevant projects have been funded. In Hungary, the implementation of the measure is still ongoing, and the only project funded so far is a country-wide hail protection scheme with almost 1,000 ground-based cloud seeding generators[69]. However, the project has not become operational yet and therefore no effects of the measure can be observed at the moment.

The measure M17 can support crop, animal and plant insurance premiums (M17.1), the creation of mutual funds for adverse climatic events, animal and plant diseases, pest infestations and environmental incidents (M17.2) and the implementation of an income stabilization tool (M17.3). These improve farms' resilience to extreme events. Insurance and mutual funds decrease the risk of climate-related income losses and spread exposure to climate-related risks by sharing financial risk across stakeholders. It may also have adverse effects on adaptation, by promoting risk-prone behaviour by farmers who feel protected. This perverse effect can be avoided through risk-based premiums which can incentivize individual farmers to change their practices and reduce their risk (Smit and Skinner, 2002). The low level of programming for M17 can be explained by the fact that some Member States already had pre-existing risk management instruments (ES) (Dwyer et al, 2016), and by the low level of uptake by farmers of such risk management tools (see below). Managing Authorities tend to avoid measures that may lead to the under-use of resources.

At least one risk management tool is available in the RDPs of Italy, France, Romania, Portugal, Hungary, Croatia, the Netherlands, Lithuania, Latvia and Malta, and of two regions: Castilla y León and Flanders. Insurance premia are expected to receive €2.2 billion (M17.1), while the amount is €357 million for mutual funds (M17.2) and €130 million for the Income Stabilisation Tool (M17.3). However, although CAP support to agricultural risk management has increased compared to the previous programming period, its share in the whole CAP budget remains very low, as it represents only 2% of the Pillar II budget and 0.4% of the total CAP budget for the 2014–2020 period (Dwyer et al, 2016). There are also large differences in the share of farmers potentially covered by these measures (Castaneda-Vera and Garrido, 2017). It has to be noted that due to the low level of implementation of the Income Stabilization Tool (M17.3), the Commission reviewed its design, which was amended in the Omnibus Regulation of 2017[70].

As for implementation, under the sub-measure M17.1, 62,836 farms (less than 0.1% of EU farms) have received support for insurance premia in EU28 (FR accounting for 86% of these) in 2015 and 2016, which represents 30.2% of the target for the period 2014-2020 (at EU-28 level). In terms of overall effects, according to case studies' analysis, measure M17 has probably contributed to a reduction in the vulnerability of some farmers, foresters and/or territories in NL and HR, while in HU and Aquitaine (FR) it may have contributed to a reduction in vulnerability at farm level. In Hungary, without support for the premia, farmers have a low willingness to pay for insurance against the risks of drought and flooding, in spite of the high level of damage caused by these adverse climatic events. However, improved knowledge and trust among farmers regarding insurance products could possibly further improve uptake (Kemény et al, 2012). In Aquitaine (FR), it can be noted that horticultural farms applying for investment support under the measure M4.1 must be covered by multi-risk insurance; this is a way of promoting insurance uptake.

In Lithuania and Romania, the measure had no or a limited effect on farmers' vulnerability over the period. Indeed, the measure has not been implemented yet in RO. In LT, uptake of the measure is too low to show significant impacts (1450 farmers, 0.75% of all farmers, in 2015 and 2016[71]). In 2017, 465 applications were submitted[72]. According to interviews, farmers in LT expect the State to support them in case of extreme climate events (as it used to do in the Soviet period) and therefore are not interested in protecting themselves against climate related impacts (see Box 15).

[69] Cloud-seeding generators are devices which allow the users to change the amount or type of precipitation that falls from clouds. These can be used in agriculture to suppress hail (or make it smaller).

[70] Regulation (EU) 2017/2393 of the European Parliament and of the Council of 13 December 2017.

[71] According to AIR 2017

[72] According National Paying Agency data collected during the case study.

Box 15: The historical drivers of the low uptake of crop insurances in Lithuania

In the soviet period in Lithuania, the State used to compensate losses related to climatic conditions. If farms were affected by adverse climatic conditions, the Ministry of Agriculture would step in, calculate losses and ask for additional funds from the State budget. Since then, several crop insurance schemes have been developed, but on the other hand the State kept providing compensation to farmers in case of adverse climate conditions, which hampered growth in crop insurance. Indeed, since free compensation was available from the State, farmers showed little interest in paying insurance premia. Furthermore, the farmers who took out insurance only insured the riskiest crops in the riskiest fields. As a consequence, crop insurance services turned out to be unprofitable.

Nowadays, the State still provides compensation to farmers during the most extreme events. For instance, in 2006, when a drought seriously damaged crop yields, farmers received compensation from the State at a total cost of more than 100 million Litas (about €30 million). Following this event, the Ministry of Agriculture took the initiative to support the establishment of a new crop insurance system, and the German insurance company Vereinigte Hagelversicherung VVaG started its operations in Lithuania as 'VH Lietuva'. However, the majority of farmers are still not interested in taking any action to reduce the vulnerability of their businesses to climate related risks or climate change in Lithuania.

Source: Interviews in Lithuania

Indeed, the presence of ad-hoc government compensation not tied to insurance coverage in the case of extreme events hinders the performance of insurance schemes. Also, to ensure effective reduction of risks, insurance premia need to be coupled with requirements for preventative and risk-reduction action (Ramboll and IVM, 2017).

As for mutual funds, interviews showed that, in Lithuania, the effects of the measure are significantly hindered by social barriers. Indeed, farmers are reluctant to participate in collective actions such as mutual funds. A targeted information campaign would be necessary to ensure a clearer perception of the activities of the mutual funds and their potential benefits.

In CZ, risk management was identified as an objective in the adaptation plan in 2015. Indeed, there is no insurance available to farmers for some risks (impacts of drought), nor mutual funds. However, the measure M17 has not been programmed in the RDP. Indeed, after extensive discussion with key stakeholders, it was concluded that the measure would not be implemented due to institutional barriers and a significant lack of will among farmers.

Support for the Income Stabilisation Tool (IST) has been programmed in only three Member States or regions (Hungary, Castilla y Leon (ES), and Italy). The IST works as a mutual fund protecting against falls in income. The rate of support is up to 65 % of the eligible costs of the mutual fund[73], but payments to farmers must compensate no more than 70 % of the lost income in the year the producer becomes eligible to receive this assistance. The effects of this sub-measure have been studied for the region of Castilla y Leon (Castañeda-Vera, 2017). The study showed that even if direct payments and crop diversification are the most effective measures in reducing income variability (due to the annual costs for farmers linked to IST and crop insurance), using crop insurance or an IST has potential for both improving farm resilience to income variability and limiting public expenditure. Indeed, the study found that direct payments are clearly the most expensive tool among the three considered in the study (crop insurance, IST and direct payments).

As for measure M6, 3.6% of the financial target was achieved by 2016 and support has been granted to no more than 965 beneficiaries[74] for the development of non-agricultural activities (M6.2 and 6.4). The RDPs supported much less off-farm diversification than in the preceding implementing periods (Dwyer et al, 2016). Therefore, the measure is unlikely to have significantly enhanced the diversification of activities across the EU. However, the measure also includes support for young farmers (under the sub-measure M6.1). Case study interviews and the literature review have shown that young farmers are more prone to adopt new practices and technologies taking into account sustainability issues such as adaptation to climate change and more generally sustainable

[73] Articles 36 and 39 of the Regulation (EU) No 1305/2013.

[74] Because the measure has been programmed under several Focus Areas there is a risk of double counting in the AIR data (because one beneficiary can be declared under several FAs). Therefore, this number could be an overestimation of the actual number of beneficiaries.

management of resources (Scherer, Verburg and Schulp, 2017). The sub-measure has been programmed in 80% of EU28 RDPs and 16,069 beneficiaries have been supported across the EU. Therefore, the payments granted to young farmers under the sub-measure 6.1 may also to some extent have benefited to the adaptation of the agricultural sector, provided that the farmers concerned are sufficiently aware of climate change impacts and opportunities (for instance through knowledge transfer and capacity building actions).

10.5.3.4 RDP land management measures (M10, M11, M12, M13 and M15)

Some land management practices can improve the resilience of forest and farming systems through effects such as improved soil structure (and therefore limited soil erosion and improved water retention capacity), improved water use efficiency, increased biodiversity and enhanced benefits from ecosystem services, etc. (see literature review). Among RDP land management measures, two measures have intended effects on climate change adaption: M10 and M15 (climate adaptation is cited in the EC Regulation). However, even though the measures M11 and M13 are not intended to have impacts on climate change adaptation, they have been allocated significant budget in most MS/MA and can have significant unintended adaptation impacts for some farming systems.

The Agri-environment-climate Measure (AECM) M10 has diverse potential effects on adaptation:

- M10.1 may improve farms' and more generally society's resilience by establishing areas of semi-natural vegetation and landscape elements, and by promoting practices that improve water retention in soils, limit soil erosion, improve resilience to floods, etc. For instance, cover crops, crop diversification, improved management of landscape features, zero tillage, increased use of forage crops, etc. are some examples of practices that can be promoted by this measure and which can, in certain circumstances, be beneficial for adaptation.
- M10.2 may improve resilience thanks to the conservation, use and development of resilient varieties (more resilient to droughts).

However, in case study Member States and regions, most AECMs have been designed to address biodiversity and environmental objectives rather than climate change adaptation (in ES, FR, HU, IE[75], NL and RO[76]). The officials interviewed in France and Spain, for example, assumed that actions beneficial for broader environmental challenges are also positive for adaptation. However, in all case study Member States at least one AECM scheme promotes adaptive practices. Interestingly in France some AECM required action at the level of the farming system, encompassing bio-physical, agronomic and socio-economic aspects of the system (pastoral systems, mixed farms, major cereal producers etc.). This is an approach which appears relevant to addressing adaptation challenges.

The area under contract in 2016 under the sub-measure 10.1 is presented in Figure 20. This area under contract is notably large in the UK compared to the other Member States. In Croatia and Malta, the measure had yet not been implemented in 2016 (no contracts had been funded according to AIR data). In France, the implementation of the measure has been partially hindered by budget reductions which may discourage farmers to apply for such measures in future years, according to interviewees. Furthermore, according to interviews, some of the less demanding measures have been dropped and the level of constraint of the remaining measures is a deterrent for most farmers.

Assessing the effects of the measure on climate change adaptation is challenging, as most Member States have offered a wide range of AECMs pursuing several objectives, among which climate change adaptation is just one.

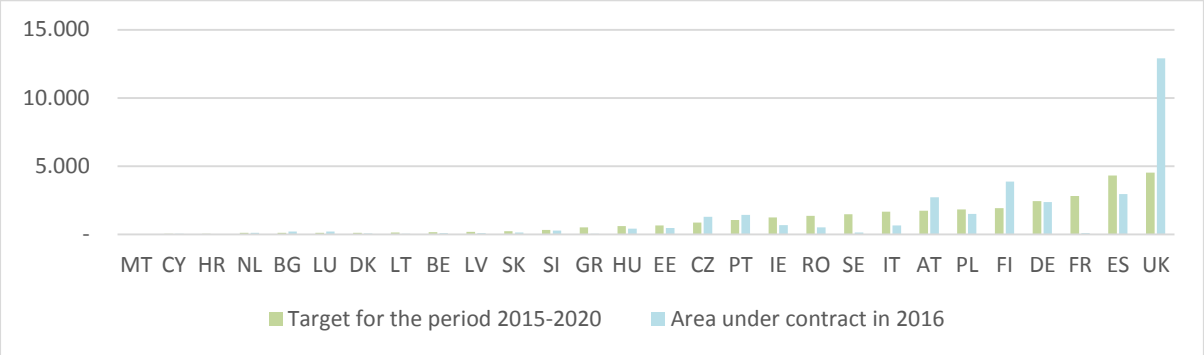
As for the sub-measure 10.2, in spite of its potential to improve the resilience of the agricultural sector at territory-level, it has not been possible to assess its effectiveness. Indeed, there is no data about its implementation available in the AIR database[77]. Also, as it is not a major measure in terms of budget or number of beneficiaries, its effects have not been much commented on during interviews.

[75] Especially the GLAS AECM scheme.

[76] In Romania, only one AECM out of 11 is relevant to climate change adaptation.

[77] Except for the total public expenditure for M10, which includes sub-measure 10.2.

Figure 20: Area under AECM (M10.1) contract in EU28 (1,000 ha)



Source: AIR data 2015-2016

Overall, the AECM measure has potential to engage farmers in new practices beneficial in the context of climate change. But to be more effective for adaptation they should tackle specifically the main climate challenges, and those are most often location-specific. However, the review of RPDs in the case study Member States showed that overall the AECMs relevant to climate change adaptation are not specifically targeted at areas impacted by climate change. One exception is a new AECM in Romania which promotes drought-resistant cropping systems (see Box 16). Thus, the effectiveness and efficiency of AECMs in fulfilling adaptation objectives could be improved through better targeting and tailoring for adaptation.

Box 16: Pilot measure for the promotion of drought resistant cropping systems in Romania

In Romania, M10 is implemented via eight sub-measures or so-called packages, one of which targets climate change adaptation. It includes a pilot measure aimed at smaller arable farmers to promote more drought-resistant cropping systems in 71 designated local authority areas (UATs) in southern Romania where around 900,000 ha of arable land is considered most at risk from drought and desertification. The package aims to promote the use of more drought-resistant crops, varieties and hybrids; the diversification of crop rotations is meant to spread the risk of crop damage due to water scarcity, and the use of minimum tillage techniques is meant to improve soil moisture.

However, the uptake of this innovative AECM has been very limited with only one applicant registered in 2017. The package is currently being reviewed by the Managing Authority by a) modifying the maximum eligible area of 10 ha of arable land (it seems that many farmers with greater than 10 ha are interested), and b) by taking into account concerns from the European Commission that there is some risk of overlap with the crop diversification requirement under greening.

Source: Interviews in Romania

It has also been reported that, under AECM, the effort of changing practices and systems falls mainly on producers whereas the whole value-chain should be involved. Some stakeholders advocate for a co-funding of AECM by other actors in the value-chain to reach the higher amounts needed to incentivize changes of practices, while others advocate payment for results, the challenge being in that case how to measure results. Results-based payments are already being trialled in some Member States (Keenleyside et al, 2014).

Concerning M15 (Forest-environmental and climate services and forest conservation), the eligible actions can improve climate resilience and help to protect the carbon content of forest soil as well as improving the overall forest carbon sink and its sequestration potential. The design of this measure by MAs supports adaptive actions in five of the case study RDPs (DE-ST, CZ, HU, RO, SP-And). More precisely, in the case study Member States and regions, the main actions relevant to climate change adaptation targeted through this measure are: the use of traditional mechanical techniques to collect/extract cut timber; planting species beneficial to forest environment; harvesting mature non-native species (DE-ST); conservation of genetic resources (HU); and knowledge transfer (HU). However, the measure has not been implemented yet in Romania. Overall, at EU28 level, 1,398,106 ha have been engaged in forest-environmental and climate commitments (sub-measure 15.1) representing broadly 0.9% of forests and other wooded land in the EU. The majority of the area supported is in the UK, where broadly 50%[78] of the forest and wooded area is involved. In the

[78] Source of data: AIR data and (Alliance Environnement and EFI, 2017)

other Member States, the measure has either not been implemented or the area supported represents less than 0.5% of forest and wooded land. Therefore, uptake data indicates that so far the potential benefits of this measure for forest resilience will mainly be in the UK. As for the sub-measure 10.2 (see above), the data and information available did not allow the evaluation team to assess of the effectiveness of the sub-measure 15.2 specifically (supporting the conservation and promotion of forest genetic resources).

The **measures M11** (Organic farming), the **M12** (Natura 2000 areas and Water Framework Directives) and **M13** (Areas under Natural Constraint) are not intended to have effects on climate change adaptation. However, RDP analysis and case study interviews showed that they can have positive unintended effects on farmers' vulnerability. Indeed, organic farming systems supported by M11 have a strong potential for building resilient food systems in the face of uncertainties, mainly through farm diversification and improved soil quality; furthermore, organic agriculture offers alternatives to energy-intensive inputs such as synthetic fertilizers which are likely to be affected by rising energy prices (Scialabba and Müller-Lindenlauf, 2010). Overall the uptake of the measure is high, covering broadly 6 million hectares[79] (for both conversion and maintenance) in 2016, which is to say 57% of the target for the whole programming period. Indeed, the area under organic certification has greatly increased since 2013 due to an increasing number of applications. This change had not been anticipated by most Management Authorities. Some Member States or Regions had to increase the budget planned for the period, most regions in France, DE-ST, HR, by reallocating funds programmed for M10 or other measures, or by decreasing the support rate/ha, or by cancelling support for maintenance (11.2) to finance conversion (11.1); payments have been delayed in some cases (in France). Therefore, the measure is likely to have had positive effects on adaptation, but these effects have been hindered in some cases due to an underestimation of organic farming growth in some MS.

The measure M12 (Natura 2000) might contribute to territorial adaptation through the protection of biodiversity and wetlands (in DE-ST, CZ, FR-Aquitaine, IE and LT).

As for measure M13 (ANC), it may contribute to climate change adaptation in some specific situation, for example by supporting production in grass-based systems in areas where the production cannot be intensified. In doing so it limits the abandonment of land which can lead to higher fire risk. Also, grass-based livestock breeding is in some areas the only productive activity that can be implemented in these harsh areas (arid, mountainous areas) since it is more resilient[80]. The mobility of pastoral systems allows a good adaptation to harsh and changing conditions since animals can move in function of the climatic conditions. Importantly it maintains a diversity of products, farming systems and habitats (including grassland) that is deemed important for adaptation at a higher level (territories, EU society) (see literature review). In that sense it mitigates the ongoing concentration of livestock. However, the potential effects are highly dependent on the biophysical criteria used for the delimitation of the areas facing natural constraints. In most case study Member States, interviewees pointed out that the measure contributes to the maintenance of grasslands (DE-ST, ES-And, FR-Aqu, HR, LT, RO). However, overall climate change constraints have not been included as a criterion to define eligible ANC areas in the Regulation (except for the selection of mountainous area). One exception is the Czech Republic where, starting from next year, the targeted area will be extended in order to include areas facing climate constraints and to prevent land abandonment due to climate change effects (especially drought). Also, the measure is currently seldom tailored to ensure that it supports systems that are either 1) resilient to climate change but are economically vulnerable due to their lesser economic profitability when compared to intensive systems, or that 2), for non-resilient systems, it supports adaptive activities (improvement or change of farming systems, or even exit strategies when necessary). However, M13 has been considered by the tracking methodology as relevant for climate action and is one of the measures that counts towards the 30% of the EAFRD contribution ear-marked for specific environment and climate related measures, in all RDPs. M13 budgets represent at EU28 scale 16% of public expenditure for RDP measures and many MS and MA achieved most of the target (in the case of FR-Aquitaine all of it) with the M13 budget. Considering that effects on adaptation remain very uncertain and rely on biophysical criteria, it does not appear

[79] 5.88 million ha under P4 and 5.97 million under all priorities (but there is a risk of double counting in the number concerning all priorities)

[80] https://cordis.europa.eu/result/rcn/170946_en.html

appropriate that M13, as it is designed now at EU level, should count towards the 30% EAFRD allocation for environment and climate related measures.

In conclusion, Table 34 presents the main results of the analysis of the potential effects on adaptation of RDP measures in the case study Member States, through combining information on 1) potential impacts, 2) levels of programming and 3) the levels of uptake in 2016. In reality the effects will depend on (uncertain) future climate change impacts, and hence on environmental and socio-economic contexts.

It shows that almost all RDP measures can have potential effects on adaptation but that their effectiveness in responding to adaptation challenges would be improved by improved tailoring and targeting.

Table 34: Potential effects of RDP measures on farmers, foresters and/or territories vulnerability to climate change in case study Member States

RDP Measures	% of EU28 RDPs in which the measure is open	# case study MAs (10) where the measure may support adaptive actions	% public expenditure for RDP measures at EU-level	Target achievement in 2015-2016[81]	'Potential effects on holdings adaptation at EU28 level
M1 Knowledge transfer	93%	9 (all but DE-ST)	1.18%	2.6%	*
M2 Advisory Services	79%	7	0.89%	1.8%	*
M3 Quality Schemes	55%	2	0.42%	2.0%	0
M4.1 Investment in physical assets	99%	all	21.87%	6.0%	**
M4.2 Investment for on-farm food-processing		2			**
M4.3 Investment in equipment and infrastructure		8			**
M4.4 Non productive investments		6			**
M5.1 Prevention of natural disaster damage	39%	3	0.91%	13.50%	***
M5.2 Restoration after natural disasters		2			**
M6.1 Young farmers	87%	4	6.96%	3.10%	*
M6.2 New business in rural area		3			n.a.
M6.3 Investment in small farms		3			*
M6.4 Investment in non-agricultural activities		3			n.a.
M7 Basic services in rural area	87%	3	6.82%	3%	*
M8.1 Afforestation	91%	4	4.5%	16.6%	*
M8.2 Agroforestry		2		0.3%	*
M8.3 Protection of forest against fire and biotic and abiotic risks		5		6.9%	**
M8.4 Restoration after natural disasters		5		5.7%	**
M8.5 Environmental value of forests		7		4.6%	**
M8.6 Forestry technologies		3		4.0%	n.a.
M10 AECM	96%	all	16.83%	23.3%	***
M11 Organic Farming	94.6%	9 (all but NL)	6.67%	15.4%	***
M12 Natura 2000 and WFD	46.4%	5	0.54%	15.3%	**

[81] Total public expenditure in 2015-2016 compared to 2020 target. This table presents financial data rather that area supported or number of beneficiaries due to the data limitations explained in the section 10.5.3. Indeed, when looking at non-financial output indicators (i.e. other than public expenditure indicators), the same area/beneficiary (or other unit) can be counted under several FA and Priority and therefore no additions can be done at measure level (except when the measures or sub-measure which have been programmed under only one FA or under the priority P4 only, e.g. M5, M10, M17, etc.).

RDP Measures	% of EU28 RDPs in which the measure is open	# case study MAs (10) where the measure may support adaptive actions	% public expenditure for RDP measures at EU-level	Target achievement in 2015-2016[81]	'Potential effects on holdings adaptation at EU28 level
M13 ANC	83.0%	8	16.90%	28.8%	*
M14 Animal Welfare	24%	1	1.57%	16.7%	*
M15 Forest Environment	28%	5	0.24%	3.8%	*
M16 Cooperation	95%	8	1.91%	2.0%	**
M17 Risk Management	12%	6	1.79%	6.2% (17.1 only)	*
M19 LEADER	97%	all	6%	2.3% (in 2015 only)	*

Legend

*** The measure has probably contributed to a reduction of the vulnerability or increase of the capacity to grasp opportunities of some farmers, foresters and/or territories

** The measure may have contributed to a reduction of the vulnerability or increase of the capacity to grasp opportunities of some farmers, foresters and/or territories.

*The measure has probably not contributed to a reduction of the vulnerability or increase of the capacity to grasp opportunities of some farmers and/or foresters or of territories or have had only limited effects

0 The practices and actions supported are overall not relevant to climate change adaptation

n.a The information available do not allow any conclusion

Source: Own compilation based on case study RDPs, interviews, ENRD data and AIR data

10.5.3.5 Combinations of adaptive measures

In addition to their individual effects, the effectiveness of some measures towards climate adaptation can be improved through relevant combinations of measures. One example is the combination of a capacity building measure with a land management measure to ensure that the practices targeted are well understood by the beneficiaries and implemented in the optimal way (according to the farm-context, the environmental needs, etc.).

The potential for such synergies in EU28 RDPs for the implementing periods 2007-2013 and 2014-2020 has been explored in a separate study and the results show that although such combinations are known to be beneficial, only a few Managing Authorities (e.g. Northern Ireland (UK)[82]) have experience of using combinations of measures in a formal and obligatory way, through joint programming and implementation (Frelih-Larsen et al, 2014). Indeed, such combinations are seen as a source of complexity (and therefore administrative burden). Therefore, measures have been mostly implemented separately without using obligatory measure combinations. Nevertheless, measures can be combined on a voluntary basis, offering beneficiaries the possibility to select one or several RDP measures according to their specific conditions and needs.

In order to promote effective (obligatory) combinations for climate action, guidelines have been provided to the Managing Authorities by DG AGRI (Frelih-Larsen et al, 2014). However, the analysis of case study RDPs for this evaluation did not reveal many examples of such combinations in favour of climate change adaptation, with the exception of training requirements (funded under M1, knowledge transfer and capacity building) as a condition of obtaining agri-environment-climate support under M10, including for AECMs favouring climate change adaptation, in some Member States (e.g. IE and HU).

10.5.4 FACTORS EXPLAINING THE ADOPTION OF ADAPTIVE ACTIONS

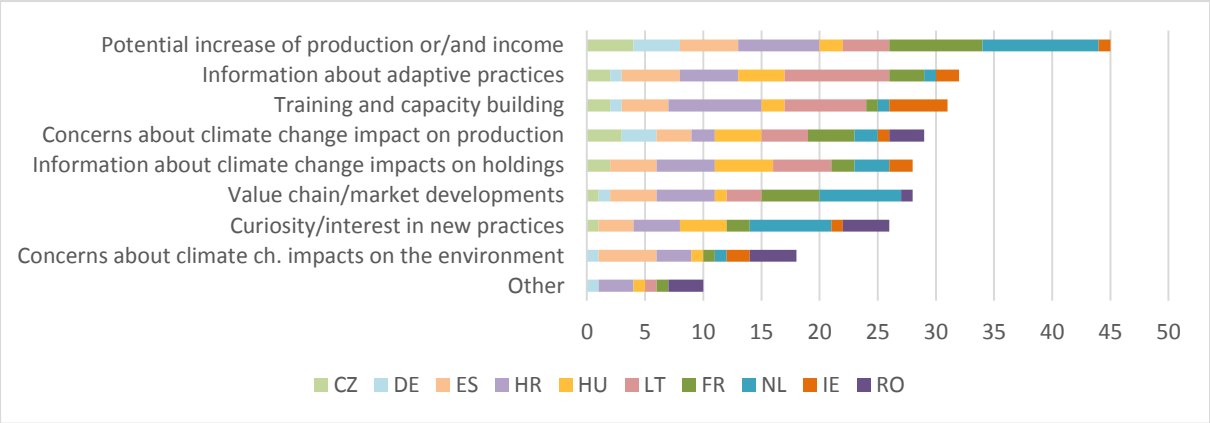
Other factors can explain farmers' and foresters' change of practices or farm/forest management, including when it comes to adaptation. Two surveys targeting 1) farmers and foresters and 2) advisers and farmers' representatives were done as part of this study in order to understand, on the one hand, their perception of climate change impacts, the changes they have made to adapt practices to climatic conditions, and the role of CAP supports in those changes; and on the other hand the barriers and drivers which affect farmers and foresters' adoption of adaptive actions. The first survey received 107 responses and the second 84 responses (in 8 and 10 case study Member States/Regions, respectively). However, one should note that the number of responses per Member States is highly variable. It ranges from four in Germany to 14 in Croatia for the advisers' survey, and from 2 in Spain to 24 in Croatia for the farmers and foresters survey. Therefore, the results presented are probably considerably skewed by the answers from a few Member States (HR, LT, RO for both surveys and ES and NL for the advisers' survey) rather than being representative of all the 8 or 10 studied. Additional information came from the main part of the case studies, where interviewees were asked what the main drivers were and what barriers were affecting the uptake of adaptive actions; hence information from three different sources is used in the analysis.

The driver most frequently identified in the surveys as a major one is the potential to increase production or/and income (see Figure 21 and Figure 22). In other words, adaptation seems to be perceived more as a way to grasp opportunities than as a way to cope with negative impacts. And the interviews carried out during the case studies confirm that up to now in most Managing Authorities/Member States economic drivers prevail, since they are more short-term concerns, and can be deep concerns. Also, interviews in case study Member States show that the sectors in which there appear to be more efforts toward adaptation are those that are impacted, that have better levels of economic profitability and that can envisage expenditure related to adaptation (the wine sector). However, other drivers have also been identified as major ones such as training and information given to farmers (about climate change and about adaptive practices) and concerns about the impact of climate change on production. During the case studies, interviewees also reported economic considerations and market developments as a major driver for change in practices (in CZ, ES-AD, HU, FR-AQ and IE), as well as training and capacity building) to a lesser extent (IE and

[82]In Northern Ireland (UK), an obligatory combination of investment in drainage with participation in the agri-environment-climate measure has been implemented.

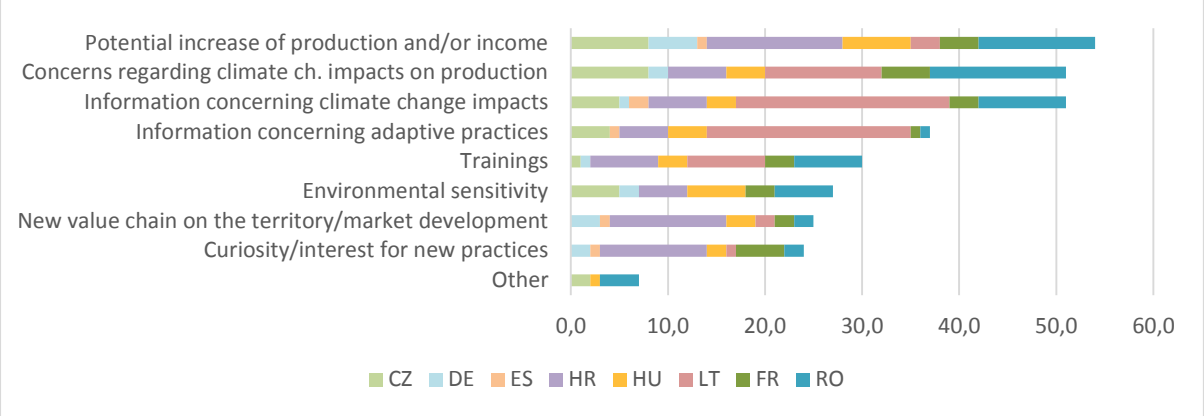
LT). It should be noted that, that although 38% of surveyed advisers consider that farmers and foresters are well or very well informed about climate change impacts, only 18% of the advisers consider that farmers and foresters are well or very well aware of them.

Figure 21: Importance given by farm advisors and representatives to the main drivers of on-farm adaptation (84 respondents)



Source: survey of 84 farm and forest advisers and representatives in 10 Member States

Figure 22: Importance given by farmers and foresters to their main drivers of adaptation (107 respondents)



Source: survey of 107 farmers and foresters in 8 Member States

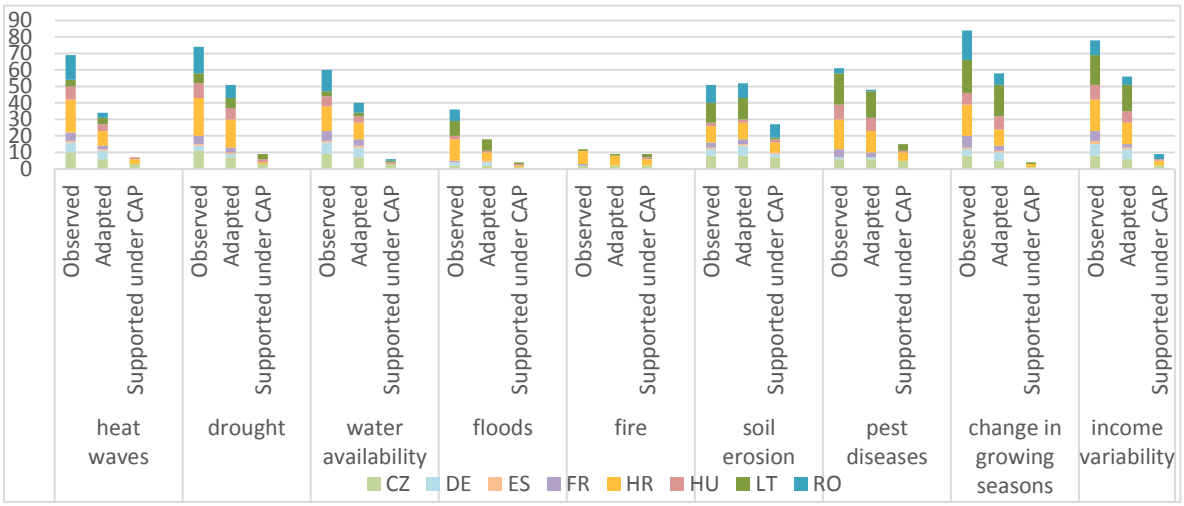
Concerning the weight of CAP measures as a driver for adaptation, case study interviews tend to point this out as a secondary driver (except in France, where CAP penalties have been identified as a driver by the expert). Furthermore, the results of farmers' and foresters' survey show that, for most of the climate change impacts considered (droughts, water scarcity, floods, fires, erosion), more than half of respondents considered their holding to be affected (the exceptions are fires, floods and soil erosion where 11%, 34% and 48% respectively felt they were affected) (see Figure 23, Figure 24, Figure 25, Figure 26, Figure 27). One explanation could be that fires and floods have more localised impacts (mostly on holdings in forests, coastal areas or near large rivers). Similarly, on average, 35.6% of the advisers and representatives considered that most or all farms were affected by the different impacts. However, even though a significant share of farmers and foresters reported that they implemented actions to adapt (38% on average for all impacts), only a small proportion of them considered that they are supported or encouraged to do so under the CAP (9.3% on average for all impacts). This seems to indicate that up to now the CAP has played a limited in the adaptation of farms and forests to climate change. However, the results of the survey of farm advisers and representatives reveal that 32% of those respondents considered that most or all farms are supported or encouraged under CAP to adapt. This difference could be linked to the fact that farmers do not necessarily link the supports they receive with CAP policy. For instance, it was reported during interviews in France that in many cases, when farmers receive CAP supports (under the second pillar) from the Region, they do not know whether this is linked to regional policies or CAP measures.

Interviews with advisers also showed that they were not fully aware of the weight of CAP in the supports received by farmers or foresters. Possibly farmers/foresters may also not know that the support they receive is linked to a climate action objective (AECM).

Finally, it can be noted that, overall, 47.1%[83] of the farm advisers considered that only some or no farms are adapted to climate change.

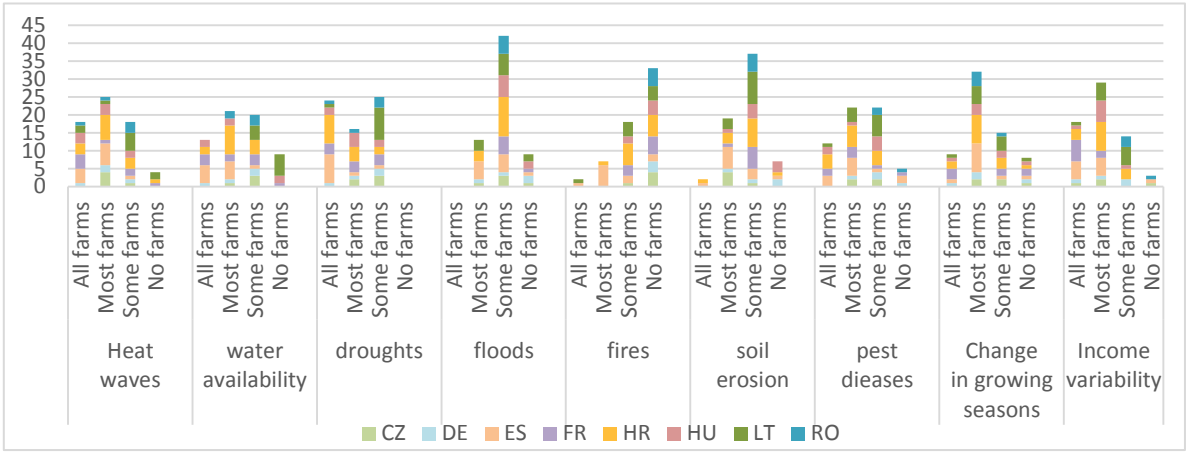
Drivers of adaptation can be the services and infrastructure provided for farmers. The literature review highlighted the collective management of the water resource or the provision of weather forecasting and early warning systems as major drivers to adaptation. Such services seem overall available to most farmers in the case study Member State, since 59.5% and 79.5% of surveyed advisers and farmers' representatives (respectively) considered that farmers have access to each of these two services.

Figure 23: Number of farms and forests which observe, have adapted and are supported under CAP to adapt per type of climate change impact (among 107 respondents)



Source: survey of 107 farmers and foresters in 8 Member States

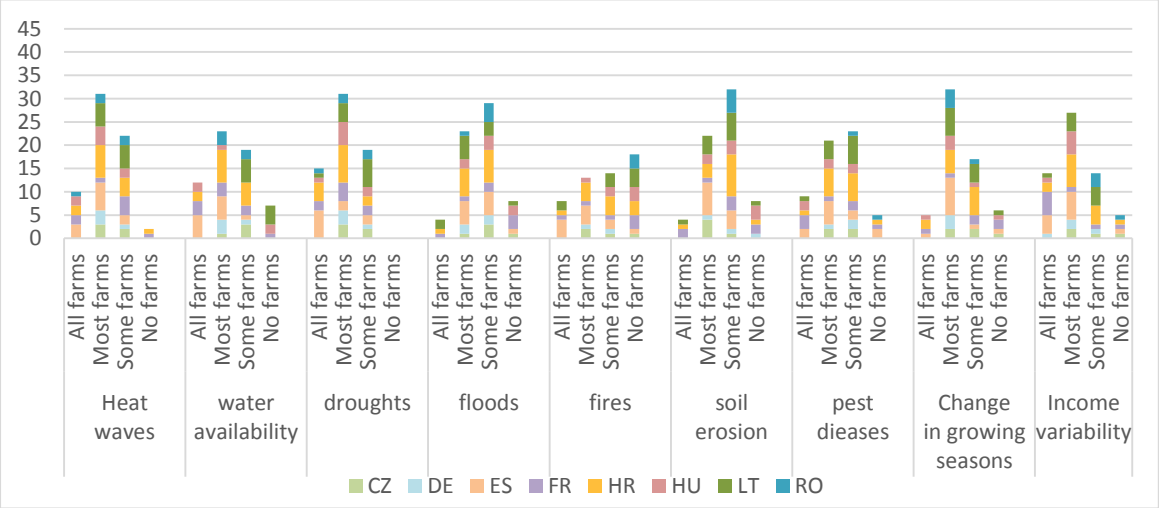
Figure 24: Number of advisers and representatives which consider that some, most, all or no farms are affected by climate change impacts (among 84 respondents)



Source: survey of 84 farm and forest advisers and representatives in 10 Member States

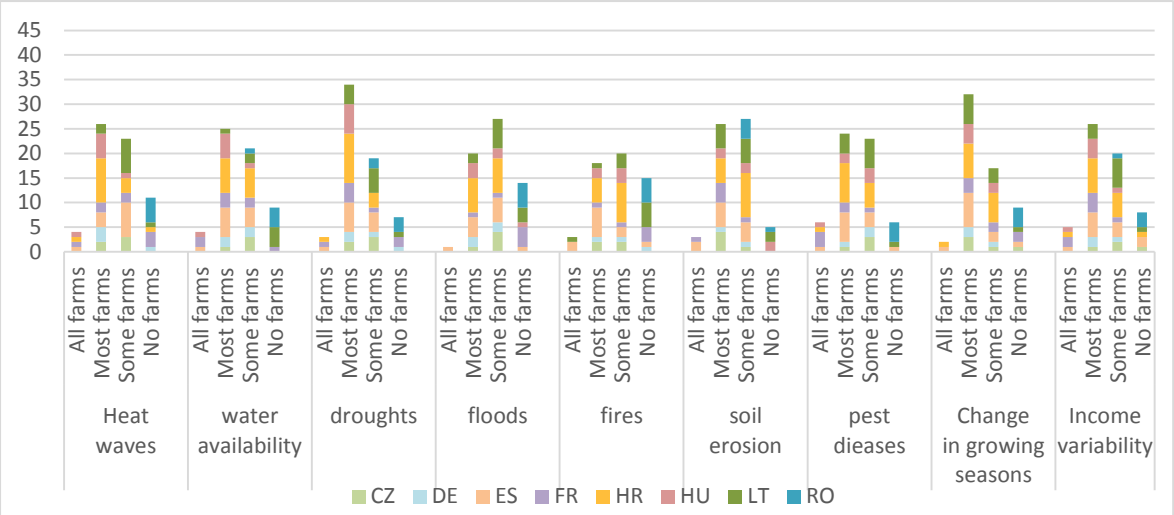
[83] Compared to 20% that considered that most or all farms were adapted, and the 32.9% who did not know.

Figure 25: Number of advisers and representatives who consider that some, most, all or no farms are aware of climate change impacts (among 84 respondents)



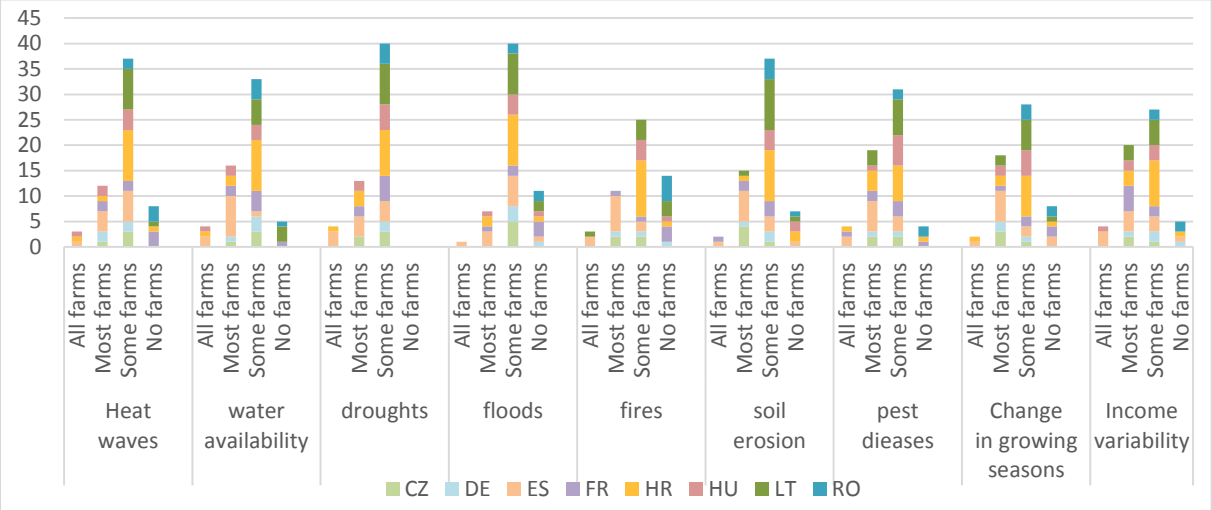
Source: survey of 84 farm and forest advisers and representatives in 10 Member States

Figure 26: Number of advisers and representatives who consider that some, most, all or no farms are supported or encouraged under CAP to adapt (among 84 respondents)



Source: survey of 84 farm and forest advisers and representatives in 10 Member States

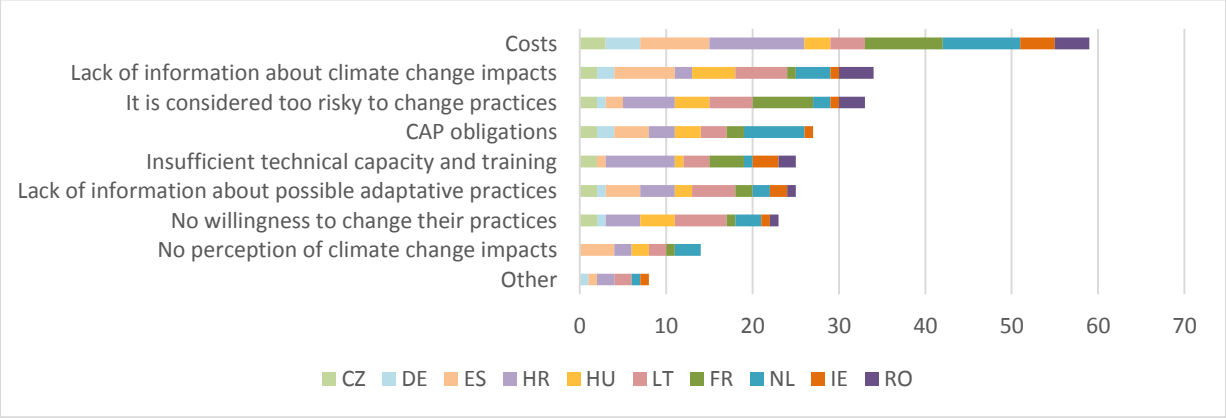
Figure 27: Number of advisers and representatives who consider that all, most, some or no farms have implemented actions to adapt (among 84 respondents)



Source: survey of 84 farm and forest advisers and representatives in 10 Member States

With regard to barriers to adaptation, in almost all case study Member States[84], the barrier most often identified is linked to economic considerations, according to farmers and foresters, as well as farm advisers and representatives (see Figure 28, Figure 29). This has been confirmed by interviews in the Czech Republic, Andalusia (ES) and Croatia. According to surveys, the other main barriers at EU level are the risks associated with changing practices and the lack of information (about climate change impacts as well as adaptive practices). This underlines the need to develop risk management tools as well as effective training and advisory services related to climate adaptation. One should note that CAP obligations are also considered as one of the main barriers by many advisors and representatives, and, to a lesser extent, by farmers and foresters. Indeed, CAP obligations have been reported as limiting farmers' and foresters' choices (including when the objective is to adapt to climate change). For example, when a farmer has declared his/her crops but wants to make changes, s/he must notify the Paying Agency in order not to be penalised under the greening measure. In Lithuania, this is seen by some farmers as limiting their ability to take advantage of changing market conditions associated with climate change (according to interviews). However, safeguards on this point have been put in the EC guidelines for MS to ensure the necessary flexibility, but these may have been insufficiently transferred to farmers, or perceived in a constraining way.

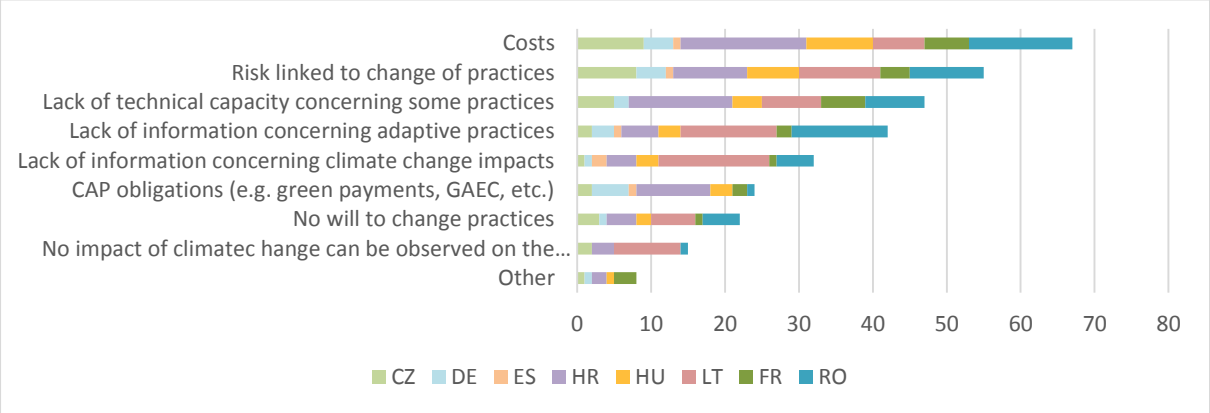
Figure 28: Importance given by farm advisors and representatives to the main barriers to on-farm adaption (84 respondents)



Source: survey of 84 farm and forest advisers and representatives in 10 MS

[84] One exception is Lithuania where the results from the farmers' and foresters' survey shows broadly equal importance given to costs, the risks associated with changing practices, the fact that farmers do not see any impact of climate change on their farm, and the fact that they do not wish to change their practices.

Figure 29: Importance given by farmers and foresters to the main barriers to adaptation (107 respondents)



Source: survey of 107 farmers and foresters in 8 MS

10.6 Conclusions

General conclusions

- The literature review showed that: 1) determinants of the vulnerability of EU holdings to climate change are highly dependent on location and context, hence indicators of vulnerability have to be defined at regional level and may differ from sector to sector; 2) indicators of vulnerability are bio-physical and also socio-economic.
- The CAP offers Member States a number of potential levers with which to encourage climate adaptation of the agriculture and forest sectors, and of EU society, although the intervention logic to achieve adaptation goals is neither explicit nor clear for many measures in the Regulations.
- Improved planning of adaptation requires specific information and knowledge which is still under development in many Member States.

CAP and planned adaptation

- The planning of climate adaptation of the agriculture and forest sector through risk assessments and adaptation plans has largely improved in the last decade at EU-28 scale. However, links between CAP measures and risk assessments and adaptation plans are lacking, although they would allow better integration of planned adaptation in the CAP; and MS have not programmed any funds to implement their own adaptation plans;
- The planning process for the ESI-Funds (including the EAFRD) did require MS and MA to gather appropriate information, and prepare strategies and actions to improve adaptation; this helped to some extent to integrate adaptation as a cross-cutting objective; the requirement to allocate 30% of EAFRD funds in each RDP to environment and climate measures has not been an effective driver since it could be fulfilled by a few measures that could have little relevance to adaptation (e.g. M13 ANC). There were no such requirements for adaptation integration for the Pillar 1 and horizontal measures, although the GAEC framework and greening requirements (as defined at EU level) have the most potential to promote adaptation, which is not fully used in Member State implementation choices;

- **CAP outcomes on adaptation of farm and forest sectors**
- The First Pillar and Horizontal Regulations have some positive effects on the adaptation of EU holdings as well as territories and EU society as a whole, for example by strengthening the EU AKIS (FAS), maintaining a minimal diversity of farming systems but also at farm level (crop diversification measure, VCS and redistributive payment), contributing to the stability of farm income (direct payments) or protecting areas and landscape features that are important for adaptation (EFA and permanent grassland measures and GAEC).
- Such positive impacts of Pillar I are achieved despite few measures having an explicit intervention logic relating to adaptation. Also, these positive effects on adaptation could have

been much greater, and achieved more efficiently, if these CAP instruments had been designed through an adaptation lens.

- Some missed opportunities for adaptation can be highlighted in Pillar I. Member States have allocated a low share of their budget to the Young Farmers Scheme, despite the fact that generational renewal is essential for the adaptation and overall sustainability of EU agriculture. In addition there has been limited use of redistributive payments and although some of the case study MS have targeted support at particular systems, the CAP as whole is still enabling specialisation to continue, which threatens resilience.
- Outcomes in terms of the integration of adaptation are quite diverse for Pillar II since a number of RDP measures have been used to tackle climate impacts, especially in Member States or Regions that already face significant impacts from climate change (DE, FR, CZ).
- Soft measures (M1 Training, M2 Advisory services, M16 Cooperation) and risk mitigation and management measures (M5, M17) are very relevant to adaptation, but they have been infrequently programmed (e.g. M1 and M2, M17), or their implementation has been delayed (e.g. M16) or they have had a low uptake (M5, M17).
- Other RDP measures such as land management measures M10 AECM and M11 organic agriculture, are targeted at broader environmental management objectives (biodiversity, water and soil management). This is valid, but design of measures through an adaptation lens would be necessary to tackle the new challenges.
- Some cases of both Pillar I and II supports that may lead to maladaptation has been detected for some measures, but this is always context- and location-specific; hence safeguards against maladaptation need to be strengthened to ensure that both Pillars have only positive or neutral effects on adaptation.
- Adaptation of EU farm and forest holdings will require in some cases transformational change, for example changes in farming systems and land use. Such changes imply important economic trade-offs for farmers. Those changes require policy incentives and financial support (EEA, 2017b), especially when they improve resilience beyond the farm. Such support would need measures dedicated to adaptation and this has rarely been the case in the current CAP 2014-2020 as implemented by Member States and Managing Authorities.

11 THE CONTRIBUTION OF TECHNOLOGICAL AND SOCIAL INNOVATION (ESQ6)

ESQ6: To what extent has technological and social innovation in the agricultural sector contributed positively or negatively to achieving the cap goals on climate change?

11.1 UNDERSTANDING OF THE QUESTION

Innovation is identified as a key-element of the Europe 2020 strategy to manage the multiple challenges facing the agricultural and forest sectors due to the effects of climate change. The emergence and dissemination of innovations in agriculture is consequently highly supported through EU policies (Pérez Domínguez et al, 2016) and especially through the CAP. Fostering innovation is one of the Pillar II specific objectives. The term innovation refers to 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations'[85]. There is now a growing body of opinion that innovation is not necessarily a linear process (e.g. successive steps of innovation emergence, development, first adoption and diffusion) but a process where innovation emerges through complex interactions between various heterogeneous actors, all of whom contribute something to the application of new or existing information and knowledge (Spielman and Birner, 2008) (SCAR, 2016). In addition to considering technological innovation, which has been a major and well-known factor shaping the development of agriculture over time, this ESQ also puts a special focus on social innovations. Relevant EU Regulations define social innovation as innovations that are 'social both as to their ends and their means and in particular those which relate to the

[85] European Commission - MEMO/10/473 06/10/2010, available at http://europa.eu/rapid/press-release_MEMO-10-473_fr.htm

development and implementation of new ideas (concerning products, services or models) and thereby benefiting society and boosting its capacity to act' (*Regulation 1296-2013* on Employment and Social Innovation). Social innovations are therefore characterized by processes of co-design or co-construction of innovation involving various stakeholders (e.g. politician, farmers, citizens, scientists, etc.) and responding to societal demands that are not fully addressed by traditional markets and/or institutions (Hubert, 2010) (ACARE, 2015) (Bock, 2012).

In this ESQ the contribution of both technological and social innovations to climate action in agriculture is assessed. More specifically, the aim is to identify and analyse the potential positive and negative impacts of innovation on climate adaptation and mitigation in the sector (e.g. impacts on agricultural GHG emissions and farm vulnerability to extreme weather events). This also includes the considerations of factors that may favour or hinder agricultural innovation.

11.2 Process and Methodological approach

The assessment described above relies both on quantitative and qualitative information utilised in a methods consists of the following steps: 1) identification of relevant technological and social innovations and their potential impacts; 2) analysis of their prevalence across EU farmers; and 3) identification and description of factors (both within and outside of the CAP) favouring or hindering innovation in agriculture. The main sources of information include: recent literature, interviews with stakeholders in case study Member States as well as an online survey targeting farmers' representatives and advisors in the case study Member States. It should be noted, however, that the response rate to the survey was in general low, and varied greatly between Member States (see Figure VI in Annex 5). This was especially problematic in the case of Romania, where no survey response was received, and thus the assessment relies on the expert judgement of the case study leader. Similarly, the Czech Republic, surveys showed incoherent results and the expert assessment provided by the case study leader was again used. Given these limitations, the two surveys should not be considered as representative, however they provide some useful information (expert views) on what is happening on the ground. Unless otherwise stated, survey results presented in this section show mean values.

11.3 Analysis

11.3.1 Identifying technological and social innovation impacting of climate objectives in agriculture and assessing their potential effects

Relevant studies addressing technological innovations for climate action, tend to be more focused on climate mitigation (e.g. (Pérez Domínguez et al, 2016)), whilst relatively few consider adaptation (Dasselaar, 2012; Smithers and Blay-Palmer, 2001). Compared to technological innovations, social innovations in the agricultural sector have been less well studied, with some notable exceptions[86].

The first step to answer this ESQ was to identify and categorise the main social and technological innovations in the agricultural sector which have the potential to affect climate change mitigation or adaptation. Based on the literature and interviews in case study Member States, a non-exhaustive list of social and technological innovations was compiled. The different level of economic and social development in the EU can induce differences in the process of innovation, and some practices considered as innovative in one Member State can be quite common practice in others. For example, shared ownership of equipment has been common in France for many years but is scarcely used in other countries such as Hungary. Some practices, considered as social innovations in this analysis, can sometimes be considered as traditional practices in other Member States. This is the case for local and urban farming which used to be quite widespread in many of the Member States, yet remains important in only a few Member States today. Innovations inspired by these more traditional forms of farming have been referred to as "retro-innovations" during interviews. Finally, in the case of genetic innovations, even if the use of genetically improved livestock or plants is quite common, the

[86] SIMRA Horizon 2020 project http://www.simra-h2020.eu/

type of technologies used as well as the criteria used for selection are highly variable (see Table 35 and Box 17).

Table 35 and Table 36 below aim to show the effects of innovations, which vary depending on the farming system and the biogeographical region where they are implemented, and how they are implemented. Moreover, it might be difficult to define a baseline to measure the impact of some innovations. For instance, in the case of genetic improvement, it is difficult to say what will be the non-innovative situation since selection is a traditional practice for farmers. It is therefore difficult to quantify the potential impacts of innovation on GHG reduction/carbon sequestration and on adaptation. A qualitative approach has thus been taken, supplemented by quantitative data when available based on literature review and interviews with experts and farm advisers.

The technological innovations with potential effects on climate objectives identified in the table below have been divided into different categories: genetic improvement, biological innovations, mechanical innovations, knowledge based-innovations or climate-controlled environment. It should be noted that some innovations imply a significant re-organisation of the farming system (e.g. anaerobic digestion) while others have only minor effects on farm management (e.g. using varieties or breeds with improved resistance to heat). Box 17 discusses some of the risks associated with the use of innovations.

Table 35: Description and global impact of some technological innovations

Category	Technological innovations description	Impact on mitigation (main GHG concerned)	Impact on adaptation (challenge concerned) **	Description of the effects on climate mitigation and adaptation
Genetic improvement	Increase heat resistance of crops	none	TV – ECE	By improving **plant resistance** to heat, drought and pests but also by selecting plants based on their agro phenology, farmers might offset negative impact of climate change on production and take advantage of the opportunities it can induce. For example, to cope with the shortening of crop growth phases (which can reduce yields), farmers can choose crop cultivars that have higher thermal requirements (EEA, 2017b). By improving the **resistance** of **animals** (to heat or pests), yield or feed efficiency, animal productivity increases and can thus reduce GHG emissions per unit of product (Pérez Domínguez et al, 2016). In addition, some studies on beef cattle indicate that animals with high feed efficiency can produce up to 28% less enteric CH_4 (Hegarty et al, 2007; Nkrumah et al, 2004). Finally, increasing heat resistance is strategic, since temperature as well as the occurrence of extreme heat waves are expected to increase. It would also make it possible to reduce energy consumption for cooling buildings. It is recognized that **intensive selection** for one genetic trait leads to losses in other traits. Breeding for milk yield, for example, comes at the expense of carcass quality, reproduction, animal health, etc., with potential negative impacts on farmers' income or climate objectives (Hristov et al, 2013). Numerous studies also showed that high producing cows were much more susceptible to heat stress than low producing cows (Collier, Dahl and VanBaale, 2006) and (Bohmanova, 2006). **General risks** relating to breeding techniques are included in Box 17.
	Increase drought resistance of crops	none	WA – ECE	
	More adapted agro phenology of crops (e.g. early variety selection)	none	WA – TV – DP -SE	
	Increase pest resistance of crops	none	DP	
	Increasing milk yields of dairy cows	CH_4 - N_2O	0	
	Increasing ruminant feed efficiency[87]	CH_4 - N_2O	0	
	Improved heat resistance of animals	CH_4 - CO_2 - N_2O	TV - ECE	
	Improved disease resistance of animals	CH_4 - N_2O	DP	
	Gender-selected	CH_4 - N_2O		By choosing the sex of their heifer and calfs, farmers

[87] For measuring feed efficiency of animals, the Residual Feed Intake (RFI) is commonly used.

	(i.e. sexed) semen			can improve their productivity (e.g. in dairy farms). This technology however implies higher cost for the semen but also a lower conception rate especially for cows, hindering productivity (Norman, Hutchison and Miller, 2010).
Biological innovation	On-farm anaerobic digesters (i.e. methanization): implies the digestion of organic material (e.g. manure, slurries and crop residues) by bacteria in sealed tanks to yield biogas and digestate (Soto et al, 2017).*	CH_4 - CO_2 - N_2O	ECE - DP	The advantages of **anaerobic digesters** for mitigation and adaptation are numerous (Boulamanti et al, 2013) (Battini et al, 2014). Apart from being a source of renewable energy and of income diversification for farmers, methanization can reduce CH_4 emissions from livestock manure (GHG emissions from manure management account for about 15% of total agriculture emissions (EEA, 2015a)). Moreover, the digestate is an easy to use (compared with traditional organic fertilizer) and safe (most of the weed seeds and pests are killed in the digestion process) organic fertilizer, making it possible to reduce GHG emissions from fertilizer production. The effect on GHG emission might depend on the type of primary feedstock used for the process (Soto et al, 2017). The use of energy crops can especially lead to many issues, (e.g. relating to land use change) (see ESQ14).
	Feed additives to reduce methane emissions (e.g. linseed, nitrate, or propionate precursors)	CH_4	0	**Feed additive and dietary manipulation** can help reducing CH_4, NH_3 and N_2O emissions (Pérez Domínguez et al, 2016). For instance, for each percent of N or fat added, CH_4 emissions from enteric fermentation are assumed to decline by 10% or 5%, respectively (Mottet et al, 2015). On the contrary, the amount of NH_3 produced from cattle manure is correlated with N intake and the amount of urea (decomposed into CO_2 and NH_3) is almost 3 times higher in manure from cows consuming a 21% crude protein diet (rich in N) when compared to a 15% crude protein diet (Burgos et al, 2010). Thus, feed additive and dietary manipulation should be used with caution, also because they can impact animal health and productivity (Hristov et al, 2013).
	Low nitrogen feed to reduce ammonia emissions	N_2O	0	
	Nitrification inhibitors in soil (suppressing the microbial conversion of NH_4 to N_2O)	N_2O	0	By limiting the microbial conversion of NH_4 to NO_2 in soil, **nitrification inhibitors** decrease direct N_2O emissions and nitrate leaching. This technology has the potential to reduce by up to 35% N_2O emissions from agricultural soils (Ruser and Schulz, 2015) but also limits fertilization need (NH4 remains available for crops).
	Bio-control agents for plant protection (e.g. with auxiliary insects or bacteria)	none	DP	In the climate change context, pest and diseases are expected to increase variability in yields. **Biological control** can make it possible to control these pests. However, because climate can be critical in predicting biological control agent population dynamics, any changes to climate may in turn alter control success (Reeves, 2017).
Mechanical innovation	Optimized irrigation equipment (e.g. drip irrigation, micro-sprinklers)	none	WA – ECE - TV	Uptake of **optimized equipment for water application** in fields should improve irrigation efficiency. Compared with irrigation with sprinklers, the use of drip-irrigation allows water savings from 10 to 35% for arable crops, from 28 to 46% for arboriculture, from 17 to 43% for fruit and vegetable production (Serra-Wittling and Molle, 2017). Moreover, with drip irrigation as water does not touch leaf surfaces, pressure from diseases might decrease (see for example (Lanier et al, 2004).

	Optimized soil management equipment (e.g. direct seeding or shallow tillage equipment)*	CO_2	SE, WA	Uses of efficient equipment eases practices of **soil conservation** in particular no-tillage and minimal tillage which enhance carbon storage in soil (Krauss et al, 2017). For instance, with chisels or strip till, farmers can make superficial or reduced tillage. Also, direct seeders equipped with row cleaners, cutting discs or furrow opener make it possible to leave crop residues on field without hindering correct seeding.
Knowledge based innovation	Fertilization assisted with digital technologies (e.g. assisted with GIS or field sensors)	N_2O – CO_2	PV	In a context of climate change, **digital technologies** can be used to optimize fertilizer (reducing N_2O and CO_2 emissions (Millar et al, 2010)) or water consumption. For instance, variable rate technologies make it possible to tailor N input across the plot and as a results to reduce mineral fertilizer application by 2-20 kg N/ha (Hoben et al, 2011; Pérez Domínguez et al, 2016). **Sensors** in soil used for arable crops and arboriculture allow water savings from 8 to 41%, the average being around 20-25%. For fruit and vegetable production, using sensors allows water savings from 30 to 89%, the average being around 45-50% (Serra-Wittling and Molle, 2017). The development of geographical information and the increase availability of **satellite imagery** (e.g. through Copernicus and Galileo) can facilitate the development of such technologies. Finally, potential general risks related to the use of digital technologies are exposed in Box 17.
	Irrigation assisted with digital technologies (e.g. field sensors to map irrigation needs)	CO_2	WA – ECE - TV	
	Information system providing timely information to steer farm management		DP – ECE – WA – TV - PV	Providing timely information to farmers on pest, weather, water or market might improve farmer's management. To be of use this information should be highly specific (focusing on sectors and/or region). It could include decision support system, newsletter, alert message system, etc.
	Mobile application to recognize in-field diseases		DP	Improving pest management through rapid identification of disease by using image analysis could reduce farmers' vulnerability. Moreover, the application could give some information to farmers about the identified disease (symptoms, protection methods, etc.).
Climate controlled atmosphere	Climate-controlled buildings for livestock	CH_4 N_2O	WA – TV – DP - ECE	Control climatic parameters such as temperature, humidity or luminosity make it possible to remove constraints related to climate change. By controlling such parameters, yield variability might decrease. Moreover, as animal performance is expected to decrease when climate parameters are outside the comfort zone of the animal, **climate-controlled buildings** make it possible not to decrease the production potential of animals and thus to limit emissions per unit of product. For instance, high temperature and low relative humidity may dehydrate mucous membranes thus increasing vulnerability to viruses and bacteria. Finally, by lowering indoor temperature and air velocities near emitting surfaces (e.g. slurry pit), ammonia emissions is supposed to reduce (EIP-Agri Focus Group, 2017). However, such climate-controlled building may increase energy consumption and GHG emissions.
	Climate-controlled greenhouses		WA – TV – DP - ECE	

Source: Own compilation.

Notes: *Innovations added after first analysis; ** Main impacts of climate change: WA: decrease of water availability (reduced summer rain fall and drought); TV: overall temperatures variations (e.g. change in seasons timing and temperature); DP: presence and persistence of diseases and pest (for

trees, crops and livestock); SE: exacerbated soil erosion; ECE: fire risks and increased frequency of extreme climatic events such as hail storm, flooding, frost, heat waves and cold spells; PV: price volatility.

Box 17: General risks associated with technological innovation

Risks of digital innovation linked with big data: with the development of new digital technologies, the amount of data produced is increasing at a considerable rate. These data can offer many opportunities to support farmers in their decision-making process and also to support the entire value chain (Wolfert et al, 2017). However, the large amount of data that is gathered raises issues around data ownership, value of data, and privacy and security. Moreover, big data is expected to cause major shifts in stakeholder organization and power-sharing (Wolfert et al, 2017). It is therefore very important that care should be taken in deciding how the large amount of data produced through digital innovations is used.

Risks of mechanical innovations and especially of robots: these can already be used to perform several tasks on the farms (harvesting salads, milking and feeing cows, deciding where to fertilize, etc.). These robots can help farmers to be more efficient in their tasks, but they rely on artificial intelligence and automated working that can lead to some issues regarding security, responsibility and employment in rural area. For instance, an irrigation ramp could fail to stop at the edge of a plot and end up on a road, endangering drivers. In the case of excessive use of fertilizer due to a robot failure, it would be difficult to know whether the farmer, the dealer or the manufacturer should be incriminated for the resulting water pollution. Responsibility issues in case of an accident or inappropriate use due to robot failure should be discussed and if necessary new rules or regulations implemented. Regarding employment, part of the agricultural labour force will be replaced by robots on farms, although it is expected that in parallel the new technology sector might create new industrial jobs.

Risks of using biotechnologies, specifically New Breeding Techniques (NBT): a variety of techniques is available to select and introduce desirable traits in organisms used for food and feed production. These range from conventional breeding techniques (plant or animal selection), established techniques of genetic modification ('traditional GMO') and a growing number of what are commonly called New Breeding Techniques (NBT). NBT use genetic engineering (e.g. cisgenesis and intragenesis[88] or epigenetic modification[89]) to develop new traits within a given species (DG for Research and Innovation, 2017). Potential risks related to the use of biotechnologies are still under analysis. For instance, they concern potential adverse effects that are: linked to cultivation and management issues (e.g. improved resistance makes it possible for farmers to grow crops in monocropping systems, with potential negative effects on soils); related to development of resistance in pests targeted by the genetically modified crops; and due to gene flow to wild relatives which can create resistance in non-target organisms (Bartsch et al, 2009). There is still uncertainty as to whether traditional GMO and conventional breeding techniques should be covered by EU and national Regulations (e.g. about their use for food and feed or their traceability), the legislation on NBT is still under development (the European Court of Justice should shortly decide whether mutagenesis should be considered as GMO and thus be under the EU GMO regulation)[90]. Finally, public acceptance and information on these biotechnologies is also an important factor to be considered, in the event that their use is allowed by the up-coming EU Regulation.

Risks related to the adoption and implementation of new technology: technological innovation can imply various costs for farmers (or other stakeholders). These costs can be both direct (price of the technology) and indirect (e.g. due to system adaptation needed in order to use the innovation). The need to pay-off these investments can thus represent the first risk that the farmers have to manage. However, it should be pointed out that many low-cost innovations exist and can be implemented at farm level with positive impacts on climate objectives (e.g. technical innovations involving systematic rethinking of the farming system without necessarily using new technologies). The risk related to costs is amplified by the fact the adoption of new technology is also associated with a need for new knowledge and the development of new expertise (and thus with a risk of ineffective or even improper use of technology which can lead to negative outcomes. These risks can largely hamper the adoption of innovations.

Risk of rebound effects: While some technologies for mitigation and adaptation can increase efficiency (e.g. less water consumed per irrigated hectare; lower GHG emissions per tonne of crop produced), there is a risk that this gain in efficiency will lead to an increase in production (e.g. a larger irrigated area). Thus the overall mitigation or adaptation benefits arising from a technological development might remain below potential, if efficiency savings are counterbalanced or eliminated by increased production or consumption. This phenomenon is referred to by some as the 'rebound effect' referring to the reduction in expected gains from technological efficiency improvements due to behavioural or other systemic responses (Perry and Karajeh, 2017).

[88] Techniques introducing genetic material from the same or sexually compatible species.

[89] Technique regulating the expression of genes by the addition of markers or tags to the control regions of genes, while not changing the gene sequence itself.

[90] https://ec.europa.eu/food/plant/gmo/legislation_en

Risks related to a top down approach: technological innovations have sometimes been built by industrial companies in collaboration with research institutes but without involving potential users. Such innovations might be poorly adapted to farmers' needs and thus achieve little uptake. However, farmers are now much more often involved in the emergence phase (thanks to social innovations) with positive outcomes in terms of adoption and dissemination.

Social innovations can be quite varied since they rely on stakeholders who decide to organize themselves to answer local needs. A categorisation of social innovations with potential impact on climate objectives is presented in Table 36 which draws together innovations related to sharing knowledge, sharing resources, financing and insurance, land conservation and management, breeding, labelling, and organisation of food production systems. Climate objectives are rarely the sole or main objective pursued by stakeholders through these social innovations. However, many of them can significantly impact climate objectives directly (e.g. water management groups) or indirectly (e.g. organisations for conserving, exchanging or selling seeds of ancient and local varieties). But it is difficult to quantitatively measure the impacts of social innovations.

Table 36: Description and global impact of some social innovations

Category	Social innovations description	Impact on mitigation (GHG concerned)	Impact on adaptation (challenge concerned)	Description of the impact on climate mitigation and adaptation
Knowledge sharing	**Collaborative online tool** which permits sharing experiences and knowledges.	All	All	By promoting communication and exchanges concerning farming practices and systems beneficial for climate mitigation and adaptation, these social innovations can have positive effects on the emergence and adoption of climate-friendly innovative practices, especially when focused on climate challenges. Web-based platforms can, for instance, be an effective means of collecting, assimilating and communicating relevant evidence, experience and knowledge (EEA, 2015b).
	Groups of farmers meeting in discussion groups, workshops or on field visits to exchange experiences and knowledge.	All	All	
	Groups of stakeholders (e.g. farmers, advisers, citizens, researchers, etc.) working together on local challenges.	All	All	
Resources sharing	Groups of farmers working on **water management** and sharing.	none	WA	Increasing water scarcity and droughts (mainly in Southern Europe) are leading to an increase in demand for water for irrigation. The optimal sharing of this limited resource requires the involvement of the different water users in the governance of the resource.
	Groups of stakeholders (e.g. farmers, advisers, citizens, policy maker, etc.) working on **water management** and sharing.	none	WA	
	Groups of farmers **sharing equipment** (e.g. through an association or an internet platform).	All	DP - SE -TV	Sharing equipment may give farmers access to modern equipment they could not pay for by themselves, which might have positive effects for mitigation or adaptation (e.g. equipment for precision fertilization, for reduced labour, etc.). This could also reduce the overall numbers of machines purchased thus limiting GHG emissions associated with their manufacture. In addition, by sharing new equipment, farmers can pool risks related to the investment, making them more resilient to income variability. Potential negative effects could arise if the farmers invest together in large and heavy equipment which might alter soil structure.

Financing and insurance	Financing through **crowdfunding and sponsorship**: online platforms that allow people to donate or invest in agricultural projects (e.g. donation in exchange for farm produce).	All	All	Such financing sources might promote farmers' investments in practices beneficial for mitigation and adaptation. However, although environmental or social concerns are often important in the projects supported, climate objectives are scarcely brought to the fore. Such sources of finance can also have an important role in territorial communication and mobilization of stakeholders, which can promote stakeholder awareness about climate mitigation issues.
	Mutual funds: common financial reserves built up from individual farmers' contributions. When a farmer suffers loss of production or income, the fund provides full or partial compensation. (European Commission, 2017)	none	ECE	Contributing to a mutual fund provides an opportunity to pool risks with other farmers and over time, improves farmers' financial resilience to extreme climatic events. One of the main issues with mutual funds is when too many farmers incur losses at the same time (European Commission, 2017). Mutual funds, especially if subsidised, might also promote risk-prone behaviours and inhibit adaptation of farming systems to climate change.
	Forward contracts: non-standardized agreements between a farmer and a buyer (e.g. an industry, a cooperative, or directly on the world market). Both parties agree to the transfer of a commodity to take place at a predefined future point in time, where the traded volume and unit price is pre-set. *	none	PV - ECE	With forward contracts, farmers are guaranteed to sell an agreed amount of output at a predefined price. Forward contracts allow farmers to manage their cash flow and reduce uncertainty, thus reducing their vulnerability to price variability. The contract can also specify additional constraints on management practices or production quality, with various effects in terms of climate. The risk is that it is sometimes difficult for farmers to fulfil the contract if climatic conditions lead to significant losses or damage in production, and the incidence of those events is expected to increase with climate change. Moreover, farmers often lack of bargaining power to negotiate such contracts. (European Commission, 2017)
	Insurance products: the farmer pays a premium and, in the event of losses covered by the insurance, receives compensation.	none	ECE	It makes it possible for farmers to improve their economic resilience to extreme climatic events (European Commission, 2017). However, this economic security might also prevent system adaptation to climate change.
Land conservation and management	**Organisations which purchase land of particular interest** (e.g. environmental or social) in order to conserve it. Then the organisation can lease or lend these areas to farmers, applying specific management rules.	CO_2	All	Agricultural land conservation is an important means of addressing land-use change and soil sealing (e.g. by built development and infrastructure), which have an important impact on mitigation through the reduction of potential carbon sequestration in agricultural soils (Cameron et al, 2017). In addition, the organisations can require the farmers to comply with specific management rules (e.g. conservation of permanent grasslands, or organic farming) with positive impacts on climate objectives.
	Land stewardship: A strategy to involve landowners, civil society and users (e.g. farmers, foresters, shepherds,	CO_2	All	Voluntary agreements between stakeholders often involve the protection and restoration of biodiversity or landscapes. This might result in the conservation of features and landscapes that are important carbon sinks or

	hunters, passive recreationalists) in the conservation of nature and landscape, often with the support of a voluntary contract (Sabaté et al, 2013).			in the promotion of management practices beneficial for adaptation (Sabaté et al, 2013). However, climate challenges are seldom the main drivers behind these agreements, which limits their impact in this respect.
Breeding	Organisations conserving, exchanging or selling **seeds of ancient and local varieties** (e.g. community seed banks)	N_2O	WA – TV - DP - ECE	Community seed banks and participatory plant breeding can enhance the resilience of farmers by improving access to locally adapted crops, and by enhancing related knowledge and skills in plant management (Vernooy et al, 2017). Better adapted varieties might also request fewer inputs, with resulting positive impacts on mitigation. Finally, the creation and conservation of a large number of varieties is also an important task for future adaptation.
	Participatory plant breeding: Breeding programmes which take place in the targeted environment (e.g. on farm) and which involve different stakeholders.	N_2O	WA – TV - DP - ECE	
Labelling	**Climate label**: a voluntary labelling system which can be used by producers or resellers who respect a set of requirements related to climate objectives.	All	All	The label or guarantee system might include criteria for mitigation (preserve carbon stocks, improving carbon sequestration through agricultural practices, etc.) or adaptation (e.g. production from a diversified farm). Moreover, it makes it possible to establish a network not just between producers but also with consumers, with potential positive impacts on climate challenges awareness.
	Participatory guarantee systems: these are an alternative to third party certification. They certify producers based on the participation of stakeholders and are built on trust, social networks and knowledge exchange (IFOAM)[91].	All	All	
Food production system organisation	**Local Food Systems** implying that the production, processing, trade and consumption of food occurs in a defined, reduced, geographical area (from 20 to 100 km radius) (Kneafsey et al, 2013)	CO_2	PV, (All)	Re-localization of production and UPAF might reduce GHG emissions due to reduced packaging, fewer intermediaries and shorter transportation between producers and consumers. However, some authors consider that such activities might not always imply a better performance in terms of energy use and environmental footprint, because of lower volumes produced and transported (Kneafsey et al, 2013). However, in order to meet consumer's expectations, the production is often more environmentally friendly and more diversified with potentially positive impacts on climate mitigation and adaptation (Kneafsey et al, 2013). Finally, when producers and consumers have signed a contract, for example the supply of vegetables once a week in return for financial commitment over a lengthy period, it helps to reduce the farmer's income variability.
	Urban and Peri-urban Agriculture and Forestry (UPAF): the growing of trees, food and other agricultural products within the urban build-up area and in the peri-urban areas (e.g. on rooftops, backyards, public open spaces, etc.) (Dubbeling, 2012).	CO_2	PV, TV, ECE	

[91] IFOAM Website https://www.ifoam.bio/fr/organic-policy-guarantee/participatory-guarantee-systems-pgs

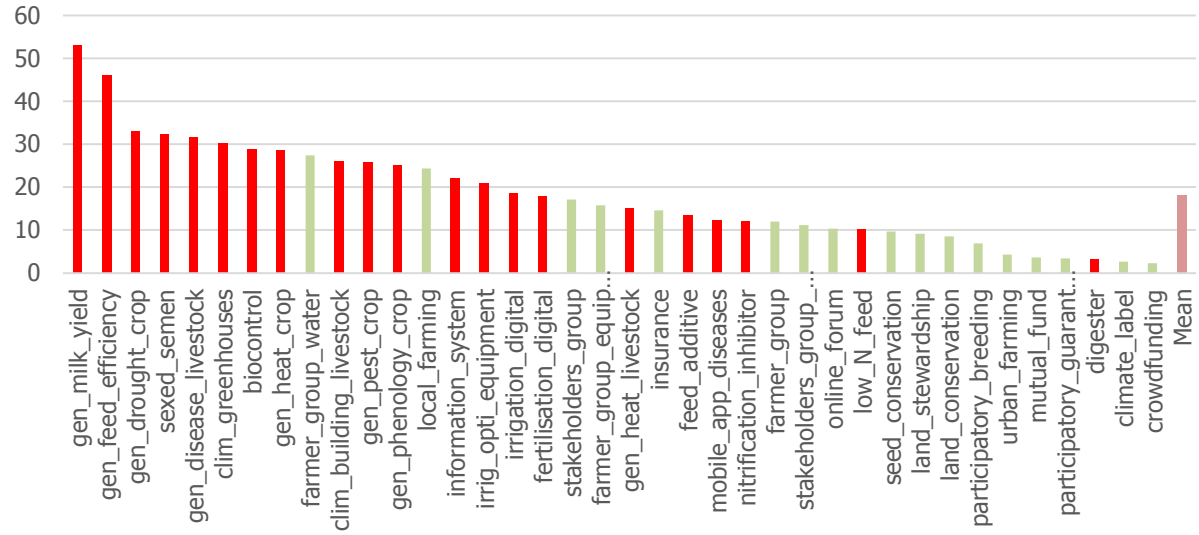
				(Dubbeling, 2012)

Source: Own compilation. **Notes:** *Innovations added after first analysis

11.3.2 ASSESSMENT OF THE LEVEL OF ADOPTION OF INNOVATIONS

Few data are available on the proportion of farmers using innovations at EU level (Soto et al, 2017) and the sparse data available are mostly regionalised and system-specific. To assess the level of adoption, two sources of information have been used in case study Member States: firstly, interviews by case study consultants with experts at MS level; and secondly, results from a survey of farm advisors and farmer representatives. Response rates in the survey of advisers and farmer representatives are quite low (see Annex 5). Moreover, as no responses were received in Romania, and results were incoherent in the Czech Republic, only the case study experts' answers are used for these Member States. Results presented in this section must thus be interpreted accordingly. The results of the adoption rates assessment are presented for all innovation sets and for the 10 case study Member States in Figure 30 and Figure 31.

Figure 30: Innovation adoption rate per technological (red) and social (green) innovation (%)*

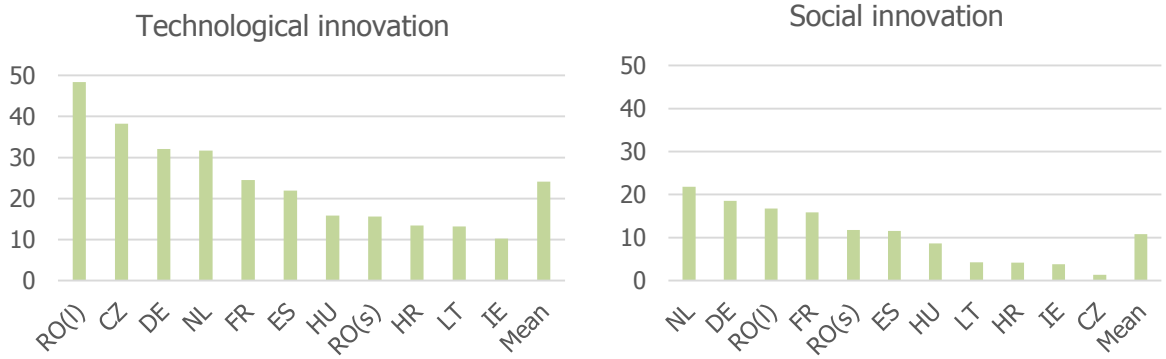


Source: Survey results of farmers' advisers and representatives **Notes:** * For innovation related with livestock (resp. crop) production, the figure shows the percentage of livestock (resp. crop) producers who were judged to have adopted the innovations.

Results show that innovation adoption is, on average, higher for technological innovations (24%) than for social innovations (11%). With regard to technological innovations, the use of genetically improved seeds or animal is quite common at the EU level as well as the use of sexed semen and climate-controlled greenhouses and livestock buildings. Social innovations are less frequently implemented by farmers, except for those participating in water management groups (and to a lesser extent in other stakeholder and farmer groups) and in local farming systems. However, it should be noted that the participation in water management groups can be compulsory in some Member States (e.g. in some regions of France or Romania). Also, the high level of participation in local farming systems can be explained by the fact that in some Member States, local farming systems are not innovative but are traditional forms of farming that have survived.

Adoption rate is also highly heterogeneous across Member States. Some Member States such as The Netherlands, Germany or France have been reported as relying extensively on both technological and social innovations, confirmed by the survey results. Yet other Member States such as Lithuania, Ireland, Croatia and Hungary rely less on innovations. The case of Czech Republic is interesting since it appears that farmers rely quite a lot on technological innovation but very little on social innovation. Case study experts explain that it is necessary to attain a certain level of social capital in order to be capable of implementing social innovations and that Czech farmers are not yet ready for that. Moreover, intra-national heterogeneity can be observed, depending on the region, the sector or the type of farm considered. In Romania for instance, two main types of farming systems co-exist: small traditional farming systems and large industrial farms owned by entrepreneurs mostly from other countries. The latter rely largely on technological innovations (mostly imported) while the former have little access to innovations. The case study expert in Romania thus decided to assess separately the level of adoption for these two types of farms (see Figure 31).

Figure 31: Innovation adoption rate per case study Member States and innovations (%)



Source: results of the survey of farm advisers and representatives in case study MS

Notes: For Romania and the Czech Republic, expert assessments have been used, while for other countries results of the online survey have been used. For Romania, the case study expert differentiated between the results for small traditional farms (RO(S)) and large farms hold by entrepreneurs (RO(l)).

11.3.3 Role of EU policies promoting innovations on climate objectives

Many EU policies have the potential to promote innovations which could impact on climate mitigation and adaptation within the CAP (mainly LEADER, EIP, M1, M2 and M16), but also outside the CAP (e.g. Europe 2020, LIFE projects, etc.).

Innovation within the CAP

Fostering innovation is a cross-cutting objective of the CAP. Thus, most of the measures can potentially influence innovation. In the EAFRD, innovation is also specifically targeted as both a cross-cutting priority and as the first of the six EU Priorities: 1 'Knowledge transfer and innovation in agriculture, forestry and rural areas' and the three focus areas linked to it (see Table 37). The main measures that are associated with these focus areas are M1, M2 and M16, because supporting training and information sharing and enhancing cooperation among stakeholders are important factors in promoting innovation. Indeed, by encouraging cooperation between stakeholders, new forms of social organisations can emerge; and better adapted and easy to implement technological innovations can be created, especially if the process of innovation is based on a bottom-up approach (SCAR, 2016). It should also be noted that not only can M16 promote innovation through cooperation but also through the EIP programmes (both at national and EU level), the National Rural Networks and LEADER approaches. Although EIP projects are mostly supported under M16 at national level, in some Member States the Operational Groups are financed under other measures such as M1 in Bulgaria and Finland, M2 in Croatia and Slovakia, or M4 in Finland and Sweden. Also, according to the Guidelines on how to promote innovation in RDPs, investment measures (M4) can also support diffusion of innovations (e.g. by facilitating the adoption of some technological innovations of use for climate actions). Finally, the risk management measure M17 is used in some countries to support mutual funds or insurance premia.

Table 37: Main features and targets associated with focus areas under the Priority 1

Focus area	Measure associated	RDP addressing the focus area	Target	Planned expenditure (EAFRD+MS contributions)
1A: Innovation, cooperation, and development of the knowledge base in rural areas	M1, M2 and M16	109 out of 112 RDPs	3.9% total RDP public expenditure under M1, M2 and M16 at EU level	156.3 billion EUR
1B: Strengthening the links between agriculture, food production & forestry, & research & innovation	M16	106 out of 112 RDPs	15 235 cooperation operations under M16	2.8 billion EUR
1C: Fostering lifelong learning & vocational training in the agricultural & forestry sectors	M1	100 out of 112 RDPs	3.9 million participants trained under M1	1.9 billion EUR

Source: Alliance Environnement analysis

Effect of the CAP measures on innovation for climate action

According to case study interviews, the mainstreaming of climate change action in M1 and M2 increased but remained generally low, thus the impact of these measures on climate-related innovations might be limited.

For M4, results are mixed. Only some Member States specifically target innovations that can have positive effects on climate objectives, as part of M4. For instance, GPS technology for tractors and for spraying machinery are supported in Ireland, irrigation modernization is supported in France and innovations are specifically targeted by a type of operation in the Netherlands called 'a guarantee for the introduction on market of risky innovations'. Moreover, it should be noted that even when innovation is not used as a criterion to select projects under M4, the low specificity of eligibility criteria often makes it possible to finance innovative equipment.

M17 has been programmed in a limited number of Member States, but when implemented has sometimes been effective; for example, in France the number of mutual funds in agriculture has increased since the introduction of this measure.

As for the EIP[92] under EAFRD, projects are implemented by 'Operational Groups' bringing together various stakeholders from different disciplines and occupations, and are mainly supported through M16 (Coffey et al, 2016). At EU level, 108 RDPs implemented cooperation projects through M16 (especially M16.1 and 16.2 and to a lesser extent M16.4 and 16.5) (Coffey et al, 2016). Out of these 108 RDPs, 98 (27 Member States) provide support for EIP Operational Groups. In the current programming period more than 3,200 Operational Groups are expected to be established. Although these groups can work on a wide range of topics, climate objectives are included within the EIP-AGRI objectives, and the work of the Operational Groups should be in line with these objectives (or at least should not run counter to them)[93]. At present no data is available to properly assess the effects of the Operational Groups on climate objectives. At the EU level, networks, focus groups, workshops and seminars have been established under the EIP-Agri to share knowledge and experiences of various subjects, most of them linked to climate objectives. For instance, out of the 28 Focus Groups set up since 2014, 23 are related to climate objectives (see Table XVI in Annex 5). As part of their work, the Focus Groups also identify the implications of their analysis for further research activities that can, for instance, be supported within Horizon2020 EIP projects.

[92] The EIP initiative is supported by two funds (Horizon2020 and EAFRD) and can therefore be implemented in two ways: at European level through multi-stakeholder projects from at least three Member States under Horizon2020; and at regional level through Operational Groups bringing together a plurality of actors (farmers, researchers, advisers, NGOs, SMEs, etc.) under the EAFRD.

[93] All the EIP projects have to contribute to the EIP-AGRI objective of promoting 'a resource efficient, economically viable, productive, competitive, low emission, climate friendly and resilient agricultural and forestry sector, working towards agro-ecological production systems and working in harmony with the essential natural resources on which farming and forestry depend' (EC Reg. 1305-2013).

Concerning LEADER, according to EU Regulation, local action groups should take into account local needs and potential, as well as relevant socio-cultural characteristics, but additional requirements (including on climate) can also be set out in RDPs. However, according to factsheets on the ENRD website[94], only one of 34 RDPs analysed specifically refers to climate challenges in its LEADER measure[95]. Finally, if the managing authorities have not sufficiently addressed climate challenges in their RDP, the local action groups (currently around 2,600 across the EU) can set out climate related requirements when selecting projects to be supported. Data are not available on the extent to which this has been done but, according to some interviewees, climate change challenges and especially adaptation challenges are becoming more and more important at local level and thus projects are increasingly addressing climate related issues.

Role of other EU policies or initiatives

Many other EU policies or initiatives are promoting innovations in the agriculture and forest sectors which can impact on climate change objectives (e.g. Horizon 2020, The European Institute of Innovation and Technology (EIT), the LIFE programme, the policies also supported by ESI-Funds other than the EAFRD such as the ERDF and the ESF). In depth analysis of the potential of these policies to support innovations relating with climate change is provided in ESQ9 on external coherence.

11.3.4 Other factors favouring or limiting social and technological innovations

Even if many innovations have the potential to address climate challenges in agriculture, most of them are rarely used. Moreover, addressing climate challenges will necessitate further innovation to devise new, better adapted and more efficient solutions (e.g. use of desalinated water is still too expensive to be implemented economically). Thus to enhance innovation for climate action there is a need to understand what factors are favouring or limiting the innovation process.

Barriers to and boosters of innovations can be categorised in different ways. For instance, they can be divided into factors impacting on the providers of innovations (e.g. manufacturers) and those impacting on users (e.g. a group of farmers). In the context of climate related technological innovations, factors impacting on the providers (on the supply side) can for instance be linked with difficulty in demonstrating the impact of an innovation (e.g. long-term impacts of an innovation on carbon storage in soil) or with lack of access to capital or investments. On the side of users, the fact that innovations are sometimes poorly adapted to 'on the ground' reality or are associated with high costs and low (often long term) returns are some of the key barriers for adoption according to (Long, Blok and Coninx, 2016).

According to the literature, factors impacting on innovation can also be divided into economic, institutional and regulatory, behavioural and psychological, organisational, consumer and market, and social factors. Economic factors are among the most frequently mentioned factors both in the literature and during interviews. For instance, the cost of innovations and low and uncertain expected returns have been mentioned as the principal factors explaining low levels of adoption during the case study interviews. Regarding innovations for mitigation, those for reduction of GHG emissions, or carbon storage are of little value to farmers (at least not directly), especially if they are scarcely remunerated for their efforts (e.g. climate related labels have not yet been developed). In the case of innovations aimed at adapting to the expected future effects of climate, the direct economic benefits are expected only in the medium to long term and thus the innovation should provide other, short-term benefits if it is to be implemented. Innovations that have a positive impact on both climate objectives and farmers' incomes (win-win innovations) are those with the most potential for adoption.

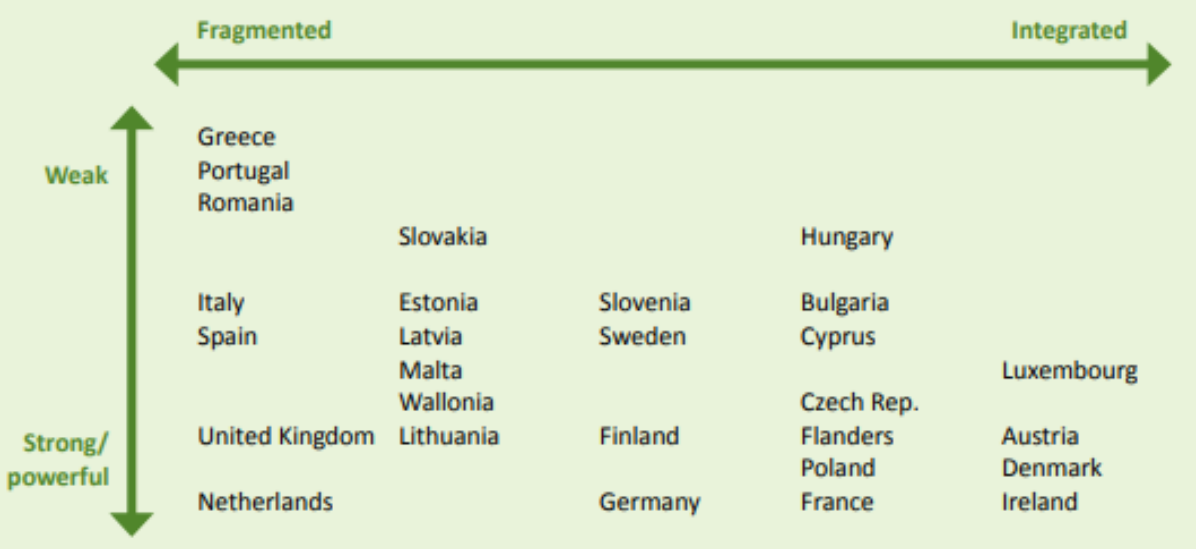
Institutional, regulatory and organizational factors are also highly important according to interviewees. For instance, a well-developed knowledge and innovation sharing network has been reported as boosting the whole process of innovation. Indeed, sharing information among stakeholders can motivate potential investors, increase the effectiveness of innovation in relation to

[94] https://enrd.ec.europa.eu/leader-clld/leader-cooperation_en

[95] The RDP for Cantabria in Spain refers to 'Contribution to the transversal objectives of environment, mitigation of climate change, and innovation' as principles for the establishment, by the LAGs, of the eligibility criteria.

farmers' needs, and provide incentives for farmers to adopt an innovation. More specifically, it has been shown that a strong and integrated innovation system (such as AKIS) – that links together agricultural research and educational systems, bringing together institutions (agricultural extension services, stakeholders platforms, political channels), agricultural value chain actors and policies - is a key factor to promote innovation (Knierim and Prager, 2015). In the EU, Member State innovation systems are highly heterogeneous (see Figure 32) and, according to experts in Member States, this can partly explain the heterogeneity observed in innovation adoption (e.g. strong innovation systems in The Netherlands, Germany and France where technological innovation adoption rates are quite high). Some tools are however available that aim to improve AKIS at the EU level, such as the EIP research and data building programme. In that context, the Copernicus programme (the European Programme for the establishment of a European capacity for Earth observation) supports innovation by providing reliable data that can be also be used for the agricultural sector (e.g. for precision farming).

Figure 32: An overview of European Member States Innovation System distinguished along a continuum from weak – strong and fragmented – integrated



Source: (Knierim and Prager, 2015)

Psychological and societal factors are also important, especially as farmers' choices are not always economically rational. For instance, even if an innovation can be both profitable and positive in terms of climate it is not always adopted by farmers. Case study Member State experts explained that changes in practices and adoption of innovations can sometimes be limited by the role of tradition, especially when farmers are poorly educated and mostly learnt how to farm from their family. In this context, social innovation and knowledge sharing can help enhance adoption.

Finally, an important point is that it is not just one factor that prevents farmers for adopting or developing innovations, but a combination of the factors mentioned above. For instance, important barriers to setting up a mutual fund include the administrative requirements, behavioural biases (individualism, lack of trust among farmers), and the need for sufficient financial reserves (European Commission, 2017).

11.4 Conclusions

Technological and social innovations in the agricultural sector have a high potential to contribute to the CAP's climate action goals. Many innovations exist which can help to limit GHG emissions and with adaptation to climate change in the livestock and crop sectors. Their overall impact depends on the pedoclimatic conditions and the farming systems where they are implemented as well as on how they are implemented. Few data are available to assess the effect of innovations on climate action. Therefore the overall impact of innovations on climate objectives could not be assessed.

At the EU level, 'fostering innovation' is a cross-cutting objective of the CAP and many measures can influence the emergence and adoption of innovations (M1, M2, M16 and M19 mainly but also M4 and M17). Many other policies (outside the CAP) can also enhance climate related innovation development

in the agricultural sector (LIFE programme, Horizon 2020, etc). Beyond policies, other factors that are also important to explain levels of emergence and adoption of innovations are mostly economic, societal, and linked with the development of strong Agricultural Knowledge and Information Systems (AKIS).

The potential for mitigation and adaptation of an innovation at EU level is highly dependent on the extent to which it is disseminated and adopted. Surveys and interviews in the ten case study Member States suggest that the rate of adoption of innovations is higher for technological innovation than for social innovation, and that within these categories some innovations are more widely taken up than others e.g. the use of genetically improved seed or livestock, and participation in water management groups. Moreover, results show that the use of these innovations is highly heterogeneous across the EU but also within individual Member States.

Some limitations and risks associated with the use of technological innovations have also been highlighted in this analysis. These can be technical, linked to data ownership, allocation of responsibility (e.g. in the case of robot failure) and to security and consumers' information.

12 EFFICIENCY (ESQ7)

ESQ7: To what extent has the CAP as implemented by the Member States generated value-for – money, i.e. to what extent has the CAP generated the best possible results towards the objective of climate action with its available budget?

- To what extent are the administrative burden and administrative costs proportional to support and results?
- To what extent is there scope for efficiency gains, simplification and burden reduction?
- Did simplification occur in the evaluation period?

12.1 UNDERSTANDING OF THE QUESTION

The assessment of the CAP's efficiency in achieving climate action objectives requires analysis of whether the budget allocated to climate action could have been used in a different way to yield better results, or alternatively if similar results could have been obtained with a lower budget.

Cost-benefit analysis of the CAP's contribution to climate objectives is very complex, because the effects depend heavily on the context and location in which the measures and instruments in the CAP are used. The benefit to mitigation of a cover crop, for example, depends on the type of soil on which it is grown, the organic matter contained in that soil and how vulnerable it is to erosion, and any changes in the extent to which the following crop requires mineral fertilisation. For mitigation we use the quantified results from ESQs 1-4 which are based on average emission factors to give a partial picture of the "cost per tonne" of reductions in net emissions. Adaptation benefits are equally if not more context and site-specific but also uncertain given the difficulty of predicting future needs and the possible adaptation responses. The value of actions undertaken for reasons of adaptation is highly uncertain for these reasons. Co-benefits also complicate the analysis since few CAP measures deliver benefits only to climate objectives. The method used to track spending in the ESI-Funds against the EU's commitment to spend 20% of its main funds on climate actions is used in the analysis to correct for this.

Due to these complexities the analysis makes only a limited assessment of value for money. It focusses on budget tracking and allocation as a means of judging the extent to which resources have been directed to the measures and actions most relevant and effective for climate action. These are compared with the quantified reductions in GHG emissions identified in the analysis carried out for ESQs 1-4 to give a very approximate idea of the CAP's cost-effectiveness as a means of securing mitigation benefits.

In order to illustrate the extent to which value for money has been maximised by Member States and to illustrate potential efficiency gains, the analysis considers the steps taken to target different measures, and the extent to which use has been made of available means of limiting deadweight and promoting additionality (including private funding where appropriate). The need to better identify and define the CAP tools relevant to climate adaptation, and to limit cases of maladaptation is also

discussed as a way to increase efficiency. Finally, the analysis considers administrative burden and the extent to which simplification of the measures addressing climate action has occurred.

12.2 PROCESS AND METHODOLOGICAL APPROACH

The first step was to analyse the budget allocated to climate action in both pillars. Spending data for each Pillar I measure from Member States' Annual Implementation Reports (AIR) was adjusted using the EU's climate tracking methodology to reflect the fact that some of the measures also have non-climate objectives are part of their intervention logic. This is the case, for example, with the greening measure which funds income support and other benefits as well as benefits to climate action. For Pillar II RDPs, the tracking methodology counts weighted expenditure on a number of the focus areas to which Member States have programmed their spending. This method has been slightly adapted in the analysis below to differentiate adaptation and mitigation spending. It should be noted that the RDP spending tracked in this way is different from the total of spending on climate and environment measures, which is required by article 59(6) of the Rural Development Regulation to be at least 30%. The latter figure is based simply on the spending on a specific set of measures and takes no account of the extent to which it has been programmed to climate-relevant focus areas.

The second step was to summarise information from previous ESQs about the benefits of the measures addressing climate action with the intention of drawing conclusions about the proportionality of the spending in the light of its benefits.

Potential sources of inefficiency and the potential for efficiency gains have then been analysed. This section mostly focused on the prevention of deadweight and promotion of additionality (especially between public and private funds), and on the extent to which climate funds have been targeted.

The last step was to assess the administrative burden and the extent to which simplification occurred both between the two programming periods (before and after 2014) and within the actual programming period (e.g. as a result of the Omnibus Regulation). This has been based on literature review, Member State notifications of their implementation choices and case studies. This part of the analysis has been carried out only for the subset of measures identified in Table 1 as having climate-relevant intervention logic. This is because it is not possible to ascribe a "climate" component to the burden associated with non-climate measures such as the basic direct payment or VCS.

Each of these steps involved methodological difficulties that are summarised in Box 18.

Box 18: Methodological difficulties encountered when assessing efficiency of the climate measures

Data on expenditure and measure uptake in RDPs is not disaggregated to the level necessary to enable analysis of the cost-efficiency or cost-effectiveness of support for different types of operation to be undertaken. For the analysis in ESQs1-4 the available uptake data has been split by type of operation using expert judgment. However, it is not possible to do the same with the cost data because the costs of different types of operation vary so widely across the EU. Analysis of the efficiency of RDP climate spending could therefore only be conducted in a generalised fashion.

The ESI-FUND tracking methodology used to establish climate budget figures for the analysis does not discriminate between spending on adaptation and spending on mitigation measures. This makes assessment of the relative cost effectiveness of adaptation and mitigation spending difficult. A method has thus been developed below to differentiate the RDP budget associated with mitigation from that for adaptation. In general, the budget calculated using the ESI-FUND tracking method is an imperfect indicator of climate spending as a whole. This is discussed further in the analysis below.

The mitigation benefits which are compared with tracked climate spending are the simulated results of individual measures, whereas the Pillar I tracked spending figure is derived from focus areas. This is an imperfect comparison as discussed below.

Some data is missing. AIR data for three RDPs was missing altogether and it was incomplete in the case of others.

Finally, a key methodological difficulty is the absence of quantified information about many of the benefits of the measures under consideration. Due to the absence of relevant data for several measures, including

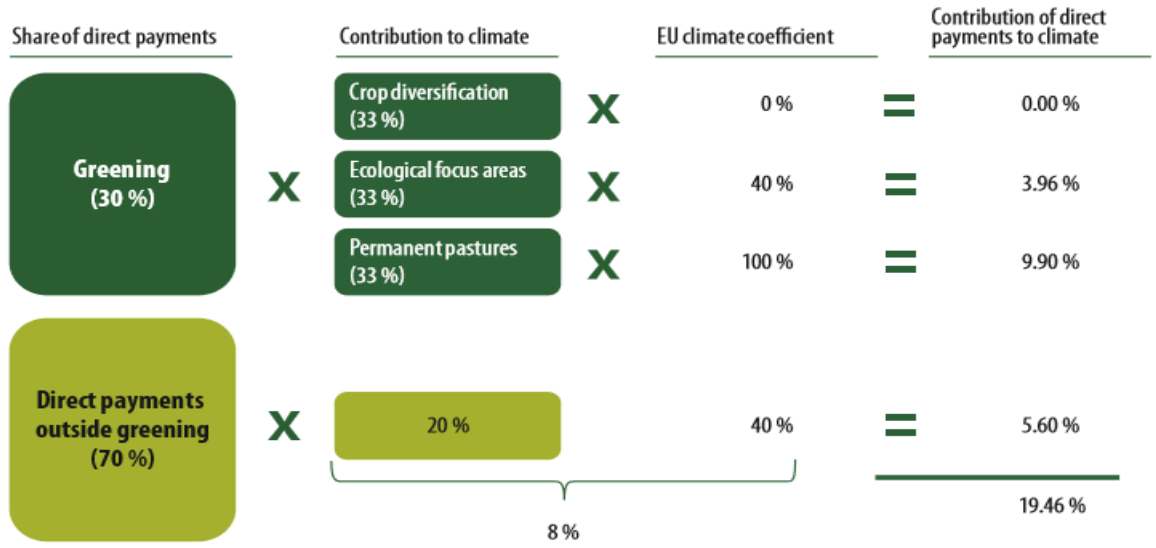
notably the greening permanent grassland ratio and cross-compliance GAEC, it has not been possible to quantify the full impact of tracked CAP climate spending. Quantified results are available for the greening ESPG measure, EFA M4, M8, M10, M11 and M12 but are subject to significant caveats regarding their accuracy. Quantified results for the benefits in relation to adaptation of these and other measures are not available due to the site specific and uncertain nature of the benefits associated with reducing vulnerability to risk. Finally, analysis of administrative burden and cost is impeded by the fact that Member States do not usually record the administrative costs and burdens associated with individual measures. A separate section on administrative costs have however been included.

12.3 ANALYSIS

12.3.1 EFFICIENCY OF CAP MEASURES ADDRESSING CLIMATE OBJECTIVES

The first step of the evaluation was to analyse budget allocations for climate action across the CAP. To do this we utilised the methodology used by the Commission to track climate spending in the EAGF and ESI-Funds. The calculation made to estimate the contribution of the CAP to climate funding for Pillar I is based on allocating one of three possible climate markers (0%, 40% and 100%) to each item of expenditure. It does not distinguish between adaptation and mitigation actions. For Pillar II, the tracking method, which is based on focus areas, has been slightly modified in order to differentiate the mitigation and adaptation budgets (Figure 33).

Figure 33: Overview of the method used by the Commission to calculate climate funding from agricultural direct payments



Source: ECA, 2016

12.3.1.1 Efficiency of greening measures toward climate action

Using the methodology in Figure 33, the shares of direct payments estimated to be contributed to climate change through greening measures are 0%, 3.96% and 9.9% for the crop diversification measure, the EFA measure and the permanent pastures measures respectively[96], for a total of 13.86% (i.e. €6.1 billion per year). Of this climate spending, €4.38 billion is attributable to the permanent grassland measure and €1.75 billion to EFA. A further €2.48 billion is attributable to direct payments other than greening.

For mitigation, the analysis made for ESQs 1-4 estimated that the permanent grassland ESPG measure had led to an annual reduction (in 2016) of 15.8 Mt CO_2eq. No quantified result was obtainable for the permanent grassland ratio. If all the climate spending associated with the permanent grassland measure were to be attributed to ESPG, then the simulated reductions in

[96] Spending at least one euro in every five from the EU budget on climate action: ambitious work underway, but at serious risk of falling short, European Court of Auditors, 2016

emissions achieved by the ESPG measure would be obtained at a cost of €221/tonne CO_2eq. However, ESPG represented only 16% of permanent grassland subject to greening, with the remaining 84% subject only to the ratio. If we assume that the same 16% of the climate spending attributable to the permanent grassland measure was paid in respect of ESPG, with the remaining 84% paid to farmers whose grassland was subject to the ratio but not designated ESPG, then the mitigation benefits of the ESPG measure are obtained at a cost of €0.7 billion or €44/tonne CO_2eq.
For the EFA measure, €1.75 billion of attributed spending is associated with mitigation benefits of 4 Mt, at a cost of €437/tonne CO_2eq. It must be borne in mind that (as with the ESPG measure), biodiversity rather than climate is the intervention logic of the EFA measure. Neither of the cost per tonne calculations takes into account the value of other benefits secured.
For adaptation, it has not been possible to quantify any benefits although measures which encourage the protection of grassland, the prevention of soil erosion, and the adaptation of farms via crop diversification have all been identified as having adaptation benefits (see ESQ5).

Overall for the greening measure, €6.1bn of annual expenditure assessed to be climate relevant is buying a simulated 19.8 Mt annual reduction in CO_2eq, plus significant but unquantifiable mitigation benefits from the protection of permanent grassland and the adaptation benefits referred to above. The budget involved amounts to €278 for each quantified tonne of CO_2 reduced, although this does not give the full picture since the unquantifiable benefits of the permanent grassland ratio are not included. Moreover, this analysis only includes the direct cost of the measure and does not considered other costs such as cost of compliance for farmers or administrative costs. According to the Greening evaluation (Alliance Environnement and Thünen-Institut, 2017), compliance costs for farmers were assessed as being negligible for all except highly specialized arable farmers, for whom the crop diversification measure entailed costs. On the other hand administrative costs for farmers are quite high especially as regards the EFA measure, but this is assessed in section 12.3.3.

12.3.1.2 Efficiency of non-greening spending on direct payments toward climate action

The tracking methodology in Figure 33 attributes 20% of non-greening spending on direct payments to climate and assigns it a marker of 40%. On this basis a further €2.48 billion a year is considered to be climate spending. The contribution of cross-compliance to climate objectives is given as the main reason for tracking a portion of non-greening EAGF expenditure as climate spending.
Only GAECs 4, 5 and 6 are identified in Table 38 as measures addressing the mitigation objective and no GAEC is identified as having an intervention logic of adaptation. The actual impacts of GAEC rules cannot be quantified and no simulation result for cross-compliance was achievable. Indeed, Member States set the detailed rules whose incidence, as discussed in ESQs 1-4, is site-specific. Also, the nature of the rules set by Member States is diverse. For example, most of the case study Member States impose the lightest possible rule for GAEC6 – a ban on burning crop residues, which is required by the regulation. But Hungary and Romania place restrictions on which crops may be grown in successive years, and the Czech Republic requires the incorporation of manure or the use of N-fixing plants. As the result the extent of the burden which these rules place on farmers is also very diverse (CRPA, TI and IFCN, 2014).

An overall assessment of the cost-benefit ratio of cross-compliance GAECs and more generally of the non-greening direct payments in respect of climate benefits, is not possible due to the lack of reliable quantitative evidence about both benefits and costs.

12.3.1.3 Efficiency of RDP measures toward climate action

Ten of the 19 Focus Areas (FA) in RDPs are treated as being climate relevant according to the Regulation[97]. These are shown in Table 38 along with the expenditure programmed and spent against each one by Member States (as revised in 2017). As is the case with Pillar I instruments, the tracking methodology allocates coefficients according to how strongly associated with climate each FA is considered to be. A coefficient is thus associated to each FA (100% in eight cases, 40% in two) which have to be multiplied by the corresponding budget to calculate the budget dedicated to climate. This method can be used to determine the budget allocated to climate action in RDPs. But since no formal distinction is made between mitigation and adaptation expenditure, a means of splitting the budget

[97] Article 2 of Commission implementing regulation (EU) no 215/2014

allocated between the two has been developed. This separation of mitigation and adaptation for planning and recording of climate action funding is also promoted through the principles developed by international actors for tracking climate financing (EIB, 2015). A FA has been considered to be beneficial for mitigation when it covers emission limitation, energy saving, soil erosion, enhanced fertilization and carbon management. A FA has been identified as positive for adaptation when it covers risk management, soil erosion and water management. Based on these criteria some FA have been identified as beneficial for both adaptation and mitigation objectives and other FA for only one of these objectives (see Table 38). As for priority 4 (restoring, preserving and enhancing ecosystems), expenditure has not been disaggregated between the FAs. As both FAs 4B and 4C are positive for both adaptation and mitigation, all priority 4 spending has been treated as positive. A similar choice has been made for Focus Area 6B since rural development can benefit both mitigation and adaptation depending on the actions implemented.

The shares of EAFRD budget allocated to adaptation and to mitigation have been calculated, based on the tracking methodology described above. The results show that the budgets dedicated to mitigation and adaptation are similar, €16.5bn and €16.9bn respectively in 2015- 2016 (see Table 38). They of course overlap to a considerable extent.

The analysis carried out for ESQs 1-4 has simulated a reduction attributable to RDP measures (M4, 8.1, 8.2, 10.1, 11 and 12.1) of 6.4 Mt CO_2eq in 2016. As with Pillar I, there are measures whose impact could not be simulated. It should also be noted that some of the measures for which mitigation effects were not measured, account for a large part of the tracked climate budget (especially M13 and to a lesser extent M7 and M19). As a result, the efficiency of the RDP measures calculated below might be underestimated. If the unquantifiable benefits are not included, the simulated reductions achieved by RDP measures are achieved at a cost of €194/tonne. No allowance has been made for emission reductions in future years which result from investment spending. In principle these will reduce the "cost per tonne" figure further. In practice the simulation for ESQs 1-4 identified very few emission reductions associated with investment. As regards adaptation, as there is no quantified assessment of adaptation benefits, and thus a judgment of value for money cannot be made.

Table 38: Adaptation and mitigation relevant focus areas

Focus Area	Climate marker (according to the tracking methodology[98])	Planned EAFRD budget allocated 2014-2020 (2017) (€M)	Total EAFRD public expenditure (2015-2016) (€M)	Adaptation *	Mitigation*	Total EAFRD public expenditure for adaptation (2015-2016) (€M)	Total EAFRD public expenditure for mitigation (2015-2016) (€M)
3B Supporting farm risk prevention and management	40%	421	427	X		171	
4A Restoring, preserving and enhancing biodiversity	100%	66,812	15,444			15,444	15,444
4B Improving water management, including fertilizer and pesticides management	100%			X	X		
4C Preventing soil erosion and improving soil management	100%						
5A Increasing efficiency in water use by	100%	2,977	53	X		53	

[98] Commission implementing regulation (EU) no 215/2014 (Annex II)

agriculture							
5B Increasing efficiency in energy use in agriculture and food processing	100%	1,042	32		X		32
5C Facilitating supply and use of renewable sources of energy	100%	1,303	22		X	22	22
5D Reducing greenhouse gas and ammonia emissions from agriculture	100%	2,071	275		X		275
5E Fostering carbon conservation and sequestration in agriculture	100%	369	553		X		553
6B Fostering local development in rural areas	40%	16,445	577	X	X	223	223

Source: own compilation based on AIR data (2017) and MS financing plan for the period 2014-2020 (updated in 2017).
Notes: *based on own analysis; X = direct link

When looking at Focus Areas it can be seen that the vast majority of the budget is programmed under Priority 4 (restoring, preserving and enhancing ecosystems related to agriculture and forestry). This is largely due to the fact that the large budgets dedicated to M10, M11 and M13 have been mostly dedicated to Priority 4 (Figure 34). It should however be noted that neither M11 (organic farming) nor M13 (support to Areas of Natural Constraint) are measures with a climate-related intervention logic (see section 2). Some reductions in emissions resulting from M11 were nonetheless simulated in the analysis for ESQs 1-4. However, no emissions reductions resulting from M13 were simulated.

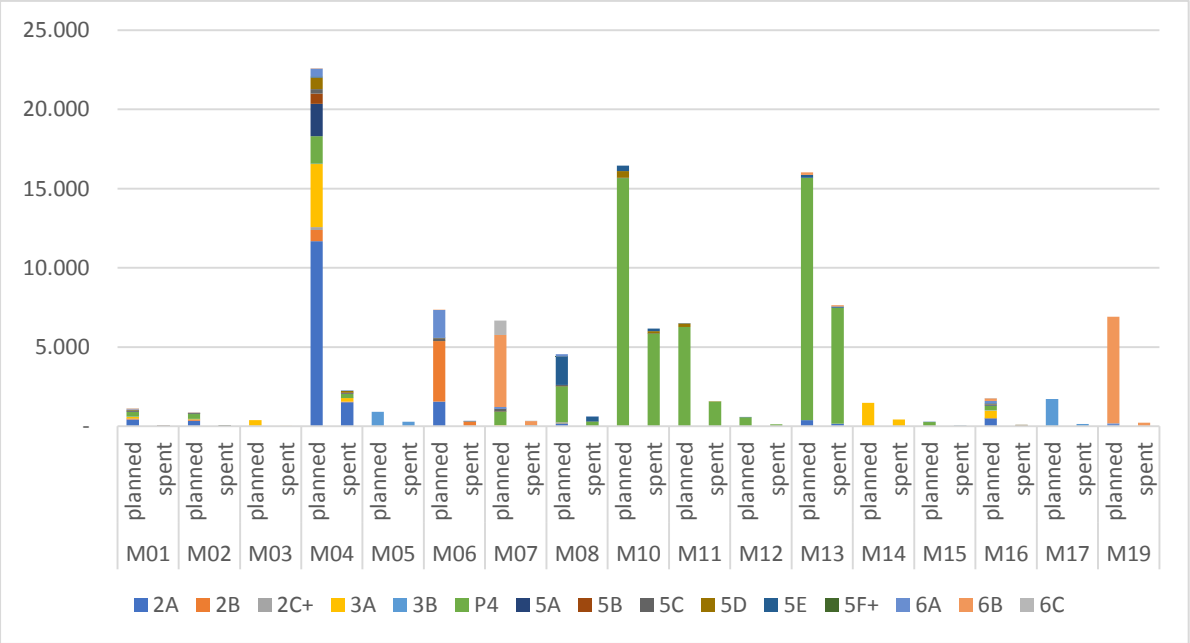
Non-climate factors can inform Member States' programming of expenditure to Focus Areas. The French case study found that some Managing Authorities have allocated the greatest budget to a single priority (usually Priority 4) in order to reduce administrative complexity. This is a further reason why the tracked figure (even when M13 spending is taken out) results in an overestimation of the cost per tonne of using RDP measures to mitigate GHG emissions. This risk of over-estimation of climate budget has also been identified in a recent study of climate mainstreaming (Ricardo et al., 2017). As for the FA under Priority 5 (Promoting resource efficiency and supporting the shift toward a low-carbon and climate resilient economy) which has climate as its principal objective, little budget has been dedicated to this priority and only a small proportion of this has been spent in 2015 and 2016. Six Managing Authorities (among the 115) have chosen not to implement Priority 5 at all. These are Finland–Aland, France-Lorraine, France-Mayotte, Germany-Hesse, Slovenia and the Netherlands. According to case study interviews, the Netherlands chose to address agricultural emissions through its national policies and therefore no measures were programmed to Priority 5. When analysing the level of Priority 5 public expenditure at Member State level, it appears that Eastern Member States (e.g., HU, RO, BG), and Portugal and Spain did plan to spend more than the average on mitigation while Scandinavian and more northern Member States (PI, AT, CZ) planned to spend less (Dwyer et al., 2016). Therefore, the targeting of budgets toward Priority 5 is quite low and variable between Member States.

More generally, it has been reported during interviews with Managing Authorities that the measures programmed under climate-relevant Focus Areas mostly impact on climate mitigation and adaptation via side-effects with their main objective being other goals such as biodiversity. However, the case study evidence also suggests that very little expenditure which might reasonably be considered to be climate spending is being allocated to Focus Areas which are not tracked.

This analysis thus showed that the quantifiable reductions achieved by RDP measures are achieved at a cost of €194/tonne with unquantifiable benefits to both mitigation and adaptation also secured. The

analysis also highlighted the limitations associated with the tracking methodologies especially for Pillar II spending.

Figure 34: Total public expenditure planned for the programming period 2014-2020 and spent in 2015-2016 per measure and per FA (million EUR)*



Source: AIR data (2017) and MS financing plan for the period 2014-2020 (updated in 2017)

Notes: *There are no common output indicators linked to the focus areas under the Priority 1 as it is a cross-cutting Rural Development Priority reflected in the rest of the Priorities

Member States are required to spend at least 30% of their RDP budget on environment and climate measures. Only spending on certain measures is counted for this requirement, and it does not matter which Focus Area a Member State allocates it to. Besides the fact that this requirement does not differentiate between environmental and climate measures, the case studies found that this ring fence was having little impact on how budgets were allocated. It is important, however, to distinguish expenditure within this ring fence from the expenditure tracked by the tracking methodology.

12.3.2 EFFICIENCY GAINS

The scope for efficiency gains in respect of the CAP measures addressing climate action has been examined through case study interviews and literature review. This part of the analysis considers how the existing budget might have been spent so as to achieve better results for adaptation and mitigation.

12.3.2.1 Preventing deadweight and promoting additionality

Both mitigation and adaptation actions can benefit private interests (e.g. farmers). Adaptation is in most cases a private good whose benefits are enjoyed locally, although both agriculture and forestry can contribute to the wider adaptation needs of society. Reductions in GHG emissions are in themselves public goods but the means through which they are achieved may have private co-benefits. As a result, private entities can in theory be expected to finance some climate actions. Good coordination between private and public funding is thus key to preventing deadweight and securing additionality.

Deadweight occurs when a measure funds actions which would have been taken in the absence of such funding. For Pillar II, most cases of deadweight reported during interviews concerned the AECM (M10) and the investment measure M4. When the requirements for support under M10 (or M11) are similar to the usual practices in an area, there is a high risk that the payment does not secure additional climate benefits. For instance, grassland is usually managed extensively in Hungary but

farmers are still paid to convert to organic even though little if any change is required. Also, in France-Aquitaine, some AECM schemes for livestock producers were mainly designed to compensate for the loss of other payments (e.g. the PHAE 'Prime herbagère agro-environnementale" scheme) with requirements deliberately set close to usual practice. Following budget cuts some of these measures with poor additionality were withdrawn.

The cost-efficiency of public spending is greatest when the costs of securing any private benefits are born by private individuals themselves. However, even where benefits accrue largely to private interests, public support may be justified on the grounds that the scale of investment needed is beyond the capacity of those interested parties to finance. Or public funding may be needed as a pump-primer to encourage private investment. M4 has been used extensively in such a way, although care has been needed to avoid deadweight effects and to ensure adequate targeting (see section below). The Rural Development Regulation also allows the use of financial instruments such as loans in place of grants to leverage private funding. However, these have not so far been used to finance adaptation actions for which the prevalence of private benefit would make them an obvious choice. The 2013 CAP reform also provided Member States with greater scope to finance risk management instruments such as an income stabilisation tool or subsidies to help cover the costs of insurance. This has encouraged private initiatives to develop sometimes from a low base. For example, according to the French Ministry of Agriculture mutual funds have expanded in France since the implementation of the dedicated measure. However, such tools have not yet been widely offered or taken up.

12.3.2.2 Use of targeted approaches

The previous analysis (ESQs 1-5) has shown the site-specific nature of both adaptation and, to a lesser extent, mitigation benefits. This means that there is a case for both sufficient flexibility to support the many types of action that can be beneficial to climate and improved targeting of that support both at EU and Managing Authority level to enhance policy efficiency with respect to climate action.

Many cases where better targeting of support would lead to an increase in efficiency have been highlighted. For example, the analysis for ESQ8 has shown that protecting carbon-rich soils such as peatland is particularly beneficial to climate mitigation, compared to protecting other soils.

Targeting has been little used in the present 2014-2020 CAP due either to the way measures are designed or to the choices made by Member States/Managing Authorities. However, a few examples where targeting has led to an improvement in efficiency can be found. For instance, Scotland has required lime and fertiliser plans via a compulsory equivalence scheme for the permanent grassland ratio measure. Under cross-compliance, the Czech Republic has rules under GAEC 5 which restrict the crops that can be grown and how the soil may be cultivated in areas judged to be at risk of erosion by water. Germany also focusses some of its cross-compliance rules on areas at risk from water erosion. Targeting in this way improves the ratio of benefits to costs. For the EAFRD, eligibility and selection criteria allow Managing Authorities to focus on particular localities, social structures and farm types. For example, in France some Managing Authorities use eligibility and selection criteria to target farmers involved in farmers' groups working on the diffusion of agro-ecological practices that are considered favourable to adaptation. Yet**,** even though it is possible to better target CAP support, the targeting is rarely used to focus climate action. For instance, interviews in several Member States and regions (Andalucía in ES, CZ, IE, LT, Saxony Anhalt in DE) pointed out that the targeting of mitigation hotspots or vulnerable and/or resilient areas across their RDP is limited and could be significantly improved. For instance, the RDP in Saxony-Anhalt does not address the protection of peatland even though there is peatland in that Land and protecting peatland is one of the most carbon-efficient measures available.

A recent study (Dominguez and Fellman, 2015) draws attention to the variation in direct and indirect costs between Member States, and the differing potential to benefit from certain measures. For instance, the room for manoeuvre and the costs associated with improving productivity (to reduce emissions per quantity produced) is limited for the western Member States whereas for other Member States (e.g., RO, LT and HU) there is still room for improvement at affordable cost (Dominguez and Fellman, 2015). Conversely, promoting technology adaption is likely to be easier in Member States where advisory services are in place and where the level of knowledge and experience in the sector is sufficient.

12.3.2.3 Better identifying climate options

As shown in the introductory section, some measures that do not have explicit climate objectives according to EU regulations are nonetheless relevant for climate. This is especially the case for measures that can be beneficial for adaptation. In order to achieve better results for adaptation in particular it is thus important to demonstrate the climate benefits which can be achieved through the use of such measures. A recent study for the European Commission advocates that a detailed assessment of the climate results and relevance of measures in necessary to improve the targeting and monitoring of climate actions (Forster et al, 2017). A clearer and more transparent intervention logic for climate could help Managing Authorities to achieve that.

12.3.2.4 Screening for maladaptation

Screening for maladaptation that will avoid public expenditure on infrastructure, or sectors that may increase vulnerability in the medium to long term, such as irrigation infrastructure in areas with depleted water resources, or the promotion of an excessive specialisation of whole areas, can improve efficiency by enabling maladaptive actions to be avoided. EC guidelines (EC, 2013) promote the use of such safeguards but the RDPs examined in the case study Member States contained no evidence that the guidelines were being followed. For instance, resilient or low emission practices could be made a condition of eligibility even for measures whose declared purpose is not climate action.

12.3.3 ADMINISTRATIVE BURDEN AND SIMPLIFICATION

The administrative burden linked to the implementation and running of CAP climate-relevant measures has been assessed. It has then been compared with the similar measures of the CAP 2007-2013 in order to assess the extent to which simplification occurred leading to a decrease in administrative burden. This analysis is based on literature review and results from case study interviews.

12.3.3.1 Administrative burden of the greening measures

The greening evaluation (Alliance Environnement and Thünen-Institut, 2017) estimated that for most Member States the one-off implementation costs of the greening measure fall between €0.24 and €0.69 per hectare, with running costs of between €0.12 and €0.60. They arose mainly from on-farm controls and the obligation to map landscape features into the Land Parcel Information System (LPIS). The Commission and farmers also incur administrative costs, with costs to farmers estimated at €86m – €217m a year. The estimated additional annual administration costs associated with the greening measure account for 3.0 – 8.5% of the total public administration costs associated with the management of direct payments. These costs relate to the greening measures as a whole.

The administrative burden of the greening measures is especially associated with their management and control (Hart, 2015). There has however been some simplification since 2015. They are summarised in Table 39.

Table 39: Relevant simplification initiatives relating to greening since 2015

Item	Content	Source
Crop diversification	Regional or sub regional control periods for crop diversification permitted.	EU (2017/1155) (Art. 1 (3))
Crop diversification	Possibility to count mixed crops as well as single species	EU (2017/1155) (Art. 1 (3))
Landscape elements / Buffer strips & field margins, etc.	Simplification of the size criteria for certain elements	EU (2017/1155) (Art. 1 (4))
Buffer strips & field margins, etc.	Simplification of the possibility to use the area	EU (2017/1155) (Art. 1 (4))
Payment reductions in case of non-compliance	Simplification of the calculation of administrative reductions	EU (2017/723) (Art. 1 (3,4))
EFA	Compensation for absent or non-qualifying EFA by another	OTSC Guidelines

	EFA (type and location can be modified by the farmer to a certain degree after the aid-application)	
EFA	Not all potential permanent EFA must be mapped in the EFA layer	EFA Guidelines
EFA	No longer need to distinguish between hedges or wooded strips and trees in line Merged EFA in amended Delegated regulation	EFA Guidelines and EU (2017/1155) (Art. 1 (4))
EFA	Allow gaps in hedges or wooded strips of up to 4 meters	EFA Guidelines
EFA	Adjacent landscape features can be located within 5m buffer around agricultural parcel	EFA Guidelines
Permanent grassland	Reduced requirement for identification in the LPIS of areas with PG-ELP	LPIS Guidelines

Source: own compilation

12.3.3.2 Administrative burden of RDP measures

It was not possible to quantify the level of administrative burden of the RDP measures. However, several issues regarding administrative burden when programming and implementing RDP measures were reported during CS interviews at Member State and Managing Authority levels and also in the literature. Most concern changes to the Regulation between the two programming periods. The costs and burden discussed are mostly not specific to climate, but they can affect the extent to which some of the measures which address climate action can be used effectively.

The new framework for the strategic planning of RDPs and the other ESI-Funds has introduced more complexity and administrative burden into the programming process (Dwyer et al, 2016). The requirements for clear identification of needs, targeting of support and attribution of spending to focus areas and objectives are important in securing value for money. However, they have an administrative cost, and case study interviews with Member State and Regional officials show that they have been found in some cases to be difficult to implement due to shortages of suitably trained staff. Member States are also required to increase the degree of coordination between the different ESI-Funds. The case studies demonstrated that Member States and Managing Authorities have found this additional strategic planning activity demanding. The complexity involved has led some Member States and Managing Authorities to program fewer measures in their RDPs than in previous programming periods and to fund some actions through national funds instead (e.g. NL, DE), to focus measures on a few Focus Areas to simplify monitoring (e.g. FR-Aquitaine), or to avoid tailoring measures to local needs.

Some specific measures have also been judged too complex by some Member States who have avoided their use in order to alleviate administrative burden. This has been the case for measures M1 and M2. Spending on measure M1 (Knowledge transfer) has decreased compared to the last period in 16 Member States (Dwyer et al, 2016). The administrative difficulties cited by Member States with this measure are the requirement for formal tendering and the restriction that funding may be paid only to a "beneficiary" who is directly involved in the knowledge transfer concerned. This has caused difficulties in Member States such as France where the use of organisations such as Chambers of Agriculture as an intermediary is commonplace. 19 Member States have decreased their expenditure on measure M2 (advisory services) (Dwyer et al, 2016). Again, service providers had to be selected through a call for tender and were required to be the only provider of the relevant advice or training in the region/country. As a result and to limit administrative burden some Managing Authorities decided not to not open the measure. This is the case for example with various regions in France, DE Saxony-Anhalt and the Czech Republic. Other Managing Authorities which did open the measure received no applications since no potential applicant had the capacity to cover the entire territory. This was the case in Spain.

The Omnibus regulation of 2017 has corrected some of these problems, especially since the Managing Authority can now be the beneficiary of the measure and the need for open tendering to select beneficiaries have been removed. It has been replaced by a selection procedure open to both public and private bodies that is intended to be objective and exclude candidates with conflicts of interest. Overall the design of both M1 and M2 from 2014 to 2018 failed to take into account the very different situations of advisors and training providers across the EU. This was especially a problem in Member States such as Spain and the Czech Republic where there are no alternative sources of public funding for farm advice and in the absence of CAP provision the task falls to private providers who are unlikely to offer advice about climate action.

The new system has also been found to increase the complexity of RDP implementation, with a considerable additional level of administrative control and monitoring (Dwyer, 2015). For example, case study interviews at Management Authority level in France reported that the need to administer and control 100% of the payments requested led to additional administrative burden and sometimes serious delays. In Croatia, the Managing Authority complained that M6 was popular with small farmers but required a disproportionate amount of analysis of their business plans.

The level of administrative burden at the level of beneficiaries has been reported during case studies as one of the important reasons why some farmers do not apply for certain forms of support during interviews. For instance, in Ireland it has been reported that the GLAS agri-environment-climate measure (M10.1) has fewer applications from dairy farmers than expected. This was attributed by the Managing Authority to farmers not finding the payment levels attractive alongside concerns about extra paperwork for both application and inspections. The same conclusions were noted by Managing Authorities in France in respect of both M4 and M10 AECM (especially for some systems with high profitability such as legume production in the North of France). Some farmers in France have tried to form associations in order to request support under M4 whilst sharing both paperwork and the risk of rejection.

According to the evaluation of forest measures (Alliance Environnement and EFI, 2017), the forest measures (M8, M15) have not been taken up in a number of Member States (e.g. in Ireland or some federal states in Germany) due to the requirements in the regulation (e.g., forest management plan, selection criteria, control and reporting requirements). The EC reinforced the requirements for transparency and traceability between the two programming periods. According to this evaluation it seems that the additional workload was mostly transferred by Member States to beneficiaries. The administrative burden is especially high for small holders with low financial and/or technical capacity. Both the workload and the delays in approvals and payments increased compared to the previous period.

12.3.3.3 Administrative burden of cross-compliance

At the MS level, running costs comprise mainly control costs (on the spot checks and other administrative controls). Since cross-compliance covers a range of climate-related and non-climate-related requirements these costs cannot be attributed wholly to climate. Moreover, no significant issue related to the implementation, inspection and monitoring of cross-compliance was identified during the case studies and the controls were considered quite effective.

At beneficiary level, the most common reason invoked to explain farmer non-compliance with cross-compliance was the complexity of the requirements and application rules (European Court of Auditors, 2016). More generally, the multiplication of regulations and tools to protect the same practices or features (e.g., under GAEC, AECM and greening measures), is an important source of administrative burden to farmers but also of confusion according to interviews undertaken in this evaluation.

12.4 CONCLUSIONS

The absence of complete and quantified information about the benefits of the CAP's climate measures complicates the assessment of efficiency. However, using the ESI-FUND tracking methodology and the simulation of benefits carried out for ESQs 1-4, €6.1bn of expenditure on the greening payment in 2016 secured a simulated 19.8 Mt of CO_2eq at a cost per tonne of €278. Reductions were achieved by the ESPG measure at an estimated cost of €44/tonne and by the EFA measure at an estimated cost of €437/tonne. The overall figure of €278/tonne is an overestimate because it was not possible

to quantify the benefits of the permanent grassland ratio and so these could not be taken into account. It also ignores benefits in the form of adaptation, which cannot be quantified.

Using the same methodology, the cost per tonne of RDP spending is estimated at €194. This analysis also omits some benefits of RDP measures which were impossible to quantify in the analysis for ESQs 1-4 as well as benefits for adaptation. The analysis highlighted the limitations related with the use of the tracking methodologies, especially for Pillar II due to the fact that choices made by Member States about how they allocate their spending to Focus Areas determines which spending will be assessed to be climate spending and which would be excluded. Results should thus be treated with caution.

When interpreting the cost per tonne figures it is important to note that many of the CAP measures analysed serve other objectives besides climate mitigation and yield further, non-climate benefits. The cost per tonne figures are therefore a guide to the cost-efficiency of Pillar I and Pillar II spending in securing GHG emission reductions, but do not reflect overall cost-efficiency in securing benefits of all kinds.

The benefits of cross-compliance cannot be quantified. As a result, its efficiency cannot be assessed.

Adaptation usually benefits private interests more than the public good, and mitigation schemes may have private co-benefits. However, Member States have made little use of measures such as loans and well-designed risk management tools to leverage private finance and internalise risk.

Given the site-specific nature of many of its benefits, better targeting is needed if efficiency is to be maximised in respect of climate action.

It has not been possible to quantify the administrative burden of individual measures addressing climate action other than the Pillar I greening measure. However, a number of the new strategic planning requirements introduced for RDPs in 2014 have been identified by Member States and Managing Authorities as a source of burden, and by beneficiaries as a cause of delays.

Significant simplification of greening requirements has taken place over the period, along with changes to address problems with the delivery of measures M1 and M2.

13 COHERENCE OF CAP MEASURES (ESQ8)

ESQ8: To what extent have the CAP measures delivered a coherent contribution to achieving the general objective of climate action and the related specific objectives of climate mitigation (reduction of greenhouse gas emissions and increase in the carbon stock) and climate change adaptation?

a) to what extent did the envisaged synergies among the measures occur?
b) to what extent have the carbon stocks in agricultural soils been protected and increased in carbon poor soils?

13.1 UNDERSTANDING OF THE QUESTION

The question concerns whether the complete set of CAP measures has, in its design at EU level and through its implementation (in the 10 case study countries), delivered a coherent contribution to climate action. Through their design, programming and implementation, regardless of their intended purpose, CAP measures can interact with the various objectives of climate action. For this reason, the question considers coherence of all CAP measures against the climate objectives rather than just those measures with a specific focus on climate action, whose external coherence with non-climate objectives is addressed through ESQ9. Coherence is defined in this context as the extent to which the design and implementation of two or more CAP measures are in synergy[99], act neutrally or are in conflict, with respect to climate action.

The question is further broken down into three components. The primary question addressing the coherence of CAP measures towards climate action as a whole, and two subsequent lines of enquiry: ESQ8a in relation to envisaged synergies between measures; and ESQ8b in relation to soil carbon

[99] Synergy is the extent to which two or more measures make a greater contribution to shared objectives together than they would separately.

stocks. These three components are interlinked but are explored step by step in order to identify clearly the conclusions and recommendations arising from each sub-question.

13.2 INTERNAL COHERENCE AS A WHOLE (ESQ8)

ESQ8: To what extent have the CAP measures delivered a coherent contribution to achieving the general objective of climate action and the related specific objectives of climate mitigation (reduction of greenhouse gas emissions and increase in the carbon stock) and climate change adaptation?

13.2.1 UNDERSTANDING OF THE PRIMARY QUESTION AND METHODOLOGY

For the primary question we first identify whether the design of CAP horizontal, Pillar I and Pillar II measures as defined in the Regulations works coherently and whether this relationship contributes to, is neutral or conflicts with the objective of climate action. In a second step, the implementation choices made in the 10 case study Member States and regions are examined to understand the extent to which the CAP measures as implemented, deliver a coherent contribution to climate action in practice.

13.2.2 ANALYSIS

First, we analyse the theoretical basis of the measures to establish the potential coherence between CAP measures in their contribution to climate action as a whole (climate mitigation and adaptation). The analysis is based on our assessment of the theoretical impact of each measure in Table 1. The outcome of this analysis is presented in Table XVII in Annex 6 with a summary provided in Table 40 below. Both tables show the theoretical coherence of each of the CAP measures with each other measure, with respect to climate action. They show whether the combined effect of pairs of measures are expected to be neutral, to reinforce or to undermine the theoretical impact they are expected to have on climate action.

Table 40 shows that the way CAP measures may be used together (as foreseen or allowed by EU legislation) is usually coherent but neither synergistic nor incoherent with respect to climate action. In other words, for the most part, the combination of CAP measures do not lead to reinforcing the impact they individually have on climate action nor does it lead to worsening it. This being said, there are some exceptions where the analysis shows theoretically synergetic or conflicting relationships between CAP measures (see Table XVII in Annex 6 and Table 40 below). Some of these cases only arise if Member States make certain implementation choices or only under certain circumstances; this is referred to as 'relationships having mixed impacts'. The analysis also identified some instances of theoretical incoherence.

Table 40: Summary table of the theoretical coherence analysis of CAP measures: number of relationships between pairs of CAP measures identified has having positive, no or neutral, negative or mixed impacts

	Number of positive relationships identified	Coherent (no or a neutral relationship)	Number of negative relationships identified	Number of relationships identified as having mixed impacts
BPS	1	21		1 (FAS may be used by MS to advice farmers on climate issues which may help BPS recipients to mitigate their emissions)
Greening CD	4 (XC, FAS, NFC in VCS and in EFAs)	18	1 (SFS)	
Greening PG	2 (XC and FAS)	19	1 (SFS)	1 (VCS)
Greening EFA	4 (XC, FAS, NFC in VCS and crop	18	1 (SFS)	

	diversification)			
VCS	3 positive relationships for VCS for protein crops (XC, crop diversification and NFC options in EFAs)	15	3 potential negative relationships for VCS for livestock (potentially exacerbating negative climate impacts when used in conjunction with M13; it can contradict with M8 (8.1 and 8.2) and conflicts with climate efforts funded by M10).	2 for VCS for livestock (greening PG ratio may help maintain livestock systems similarly to VCS for livestock; but their climate impact is context specific. FAS may be used by MS to advice farmers on climate issues).
SFS		19	3 (exemptions from the 3 greening obligations)	1 (FAS)
M1	6 (Knowledge, training and advice can maximise the climate benefits potentially arising from M8, M7, M10, M15, XC and FAS)	10	-	7 (M2, M16, M4, M3, M11, M5, M17) – strongly depending on MS/region implementation choices
M2	6 (Knowledge, training and advice can maximise the climate benefits potentially arising from M8, M7, M10, M15, XC and FAS)	10	-	7 (M2, M16, M4, M3, M11, M5, M17) - strongly depending on MS/region implementation choices
M16	4 (M7.2, M10, M15, M5.1)	12	-	7 (M1, M2, M4, M8, M3, M11 and FAS) - strongly depending on MS/region implementation
M4	3 (M4.3 and M4.4 in particular can support the potential positive climate effects arising from M10, M15 and XC)	14	-	6 (M1, M2, M16, M3, M11 and FAS)
M6	-	22	-	1 (FAS)
M8	4 (M1, M2, M15, XC)	16	1 (VCS-livestock and M8.1-8.2 can contradict)	2 (FAS and M16)
M3	-	16	-	7 (M1,M2, M16, M4, M10, M11 and FAS)
M7	3 (M1, M2 and M16)	19	-	1 (FAS)
M10	5 (M1, M2, M16, M4 and XC)	14	1 (VCS-livestock)	3 (M3, M11 and FAS)
M15	6 (M1, M2, M16, M4, M8 and XC)	16	-	1 (FAS)
M11	1 (XC)	15	-	7 (M1, M2, M16, M4, M3, M10 and FAS)
M12	1 (XC)	22	-	-
M13	1 (XC)	20	1 (potentially exacerbating negative climate impacts when VCS-livestock is combined with M13)	1 (FAS)

M14	-	23	-	-
M5	1 (M16.5 can maximise M5.1 impact)	19	-	3 (M1, M2, FAS)
M17	-	20	-	3 (M1, M2, FAS)
Cross-compliance	15 (because XC is conditional to a range of measures and is beneficial for climate, it positively interacts with BPS, the 3 greening obligations, VCS, M1, M2, M4, M8, M10, M15, M11, M12, M13 and FAS)	8		-
FAS	6 (FAS must cover XC and the 3 greening obligations and can maximise the benefits from M1 and M2).	2	-	15 (BPS, SFS, M16, M4, M6, M8, M3, M7, M10, M15, M11, M13, M5, M17 and VCS)

Source: Own compilation.

Note: XC: cross-compliance (in this table it refers to GAEC 1, 4, 5, 6, and 7); SFS: Small Farmers Scheme; VCS: Voluntary Coupled Support; FAS: Farm Advisory System.

Some elements of cross-compliance (GAECs 4, 5, 6 and 7) are designed to secure climate benefits, with others (especially SMR1) having theoretical impacts. As cross-compliance is a condition of the BPS (which itself entails the implementation of the greening obligations for farms which are not exempt), VCS, M10 and M15, it can potentially work coherently with each of these measures. Member State Farm Advisory Systems (FAS) must assist farmers in the implementation of cross compliance, therefore it also provides an indirect but coherent theoretical contribution towards the general climate objective. Other positive or potentially positive relationships between CAP measures include:

- the greening crop diversification obligation, the greening EFA obligation and VCS for nitrogen-fixing crops which can work together to stimulate the production of legumes with associated reductions in emissions of N_2O;
- measures M1 and M2 have the potential to deliver a coherent contribution to climate objectives along with the investment measures M4 and M8, the environmental and climate measures M10 and M15, the risk management measures M5 (and with M17 to a more limited extent) as well as M3, M7.2 and M11. Similarly, if M1 and M2 were used to better implement cross-compliance from a climate perspective, this would lead to a synergistic contribution towards the climate objective.
- M16 (the cooperation measure) has in theory the potential for coherent interaction with the same range of CAP measures (M4, M8, M10, M15, M5, M3, M7.2 and M11) in relation to climate, by enabling these measures to be implemented on a larger scale with the involvement of more than a single beneficiary.
- M4 (especially M4.3 and M4.4) and M8 could in principle work coherently with the area-based environment and climate measures M10 and M15, respectively[100]. For example, the M4 investment measure can pay for equipment needed to undertake management practices agreed as part of an AECM contract.
- Farm Advisory Systems in MSs are required to offer advice to farmers on the implementation of the greening obligations. As some of the greening options can have climate benefits (e.g. the permanent grassland measures, some EFA options, the crop diversification measure if legumes are grown), the provision of advice could help farmers better take climate considerations into account in the way they implement greening. EU Regulations also provide that FAS *may* supply information on climate mitigation and adaptation. If Member States

[100] Except for M4.3 (support for investments in infrastructure relation to development, modernisation or adaptation of agriculture and forestry) which may be used jointly with M15 for forestry.

were to choose to do so this would further strengthen the coherence between the FAS and other CAP measures with an impact on climate objectives.

As identified in the descriptive chapter and assessed in the analysis for ESQs 1-4, VCS for livestock is likely to have an overall negative impact. No combined effects with other CAP measures were found whereby a CAP measure would further increase the levels of emissions caused by VCS for livestock but a number of likely negative relationships are noted, with M13, M8 and potentially M10. However, the fact that VCS support for livestock is available, has an impact on the overall coherence of the set of CAP measures and is discussed in the conclusions. We note that the impact of VCS for livestock on climate mitigation may differ in some particular circumstances and therefore its actual impact on the ground may in some cases be less negative than the theoretical analysis suggests. The way VCS for livestock was implemented in the case studies casts some light on the topic and is discussed below.

The other instance of incoherence or inconsistency with the climate objective relates to the exemption of the beneficiaries of the Small Farmers Scheme (SFS) from greening (see Table 40). Small farmers account for a large group of beneficiaries (2.6 million, or 50% of all direct payment beneficiaries[101] in the 15 Member States which chose to implement the Small Farmers Scheme). Although the area covered by the SFS only accounts for a much smaller proportion (7%), their exemption nonetheless represents a sizeable missed opportunity for climate action, stripping away the potential climate benefits arising from greening on 6.4 million hectares.[102]

The analysis of the actual implementation choices made in the 10 case study countries enables a more concrete assessment of whether CAP measures have delivered a coherent contribution to the climate general objective of the CAP in practice.

The case studies show that most Member States did not design their CAP implementation with climate objectives in mind. As a result, there were few instances of measures being deliberately tailored so that they worked together synergistically to climate ends. In the Czech Republic for example, climate action and carbon management were not found to have been an important consideration during the elaboration of the RDP measures. Similarly, in Spain, the Pillar I choices were designed without taking climate objectives into consideration. However, in France, and despite a certain degree of confusion between biodiversity and climate objectives, coherence of climate action using the CAP measures was reported to have improved. For example, stricter conditions were adopted in the 2014-2020 programming period for irrigation projects.

This section goes through the main cases of incoherent relationships between CAP measures, followed by those having mixed impacts and then those that were found to deliver a synergistic contribution towards the CAP's climate objectives.

One common example of incoherence is the choice of most MSs in the case study countries (in CZ, ES-Andalucía, FR-Aquitaine, RO, HR, HU and LT) to support ruminant livestock through VCS. However, in a few countries, it was possible to establish a trend in specific locations linked to how VCS for livestock is implemented, with both positive and negative examples:

- In Andalucía, the livestock systems receiving VCS are in practice mainly extensive (this is different from the rest of Spain) and located in locations of ANC with steep slopes which are often prone to water scarcity. This means that, for climate mitigation and adaptation, the impact of VCS could be relatively positive in this specific case, by contributing to maintaining grassland systems on steep parcels which may otherwise suffer from soil erosion following abandonment[103] and for which alternative uses may increase water consumption).
- In France, the negative effects of VCS for livestock (which is combined with VCS for protein crops and fodder to form a package of measures supporting livestock) could be limited by the fact that the support decreases with the number of animals[104]. In addition, there are some specific areas where declining livestock numbers have led to the loss of permanent grassland, with negative impacts on carbon storage. Thus, VCS for livestock may have helped mitigate this trend to some extent (interviews show it has been the case in Aquitaine), although some

[101] 2015 DG AGRI data
[102] 2015 DG AGRI data
[103] If grassland is afforested, soil C losses are generally incurred for one or two decades; see ESQ8b.
[104] In order not to favour intensive livestock farming systems, the payment per hectare decreases as the number of livestock per hectare or the forage area increases. While the rules limit the amount of VCS support that can be received, they do not require specific livestock densities to be complied with.

academics argue that VCS support to cattle has prevented some livestock farmers from diversifying towards less GHG-intensive livestock systems in France such as poultry or pigs (in Brittany in particular)[105].

- In Croatia, the number of dairy farms decreased by half since 2012 and sevenfold since 2004. In this context, VCS for livestock focuses on restoring production with potentially high impact on GHG emissions. The coupled support to protein crops (often soya is grown in HR) is conditional on keeping minimum number of livestock units per eligible hectare (previously 4, reduced to 2 LU for 2017). From a climate mitigation perspective, this is incoherent in that it further supports the maintenance and/or increase of livestock numbers in Croatia. The VCS budget for livestock accounts for about 75% of all VCS in Croatia.
- Similarly, in Romania, the choice was made to allocate a very significant budget to VCS for livestock. For comparison purposes only, this corresponds to about 85% of the total AECM budget[106]. There are however thresholds capping the number of animals per farm that are eligible for VCS, as follows: up to 100 animals for milk buffaloes, up to 250 for beef and dairy and up to 500 for sheep and goats.
- In the UK-Scotland, VCS for sheep also has an upper payment limit of one ewe hogg to every four hectares of eligible land. In addition, it is only available to farms with minimum 80% of their land located in "region 3" which is characterized by low fertility and mostly extensive livestock systems.

Overall, VCS is offered by so many Member States to the beef, veal, dairy, sheep and goat sectors and with so few eligibility rules which could limit its production effects (as discussed in the analysis for ESQs 1-4) that it is extremely likely that VCS for livestock increases net GHG emissions within the EU overall. The existence of such widespread coupled support to a sector which is the primary source of GHG agricultural emissions is clearly not coherent with the objectives of climate action.

Beyond livestock, coupled support in other sectors was found to be potentially incoherent in relation to climate adaptation. For example, VCS is also provided to support the fruit and vegetable, cotton and rice sectors in Andalucía, whose production drives the overexploitation of water resources in the region.

VCS to protein crops was found to deliver a coherent contribution with a number of other CAP measures also supporting the growing of legumes; this is further discussed in ESQ8b (section 13.4).

The availability of direct payments to farmers may act as a barrier to afforestation/creation of woodland, supported under Measure 8.1, which results in an incoherent contribution to climate mitigation and adaptation (Alliance Environnement and EFI, 2017).

Both cases of coherence and incoherence were found in relation to the implementation of the ANC measure (M13), as follows:

- In FR-Aquitaine, the ANC measure (M13), the greening PG ratio obligation and some AECMs (e.g. PHAE "prime à l'herbe" or grass premium) work coherently to protect permanent grassland. In Aquitaine, most of the area supported under M13 was traditionally used as grassland by livestock farmers. In sub-mountainous areas however, such extensive livestock farmers are not eligible for ANC support, which has led to a switch from livestock to arable farming, with net local detrimental impacts on GHG emissions due to the conversion of grasslands. Soil erosion issues have since also arisen from arable farming in these areas. This shows that more could be achieved if M13 and its eligibility criteria was more purposely tailored to consider potential local climate impacts.
- In Spain, M13 is available in mountain areas (>1,000m) or areas with slopes >20% (or a combination of these criteria) as well in other areas characterised by low proportions of arable land, scarce or declining population density or areas with specific limitations such as the Doñana or the Sierra Nevada national parks. Overall, most M13 beneficiaries in Andalucía are located in steep or mountainous regions which in practice means that this support is relatively positive from a climate action perspective. This is because it is likely to help maintain agricultural activity that is extensive (this is specific to Andalucía and unlike other

[105] Personal conversation, 2018.

[106] For the 2015-2020 period, Romania allocated €808.9 million to support ruminant livestock through VCS which (for sake of comparison) is equivalent to 84% of the total budget of €958 million committed to M10.

regions of Spain), prevent soil erosion as well as limiting fire risks (whilst providing important biodiversity and culturally beneficial outcomes).

- In Croatia, with the introduction of CAP payments, farmers brought back into production or continued to manage some marginal, almost abandoned agricultural land, in particular permanent grassland in ANC regions[107], with positive impacts for climate in terms of resilience to fire. There is a positive relationship with FAS and M10/M11 in Croatia in relation to climate action as the management of soil carbon is an integral part of the compulsory training for beneficiaries of M10 and M11 payments.
- In Hungary, M13 is incoherent with climate objectives as it helps retain intensive agricultural production on lower quality land, which in some regions is likely to require more inputs to generate the same quantity of output, leading to higher emissions in relative terms (i.e. per unit of output, because yields are lower for a same amount of input).

Measure 5 was programmed in only in 3 of the 10 case studies: DE-Saxony-Anhalt, ES-Andalucía and Hungary. In Hungary the measure is allocated only 0.5% of the RDP budget and has been used to support the development of a country-wide hail prevention system. In DE-ST, the focus is on limiting flood risk. While the authorities state that they wanted to implement natural water retention measures and green infrastructure to promote synergies with Natura 2000 and biodiversity protection sites (and likely, climate mitigation and adaption), in practice the measures programmes four actions[108] which do not integrate natural retention features. In ES-Andalucía, amongst other actions, M5 covers investments to prevent losses of fertile soil due to erosion including by planting strips of shrub or tree vegetation[109], going over and above cross-compliance requirements. In that case, the two measures are implemented in a way that delivers a coherent contribution because the M5 description in Andalucía includes an explicit reference to cross-compliance along with a requirement to reinforce the GAEC obligations.

In most case study countries, good examples of coherence were identified between the GAEC requirements, greening and some M10 operations in relation to climate action and through the use of soft measures[110]. See also 13.4 for more detailed examples of how these measures work coherently to protect and enhance soil carbon in particular.

- In France, the crop diversification obligation under greening, the EFA option to grow nitrogen-fixing crops and some AECM operations (e.g. 'SGC', 'SPE', 'PHYTO2', 'IRRIG4/5'[111]) coherently promote crop diversification, particularly through protein crops, which is coherent with the adaptation and the mitigation objective (inter alia where reduced chemical fertilisers are required, and reduced reliance on feed imports). The domestic production of feed is a priority in France with VCS used by livestock farmers to support the production of dried fodder, and by arable farmers who are producing fodder under contract to livestock producers. This may have some indirect climate benefits, however, the French equivalence scheme which maize farmers can choose as an alternative to crop diversification has mixed effects in relation to climate. On the one hand, allowing maize monocrop farmers not to diversify is incoherent with the climate objective, as mono-cropping and irrigated systems (typical of maize production in Aquitaine) both contribute to and are highly vulnerable to climate change. On the other hand, GAEC 4 and the maize equivalence scheme work coherently, as both require soil cover to be put in place over winter.

[107] Much of this grassland was under the jurisdiction of Croatian Forests, the public company managing state-owned forests, which is now leasing this land to farmers.

[108] Dyke construction and relocation, remediation after flooding events, and the construction of two flood reservoirs (dams)

[109] Other investments listed as possible actions against soil erosion include retaining walls, drainage systems and evacuation of rainwater.

[110] Although sometimes the benefits arising from the use of soft-measures are limited on the ground

[111] 'SGC' (systèmes de grandes cultures) and 'SPE' (systèmes de polyculture-élevage) are groups of M10.1 operations committing farmers to a bundle of requirements in arable crop systems and mixed farming systems respectively. These measures require more than 3 crops to be sown and for SPE, the maximum ratio of the dominant crop is 48%. 'PHYTO2' pays farmers for not using chemical herbicides; 'IRRIG4' and 'IRRIG5' promote the cultivation of legumes in irrigated systems.

- In France, in Basse Normandie, M4.4 aims to restore the 'bocage' system (traditional hedgerows) which is then protected as landscape features under GAEC7.
- The EFA options of terraces and landscape features are available to farmers in Romania and they complement the GAEC 5 and 7 requirements regarding the maintenance of terraces and maintenance of other existing landscape elements on agricultural land. Together these measures work coherently towards promoting soil conservation and improved resilience to droughts and floods.
- Although the conservation of soil carbon has not been an explicit objective of any climate-related strategies in Romania, there is good coherence between the GAEC standards and (where adopted) the operations programmed under M10, in particular for green cover/catch crops and N fixing crops. M10 Package 4 (green cover) operation explicitly builds on GAEC 4 by stipulating that the green cover established must be different from/additional to the area under GAEC 4[112]. The EFA options chosen in RO include green cover and N fixing crops, which is also coherent for climate mitigation. This being said, some negative adaptation impacts were flagged, especially by farmers from the lowland plains of Romania, due to increased soil cultivations associated with over-wintered cover crops which damaged soil structure and interfered with soil moisture regimes. In those increasingly arid regions, preserving soil moisture in autumn and spring is key for climate adaptation (e.g. many farmers adopt minimum tillage techniques for this reason), therefore having green cover is inappropriate from a soil water management perspective.
- M10 in ES-Andalucía includes support for operations that are coherent with climate action such as integrated pest control, increasing crop diversity in the *dehesas* to improve carbon sequestration in soil or through integrated production prioritising wetlands in Natura 2000 areas. However, M10 in Andalucía also includes operations that support the continuation of systems inherently incoherent with the climate objective, such as the operations 'sustainable systems for agro-industrial crops (10.1.5)' and 'sustainable systems for intensive horticultural crops (10.1.9)'. While the aim is to make these systems less damaging, there is an inherent issue associated with providing support to these systems, especially in relation to climate adaptation in a region where they substantially contribute to water scarcity.
- In Hungary, these is an evident case of incoherence between the granting of CAP support to areas drained for cultivation purposes (contributing to increased flood risks elsewhere in the country) and one M10 operation (TO4.4.2) which on the contrary supports management practices that improve water retention in agricultural land to avoid flood risks.

A number of positive examples were also identified where the use of knowledge and advice measures in combination with other measures benefitted climate action. However, low uptake of these measures was found to be a barrier to the realisation of these benefits in a number of case study countries:

- Agricultural emissions represent a high share of Ireland's total emissions, and are thus a priority in country-wide mitigation efforts. As a result, M1, M4 and M10 were designed jointly to tackle this challenge. Support to farmers under both the AECM scheme ("GLAS") and the Beef Data and Genomics Programme delivered through M10.1 is conditional on attending compulsory training supported under M1.1. In this training, participants have to complete a Farm Improvement Plan which usually includes either a Nutrient Management Plan or a Carbon Navigator Plan[113]. In addition, support to non-capital investments (M4.4) is fully integrated within the GLAS agri-environment scheme (M10.1) and jointly these measures have the potential to facilitate climate action. Nutrient Management Plans are also pre-requisites for accessing M4.4, to be involved in the GLAS scheme (M10.1) and to benefit from the Targeted Agricultural Modernisation Scheme ('TAMS II') which is Ireland's agricultural investment scheme funded under M4.1.

[112] GAEC 4 in Romania is as follows: "in winter, the arable land must be covered with winter crops and / or remain uncultivated after the harvest on at least 20% of the total arable area of the farm". Additional conditions also apply under M10, e.g. specific crop species, dates, etc.

[113] This is an online farm management package enabling farmers to measure environmental and climate gains that can be made on farm by setting targets in key areas.

- In Croatia, the management of soil carbon is an integral part of the compulsory training provided by the FAS for beneficiaries of M10 and M11 payments.
- Training under M1 in Hungary is made compulsory for beneficiaries of a range of other RDP measures. If training is provided to farmers about the best ways to mitigate or adapt to climate change, this requirement could lead to climate benefits in helping tailoring the implementation of measures it is conditioned to which include: the agri-environment programme (M10.1), conversion to organic farming (M11.1), compensatory aid for Natura 2000 grasslands (M12.1) and compensatory aid for Natura 2000 forest areas (12.2).
- In ES-Andalucía, M2.3 (training of advisers) specifically includes maintaining good soil quality as a topic. However, in practice, this measure received very few applications due both to administrative complexity and issues linked to the type of potential beneficiaries who could apply for this measure.
- FAS in CZ focuses on carbon management (e.g. adding organic matter to soils, dissemination of knowledge on the organic matter balance in soils) mainly through demonstration farms and seminars, and less through on-farm advice. Support to help farmers to benefit from FAS advice in CZ was available under M2 but EU eligibility rules restricting the type of potential beneficiaries prevented advisors from applying. The very small number of applications received led to the measure being removed from the programme.
- In Romania, the case study shows that in practice, the majority of farmers operate without affordable access to good quality technical and business management advice. This is, for the most part, due to the on-going lack of a functional Farming Advisory System (FAS) for informing, explaining and supporting the regulatory obligations and implementation choices regarding cross compliance and greening. Whereas larger farm businesses increasingly employ on-farm specialists / agronomists (as well as some specialist consultants), according to most interviewees, climate action under the CAP would be much greater in Romania if the state-funded agricultural advisory system was better structured and/or M2 (advisory services) was better funded and more broadly targeted in the RDP 2014-2020. A EUR 63.6 million budgetary commitment has been made to Measure 2.1, however, the measure has not been launched to date due to uncertainties around changes in public procurement legislation.

Finally Saxony-Anhalt in Germany coherently designed a series of CAP measures to respond to soil erosion issues. Taken together these measures reinforce each other in the delivery of this objective, which has positive repercussions on both climate mitigation (mainly through carbon removals) and on adaptation (especially in relation to flood management in this region). They are described in Box 19.

Box 19: An example of synergistic use of CAP measures towards the general objective of climate action: the case of soil erosion in Saxony-Anhalt

In DE-Saxony Anhalt ('DE-ST'), there are good synergies between CAP measures to prevent or address soil erosion issues, which have climate benefits, as follows:

- GAEC5 is targeted to land prone to erosion risk (classified in two categories of more or less intense risk of water erosion and one category for land subject to wind erosion risks). The focus is on preventive measures at the level of field / farm (soil cover, reduced tillage).
- Catch crops/green cover and nitrogen fixing crops are available options under greening EFA. The German Legumes Strategy also contributes to increasing catch crops / legumes, and this is linked to the uptake of legumes as an EFA option.
- ANC payments (M13) exclude maize and crops with higher risk for erosion (e.g. sugar beets).
- M4 investment support can also be used to rearrange fields and establish structural elements to decrease the size of fields or introduce hedges / field woods to reduce the potential flows of floodwater.
- M17 (Stadt-Land) provides funding for targeted solutions for areas where soil erosion might have already occurred, or as a preventive measure – this is done through collaboration of municipalities, local (Landkreis) technical authorities (including nature, water, soil protection officers, and land planning) that combine land amelioration (reorganizing, changing ownership of fields) with CAP measures (planting hedges, no-tillage).

Together these implementation choices aim to help implement both Saxony-Anhalt's Soil Erosion Concept and the Flood Protection Concept, which in turn increase the sensitivity and capacity of local communities to deal with erosion issues.

FAS in DE ST offers advice on soil management broadly, but this appears primarily focused on the issue of soil

erosion.

13.3 SYNERGIES (ESQ8A)

ESQ8a: To what extent did the envisaged synergies among the measures occur?

13.3.1 UNDERSTANDING OF THE SUB-QUESTION ESQ8A

This sub-question develops the evaluation of coherence further to consider the extent to which synergies between CAP measures have been realised in practice. This question is therefore understood to be a complementary contribution to the primary question requiring the setting out of clear examples of climate action synergies that have occurred through the implementation of CAP measures.

13.3.1.1 Analysis

Based on the analysis of internal coherence as a whole, a series of individual fiches describing examples of climate action synergies were prepared and are available in Annex 6. These are the result of a thorough review of the available literature complemented with information from the case studies. Notable examples of synergetic use of different measures to promote climate action include DE-SA where GAEC5, EFA, the ANC measure (with erosion-causing crops made ineligible), M4 and M17 operate together to deliver protection from soil erosion and better management of floodwater. IE, HR and HU all insist that farmers take up training in soil carbon management as a condition of access to certain RDP schemes.

13.4 CARBON STOCKS IN AGRICULTURAL SOILS (ESQ8B)

ESQ8b: To what extent have the carbon stocks in agricultural soils been protected and increased in carbon poor soils?

13.4.1 UNDERSTANDING OF THE SUB-QUESTION

This sub-question focusses on the impact of the protection and increase of soil carbon stocks on the overall coherence of CAP measures vis-à-vis its climate objectives.

As agriculture and forests are the two primary land using sectors in the EU (74% of EU land use[114]), the extent to which the current combination of the CAP measures has protected and increased (or not) the carbon stocks in agricultural soils has great potential for GHG emissions mitigation. The question focuses on one function of soils which is mitigation through protecting carbon stocks and improving carbon sequestration and on CAP measures which may have an impact on enhancing these soil functions.

13.4.2 PROCESS AND METHODOLOGICAL APPROACH

The analytical approach focuses on the extent to which each CAP measure addresses the objective to protect and increase carbon stock in soil; and, the coherence between the CAP measures towards this objective of soil carbon protection and improvement of carbon sequestration. We first assess the theoretical potential coherence of the CAP measures at EU level and then the coherence in practice at Member State or regional level in the case studies (and other Member States where information was available).

The preliminary step of this analysis was to list the actions with positive or negative effects on SOC (Soil Organic Carbon), based on literature analysis and the analysis in ESQ1 to 4. The second step consisted in identifying which CAP measures may result in such actions or practices being undertaken. This was based on an assessment of EU Regulations, the intervention logic and the results from ESQ 1 to 5, and on a literature review (e.g. a recent study on soil protection policy in EU Member States (Frelih-Larsen et al, 2016)) and on the case studies. Finally the theoretical and actual coherence between the CAP measures towards the objectives of soil protection and carbon stock increase was assessed. Coherence judgements are made in qualitative terms according to whether the relationship

[114] Eurostat 2015

between the CAP measures is synergistic or complementary; neutral; or in competition or contradictory.

13.4.3 ANALYSIS

13.4.3.1 Identification of actions with positive or negative effects on soils

SOC levels in agricultural soils are the result of the balance between in-flow of organic matter and out-flow through mineralisation and soil erosion, which can be increased by tillage (Lemus and Lal, 2005). Since the industrial revolution, the conversion of natural ecosystems to productive ones has resulted in the depletion of SOC levels, releasing 50 to 100 Gt of soil carbon into the atmosphere in the world (Lal, 2009). Carbon sequestration in soils is a very slow, temporary and reversible process (Arrouays and et al., 2002) (FAO, 2002). The expected temperature increase in the future due to climate change could disrupt soil equilibrium and increase the mineralisation rate, leading to a potential removal of soil carbon (Mollier, 2016).

A list of the main agricultural practices that impact soil carbon storage positively or negatively was prepared and is provided in Annex 6.3. It provides some details about the nature and the scale of the potential effects of different practices on carbon stocks.

The practices that seems to have the best potential to improve soil carbon storage are the conversion of arable land to permanent grassland or to woodland, the restitution of crop residues and the introduction of legumes in crop rotation. On the other hand, the conversion of meadows/woodland to arable land and to bare fallows have a particularly negative impact on soil carbon stocks (Arrouays and et al., 2002).

13.4.3.2 CAP measures supporting practices which interact with the objectives of protection and increase of carbon stocks in agricultural soils

Having identified the practices which have the potential to increase or protect soil carbon stocks in agricultural soils, we classify them into three main groups. For each group, the main CAP measures promoting actions that may be positive or negative for carbon sequestration in soils are identified:

- **Practices related to changes in land use** are supported by the following CAP measures: greening PG[115], EFA (fallow option), M10 (AEMC), M13 (ANC[116]), forest measures (M8, M15), direct payments (coupled/decoupled);
- **Practices related to land management**: greening EFA and crop diversification, VCS (for protein crops), M4 (Investment in physical assets), M10 (AECM), M11 (Organic farming), M12 (Natura 2000) and GAECs related to soil carbon (GAEC 4, 5 and 6, which are explicitly related to soil carbon and GAECs 1 and 7);
- **Practices related to grassland and forage systems**: greening PG, M10 AECM, VCS (for protein crops, animal production).

For each of these measures, the CAP 2014-2020 Regulations and implementation choices at MS level and their coherence with soil carbon objectives have been analysed. The detail of this analysis is presented in Annex 6.3 and its findings are used to inform the assessment of the coherence which follows.

13.4.3.3 The coherence of the CAP measures toward the objectives of protection and increase of carbon stocks in agricultural soils

This section presents an assessment of the coherence of CAP measures vis-à-vis the objectives of the protection and increase of carbon stocks in agricultural soils. We identify both synergies and conflicts which can arise between CAP measures at EU and MS levels.

Several CAP measures promote leguminous crops cultivation and can therefore work in synergy to promote carbon stock increase in soils (see Table XVII in Annex 6 or the summary Table 40). These include: VCS for protein crops (some leguminous crops are eligible to VCS in 16 MS[117]), the greening

[115] Permanent Grassland

[116] Area under Natural Constraints

[117] According to MS decisions notified to the Commission by 1 August 2014 for the year 2015

EFA measure (27 MS have allowed leguminous crops as EFA) and the AECM (e.g. in ES, FR, PL and DE, but only in some regions) (see Box 20) (Alliance Environnement and Thünen-Institut, 2017). Also, legumes can be options for some farmers to diversify their cropping pattern under the greening crop diversification measure. There is a risk that these measures could overlap, but Member States were required to put in place rules to avoid any double funding[118]. Overall, the association of several measures targeting leguminous crops cultivation provides an enhanced incentive for farmers to grow these crops. For instance, in Germany, it was found that legumes formed a higher proportion of the total EFA area in those German Laender that programmed measures promoting legumes for both EFA and AECMs (Zinngrebe et al, 2017) compared with the ones that did not.

Box 20: Potential synergies for carbon stock increase promoted under the French Protein Plan

The French Ministry of Agriculture has published in 2014 a plan for the development of plant protein in France. One of the main tools mentioned in the plan is the combination of several CAP measures in synergy to increase protein crop production. More specifically, the CAP measures mentioned are:

- coupled support for protein rich plants (dehydrated alfalfa, soybean, protein crops);
- coupled support for the improvement of livestock farm self-feed autonomy (by providing support to farmers producing their own protein feed or under contract with a livestock farmers to sell their protein crops production);
- coupled support for the production of protein rich plants seeds;
- the EFA measure (protein crops are allowed as an option);
- several AECMs (promoting crop diversification with the introduction of leguminous crops in the rotation).

Source: Plants Protein Plan for France 2014-2020

Similarly, the implementation (and/or retention) of landscape features, catch and cover crops, buffers strips, agroforestry were also highlighted as beneficial to carbon stocks (see Annex 6.3) and are promoted under various measures, mostly the greening EFA measure, GAECs, AECMs, the forestry measure M8 (for the creation of new agroforestry area) and the investment Measure M4 (e.g. when it supports the creation of landscape features, see Box 21). However, their contribution to the increase of carbon stocks depends on MS/regional implementation choices (see Box 21). In particular, the AECM measure can be used to both complement cross-compliance and EFA measures. For instance, in Poland, under the EFA measure, catch crops must contain a minimum of two species to satisfy the greening requirement. AECM support may then be provided for the inclusion of additional species in the catch crop mix (Alliance Environnement and Thünen-Institut, 2017). In some cases, the measures may overlap (e.g. cross-compliance SMR and GAEC standards and the EFA elements relating to landscape features and buffer strips), however, detailed rules have been put in place to avoid any double funding. For example, in the Netherlands, GAEC 4 requires farmers to sow a green manure crop after maize or cereals on sand or loess soils, whereas these areas are not eligible to the greening option (Alliance Environnement and Thünen-Institut, 2017).

[118] E.g. for AECM, in all the Member States mentioned, in order to avoid double funding with the EFA measure, the payment has been reduced (either by excluding the area declared as EFA or subtracting the 'income forgone' element).

Box 21: Potential synergies for the increase of carbon stock and their protection in Romania through the promotion of cover crops cultivation

In Romania, the CAP 2014-2020 shows good potential for synergies for the promotion of cover crops (which has been identified as beneficial for carbon stock increase in Annex 6.3). Cover crop cultivation is promoted under:

- the EFA measure (green cover has been chosen as an option for farmers to comply with the 5% requirement);
- GAEC 4 which requires that at least 20% of arable land is covered with winter crops and/or remain uncultivated;
- M10 – Package 4 which promotes the use of green crops for winter soil cover;

Some synergies might also arise from the measure M11 (Organic Farming) since cover crop cultivation are a common practice among organic farms to enrich soils.

In France Basse Normandie, M4.4 aims to restore the bocage system[119], which are widely recognized for their benefit against erosion, so farmers can receive financial support to establish/restore hedges which then count as EFAs.

Source: Regulation review in Romania and (Alliance Environnement and Thünen-Institut, 2017)

However, one conflict was identified in relation to landscape features in cross-compliance and in the EFA measure in France. In 2013-14, GAEC 7 was changed to require the maintenance of all perennial elements of the countryside for all farms above 15 ha of eligible arable land, which restricted the scope of the cross-compliance requirement. This was corrected with the introduction of the EFA measure, with GAEC 7 rules now protecting only some landscape features[120] on farms of any size (Alliance Environnement and Thünen-Institut, 2017).

The permanent grassland measure constrains the conversion of permanent grassland into temporary grassland and the reduction of grassland via ploughing (through the ban of ploughing on ESPG), which were both identified as beneficial for carbon stocks in Annex 6.3. In addition, there are several CAP instruments and measures with which the permanent grassland measure (both the ratio and ESPG) can interact and may provide synergies for carbon stocks protection. For example, the AECM (M10) and the Natura 2000 (M12) measures may act in synergy with the PG measure, improving the grassland management toward improved carbon sequestration. Three Member States have offered payments under AECM for the conversion of arable land to permanent grassland (DE[121], CZ and UK-En) (Alliance Environnement and Thünen-Institut, 2017; Frelih-Larsen et al, 2016). However, these measures can also be designed to serve other objectives (particularly biodiversity) and therefore the potential synergies highly depend on whether the main objective was to favour carbon sequestration when designing the measures at Member State/region level.

Some Member States have designed eligibility criteria for permanent grassland in a restrictive way, excluding large areas – for example of wooded pasture in Spain. Doing so means that the carbon stock in the excluded areas cannot benefit from the protection afforded by cross-compliance GAEC and support through greening. Excluding areas from these protections is incoherent with climate objectives, although it may serve wider policy objectives important to the Member State concerned such as focussing income support where it is most needed. The way in which the CAP eligibility criteria and the permanent grassland definition are applied in Member States is not always coherent with the permanent grassland ratio obligation under greening and with the other Pillar II measures in relation to the objective of protecting and enhancing carbon stocks. In some countries the implementation of permanent grassland definition (with a limited proportion of trees and shrubs) led to the exclusions of large areas of permanent grassland, even where this meets the criteria set out in the direct payments regulation – for example the exclusion of large areas of wooded pasture in Spain (Alliance Environnement and Thünen-Institut, 2017).

As also identified in the main part of ESQ8, soft measures (the RDP measures M1, M2 and M16 and the horizontal measure Farm Advisory Systems) can facilitate the implementation of actions beneficial for carbon stocks and promoted under other CAP measures, e.g. legumes cultivation, grassland

[119] A traditional landscape characterized by small hedged fields
[120] Hedges <10m width, ponds and groves between 0.1 and 0.5 ha
[121] In the county of Mecklenburg Vorpommern

management, agro-forestry, etc. For instance, in some Member States, the Farm Advisory Services covers soil management (e.g. LT, CZ, DE, HR, IE and FR) which may encompass specific advice on how to maintain or increase soil carbon stocks. In several Member States, specific advice is offered to AECM beneficiaries in relation to better soil management (e.g. HU, IE, see 13.2 and Box 22).

Box 22: Combination of three RDP measures in Ireland for the Green Low-Carbon Agri-Environment Scheme

The Green Low-Carbon Agri-Environment Scheme (GLAS) is an AECM scheme which aims to preserve traditional hay meadows, low input pastures and habitats and support carbon stocks retention in soil through margins, catch crops cultivation and minimum tillage.

Beneficiaries of the scheme are required to attend approved training courses (funded under the sub measure M1.1). The courses are designed to provide an introduction to the GLAS scheme and information on the practices promoted under the scheme. It can also include educational courses on climate change mitigation and related subjects such as nutrient management plans. The courses are provided by accredited advisors to 20-30 farmers, for 6 hours in total.

Furthermore, a number of non-productive investments (sub-measure 4.4) are delivered via the GLAS agri-environment scheme. These include non-capital investment in relation to landscape features (e.g. planting, laying and coppicing new hedgerows or planting a grove of native trees). Support to these investments is available to all GLAS applicants.

Source: Regulation review and interviews in Ireland

13.5 OVERALL INTERNAL COHERENCE ANALYSIS

Most CAP measures do not have a climate objective but they may interact with climate action as a secondary, indirect effect as established in earlier chapters of this report. In this coherence analysis, the relationships between CAP measures are analysed to understand whether the set of CAP measures as a whole (and regardless of their intervention logic), provides a coherent contribution to objectives of climate action.

At the EU level, the way CAP measures may be used together (as foreseen or allowed by EU legislation) is usually coherent but neither synergistic nor incoherent with respect to climate action, i.e. the combination of most CAP measures do not lead to reinforcing the impact they individually have on climate action nor does it lead to worsening it. There are a few exceptions summarised below.

A number of CAP measures jointly have the potential to deliver a synergistic contribution towards climate objectives. These include greening crop diversification, EFA and VCS for nitrogen-fixing crops; the use of soft measures (M1, M2, FAS) and cooperation measures (M16) in association with a range of other RDP measures as well as cross-compliance and greening; the investment measures (M4, M8) combined with the RDP environment and climate measures (M10, M15), when used to support climate-relevant investments and management practices. The case studies show that some of these theoretically positive relationships did occur in some Member States, including in Romania, Ireland, Croatia, Hungary, France and Saxony-Anhalt in Germany. In most of these cases, climate benefits arise from measures intended to protect soils or landscape features, with the exception of Ireland where climate mitigation and adaptation are the explicit target of the measures.

With respect to incoherence, the analysis of MS implementation choices reveals a number of inconsistencies. For instance, M10 in ES-Andalucía includes operations aimed at developing more sustainable practices for production that are inherently incoherent to the climate objective. Similarly, VCS is provided to fruit and vegetable, cotton and rice sectors whose production drives the overexploitation of water resources in the region. There appears to be an inherent issue associated with providing support to these systems, especially in relation to climate adaptation, in a region where they substantially contribute to water scarcity.

In a similar vein, inconsistency was found in some case study countries where direct payments are granted to agricultural activities taking place on peatland/wetland (e.g. NL, LT) with no conditions preventing these from being damaged (which results in high levels of GHG emissions). In HU, agricultural land on which DPs are granted often has to be drained to be cultivated, which increases an already high probability of flood risks and flood damage when they occur. These examples show that the CAP as a whole fails to prevent inappropriate land management with respect to climate

action. There appears to be a lack of climate safeguards which would be evident if climate considerations were more systematically taken into account in CAP implementation decisions. For the CAP to be a coherent package, it would need to include stronger cross-compliance requirements linking the receipt of direct payments to practices that prevent significant climate negative impacts to arise from farming activities.

M13 is not a climate action measure but it has had potential positive climate effects by maintaining grassland systems in FR-Aquitaine, ES-Andalucía and HR. However, it can have some negative climate impacts too as shown by the case study in HU. M13 can be targeted using climate-relevant criteria of low temperature and/or dryness. Since these may be the result of climate change, the measure thus has the potential to compensate for vulnerability to climate change. It is debatable, however, whether making open-ended payments to compensate for permanently adverse climatic conditions, as opposed to paying for adaptation to those conditions, is coherent with the objectives of focus in this evaluation. MS have generally chosen to allocate substantial shares of the RDP budget to Measure 13. The fact that these significant budget amounts count towards the 30% spending requirement to potentiate climate action is incoherent given that M13 is not a climate measure per se and was shown to have both positive and negative impacts on climate action objectives.

While no measures were found to worsen the negative impact of providing coupled support to livestock[122], the fact that this targeted measure is available clearly means that the CAP measures as a whole do not represent as coherent a set of measures as they could for climate. This is especially the case given the way this measure has been implemented in the Member States, whereby support is both widely available and often unconstrained by eligibility rules which could limit its impact on production and emissions. For example, MSs could have chosen to implement rules about stocking densities but have largely have not done so. Rules limiting the number of animals receiving VCS for livestock exist in France, Romania and in UK-Scotland[123], but they help limit the measure's incoherence rather than truly realign it with climate action. It is possible for VCS support to livestock to have a positive impact on climate, if it supports extensive livestock farming which would otherwise be replaced by arable farming (to the extent that the greening PG ratio obligation and other constraints permit it). This appears to be happening in parts of FR-Aquitaine and ES-Andalucía[124]. A vast majority of MSs chose to implement VCS for livestock[125] and 63% of the EU VCS envelope supports livestock. Looking at the contribution the measure makes within the whole set of CAP measures, the VCS measure to livestock as designed and as implemented is deemed incoherent with other CAP measures contributing to climate mitigation, since it provides a large and targeted financial support to a sector which contributes to nearly 60% of agricultural emissions in the EU[126].

Overall, the contribution of the CAP measures vis-à-vis the climate objective could be more synergistic than it currently is. A number of examples show that the CAP's potential has not fully been realised. At the EU level, the exemption of small farmers from the greening obligations has reduced the overall scope of this measure which has climate benefits. At MS level, a number of Managing Authorities have failed to make sufficient use of advice measures which can strengthen the impact of other beneficial measures. In some cases, this was due to an incompatibility between the EU eligibility rules for potential M2 beneficiaries and the structure of the advisory and training systems in those countries (CZ and ES-Andalucía).

In relation to soil carbon, limiting soil deterioration especially on carbon rich soils (e.g. peatland, permanent grassland), the introduction of organic matter in soils (e.g. leaving crop residues in fields, introducing legumes in crop rotation) and changes in land use (e.g. the conversion of arable land to

[122] Although a number of likely negative relationships are noted, with M13, M8 and potentially M10.

[123] In Scotland, VCS to sheep has an upper payment limit of one ewe hogg to every four hectares of eligible land (itself subject to further criteria). In Romania, there are similar thresholds for the number of animals per farm that are eligible for VCS (dairy cows, milk buffaloes, beef, sheep and goats). In France, the VCS livestock support decreases with the number of animals.

[124] Even in these positive cases, from a strict climate mitigation point of view, the net impact would depend on whether the benefits of maintaining grassland systems (C stocks, avoided N_2O emissions) outweigh the emissions from the livestock themselves.

[125] 24 Member States offer VCS to beef and veal, 19 MSs to milk and dairy products and 22 to sheep and goat meat.

[126] 59.3% in 2016 (source: EEA [env_air_gge])

grassland or forest) are all practices with great potential to protect or increase carbon stocks in agricultural soils. On the contrary, the conversion of grassland to arable land and arable land to bare fallow can have negative impacts. These actions have different sequestration potential, quantitatively their impact (positive or negative) depends on the sequestration which can be achieved per ha and the agricultural area where these practices can be undertaken. For example, no tillage has a limited effect on soil carbon sequestration per hectare but has a great potential in terms of applicable area. Finally, the effects of these practices also depend greatly on what the standard practice is for farmers in a given area (defining the baseline on which the action is applied) as well as how farmers implement the beneficial soil practices (e.g. for cover crops, the effect on sequestration depends on the period over which the cover is implemented). Finally, carbon storage is a reversible process, which means that benefits to a large extent depend on the continuation of beneficial agricultural practices over time (Chenu et al, 2014).

In the CAP, the greening measures (especially the ESPG and EFA measures), AECM and GAEC standards (GAEC 4, 5, 6 as well as 1 and 7) have a strong potential to protect and enhance soil carbon in agricultural soils. In the case studies, some synergies and conflicts were identified, e.g. between AECM, greening and VCS in France (e.g. for protein crops and grazing livestock systems with low density) and through the use of soft measures (as identified above for climate action more generally). Evidence suggests that there can be conflicts between direct payments and measures promoting afforestation/creation of woodland (through Measure 8.1) because direct payments tend to be chosen by land holders over afforestation.

As identified above, there is scope for further improvement to realise the potential synergies that can be achieved through a better utilisation of CAP measures in relation to soil carbon. For instance, in the case studies, no GAEC requirements or AECM operations were found to target carbon poor soils specifically. In addition, although AECM contracts can be extended to cover longer periods of time in order to achieve or maintain the environmental benefits sought, no MS have chosen to do so. This would have however improved the coherence of these contracts with the objective of carbon sequestration by bringing their duration closer to the time needed for biochemical processes to achieve carbon sequestration (Verschuuren, 2017).

The impermanence of carbon sequestration is another issue against which the CAP currently offers no safeguard. Finding means to maintain soil carbon benefits after an AECM or another type of contract ends would offer another protection to the carbon stocks created. This could be about ensuring that newly created landscape features cannot be removed at the end of the contract through e.g. specific cross-compliance requirements protecting the same landscape features[127].

A better consideration and integration of soil function of carbon sequestration in the CAP Regulations and in MS choices would improve the overall internal coherence of the CAP towards the objectives of increased carbon sequestration and protection of carbon sinks.

13.6 Conclusions

In conclusion, a number of cases of incoherence between the CAP measures were identified which limits the coherence of the CAP measures' overall contribution towards its climate objectives. CAP measures generally are not intended to respond to climate objectives. While they can interact in a way that incidentally has an impact on climate action, this interaction is generally not designed nor implemented in a way that seeks to steer their contribution towards more climate action. There is therefore ample scope to improve the CAP's internal coherence, as shown by the number of inconsistencies or unrealised synergies detected in the case studies.

Member States should be encouraged to think about how they may utilise CAP measures to respond more coherently to the CAP's climate objectives. Screening implementation choices through a climate lens may reveal cases of incoherence not immediately detectable (especially in relation to adaptation where impacts are site-specific). It may also highlight cases where climate synergies may be easy to achieve between some CAP measures. At EU level, it is important to find ways to encourage MSs to perform this more systematic review of their implementation choices in relation to climate objectives,

[127] For example, in FR-Basse Normandie, M4.4 aims to restore the bocage system which is then protected under GAEC7.

as well as to add climate safeguards where EU legislation currently allows incoherent choices to be made.

14 EXTERNAL COHERENCE (ESQ9)

The question concerns whether the subset of CAP measures with a climate focus has been coherent and delivered synergies with the other CAP general objectives (ESQ9a), with other EU policies related to climate change and contributing to the 2020 objective of -20% reduction in GHG (ESQ9b) and with relevant MS national policies (ESQ9c). The three components are explored step by step in order to identify clearly the conclusions and recommendations arising from each sub-question.

14.1 COHERENCE WITH THE OTHER CAP GENERAL OBJECTIVES (ESQ9A)

ESQ9a: To what extent have the CAP measures towards the objective of climate action been coherent and delivered synergies with the other general CAP objectives (sustainable management of natural resources such as water and biodiversity, viable food production such as healthy food and food security and balanced territorial development such as afforestation)?

14.1.1 UNDERSTANDING OF THE QUESTION

This evaluation sub-question tests the hypothesis that the climate-focussed CAP measures used to deliver against the objective of climate action are coherent with the broader aims of the CAP's three general objectives for the 2014-20 period, namely:

- **Sustainable management of natural resources**, with the following specific objectives (other than climate action): restoring, preserving and enhancing biodiversity, including in Natura 2000 areas and in areas facing natural or other specific constraints, and high nature value farming, as well as the state of European landscapes; improving water management, including fertilizer and pesticide management; preventing soil erosion and improving soil management;
- **Viable Food Production**, with the following specific objectives: maintain market stability; meet consumer expectations; enhance farm income, improve agricultural competitiveness;
- **Balanced Territorial Development**, with the following specific objectives: promoting social inclusion, poverty reduction and the socio-economic development of rural areas, including the role of afforestation

This question requires an evaluation of internal coherence with the achievement of other CAP objectives, whereas the coherence with which the CAP measures as a whole address climate objectives is evaluation for ESQ8. This evaluation question focuses on the extent to which the climate-focussed CAP measures are theoretically coherent with the CAP's non-climate objectives, and have been designed at MS/regional level to be implemented in practice (in the 10 case study countries) in a way that is coherent with the achievement of those other CAP objectives.

Coherence judgements are made in qualitative terms for each measure-objective association on the following four-point scale: synergy; neutral relationship (neither synergistic nor conflicting); conflicting (where the measures work against the general objectives); indeterminate, where synergies or conflicts are context specific and depend on implementation choices on the ground.

14.1.2 ANALYSIS – COHERENCE OF THE CAP CLIMATE MEASURES WITH THE WIDER OBJECTIVES OF THE CAP

Analysis by CAP objective is set out below followed by an overview within the conclusions section. This summary analysis is complemented by detailed tables included in the Annex 7 to the report. The summary focuses on areas where the risk of incoherence or conflict has been identified or where particular opportunities for synergies are noted.

14.1.2.1 Coherence of climate measures with the CAP objective of sustainable management of natural resources

Although we have identified a number of CAP measures as "climate measures" as described in the introduction, almost all of those which can or must contribute to mitigation objectives, and all of those which can be used to support adaptation, also contribute to environmental objectives. In fact, this evaluation has shown that climate benefits usually arise as co-benefits (intended or not) when measures are used primarily for other environmental purposes. Incoherence – theoretical or actual – is rare as is shown by Table 41. Examples (theoretical and actual) which emerged from case studies include:

- Greening – crop diversification – can be seen as an adaptation measure since crop diversification is a valid adaptation strategy. However the French case study shows that farmers who divert out of maize into soya production may add to water stress. Because the measure leaves the choice of crops up to farmers, a range of both synergistic, neutral and incoherent impacts is possible;
- Investments via M4 in climate-related plant such as that for renewable energy might lead to the fragmentation of habitats or landscapes, although the case studies did not find examples of this and wider environmental protection laws including those for environmental impact assessment and appropriate assessment provide protection;
- M5 Disaster Risk Reduction and M17 Risk Management – both these actions were flagged as potentially coherent and synergistic or incoherent and in conflict with all the sub objectives linked to the sustainable management of natural resources dependent on the approach to implementation. The emphasis on preventative action under M5 was seen as positive, potentially promoting synergies in particular in relation to water and soil management and biodiversity protection. This was noted based on the potential to support green infrastructure and the promotion of ecosystem services as a tool to mitigate risks particularly in the in case of flooding and drought. Conversely an emphasis on grey infrastructure support i.e. engineering of river catchments, dams, can impact on biodiversity and the quality of water bodies, as well as forgoing the wider benefits for example of infield action to promote increased water retention in soils. This dichotomy was noted in the Saxony-Anhalt case study where it was noted that both green and grey infrastructure can be supported under the RDPs measures.

In the case study for Saxony-Anhalt an instance of potential conflict between water objectives and soil carbon sequestration was noted. In that it was considered that the latter was not specifically included in the RDP because of the trade-off between increased SOC and nitrate reduction. There was a concern from a water management perspective, particularly linked to ground water nitrate levels regarding the increased input of organic material (for example slurry).

Box 23: Use of Measure M5 in Saxony-Anhalt

M5 covers 144,000ha of agricultural land in Saxony-Anhalt in flooding areas affected by 'extreme flooding'. Flood protection is a priority for RDP in Saxony-Anhalt. The RDP states that synergies are sought with N2000 and biodiversity protection via funding of retention areas and meadows / pastures and that, where possible, natural water retention measures and green infrastructure are favoured over grey measures. However, the measure specifies four actions that focus on: dyke construction and relocation, remediation after flooding events, and construction of two flood reservoirs (dams). So it is not clear from the measure description how natural retention features will be integrated. Uptake or implementation data was not yet available for 2014 – 2020. In 2007 – 2013 period, the RDP funded 280ha of retention areas, five dyke relocations, and two flood control reservoirs.

- M8 forest investments – it was noted that, particularly in the case of biodiversity protection, that there could be potential for both synergies and conflicts depending on the nature of investment supported and how this interacts with existing habitats and biodiversity in the local area. For example support for afforestation may promote diversification of habitats but may also replace habitats in particular grassland and semi-natural habitats (which have been noted to be at greatest risk of conversion in studies examining the impact of increased biomass demand for energy for example the RECEBIO study). Support for additional extraction of material from existing forests and woodlands may increase disturbance of species, or provide for alternative habitats depending on the existing state of management. The same is true of landscapes, in that synergies or conflicts will depend on the existing cover and alternative land uses.

Importantly, however, measures M1, M2 and M16 focused respectively on knowledge sharing, advisory services and cooperation are seen as coherent with delivering all the sustainable management of natural resource sub objectives and, depending on implementation, offering significant opportunities to maximise synergies. In the case of water and soil management M16 offers particular opportunities both for investment in technology but also for managing challenges across farms at a landscape or river catchment level. This approach is noted as more effective in dealing with threats and is noted specifically in approaches to soil and water management. Recent analysis under the Pegasus project noted the importance of information, knowledge sharing and cooperation in delivering ecosystem services and public goods from agriculture.

Examples of synergies found within the case studies between the use of the climate measures for climate purposes and for other aspects of sustainable natural resource use were noted. These particularly involve the existence of synergies between the climate measures and the sub objectives of biodiversity, soil and water management. Examples are summarised below:

- Hungary – the "HNVA" AECM schemes have been highlighted as main contributors to biodiversity/nature conservation;
- Germany - Planting of hedges and field woods creates habitats and contributes to biodiversity protection;
- Czech Republic - the National action plan for adaptation to climate change (MŽP 2015b) includes the requirement to focus on knowledge transfer including advice on climate change. The risk assessment notes the need for knowledge transfer and advice to farmers;
- Germany – Saxony-Anhalt - The measure Flurneuordnung, land amelioration / restructuring, funded under M4.3 supports an integrated approach at local level to deal with soil erosion risk. The Flurneuordnung is based on developing a location-specific plan, agreed on by a community of stakeholders (landowners, farmers, technical authorities, municipalities) and then implementing this plan. The measure allows for a combination of measures to be put in place by stakeholder groups in response to soil erosion events or as a preventative approach;
- Spain – It was noted that while changes to promote water efficiency are positive, synergies with biodiversity and water are not being maximised as savings achieved in response to M4.3 are not secured for the future or for ecosystems but used to promote other types of production.

14.1.2.2 Coherence of climate measures with the CAP objective of viable food production

None of the climate measures were identified as being explicitly in conflict with the objective of viable food production or its associated sub measures although the greening measure entailed inevitable additional administration costs for farmers which varied according to implementation choices made by Member States. Table 41 shows that the climate measures were considered to be synergistic, neutral or synergistic/in conflict dependent on implementation. There is, therefore, considered to be a relatively high level of coherence between the climate measures and the delivery of objectives for market stability (including food security), enhancing farm incomes, improving agricultural competitiveness and meeting consumer expectations including the desire for healthy food. The potential for conflict, however, was noted based on implementation decisions in relation to a number of measures. A more detailed explanation of these potential incidences is set out below.

- Greening – administrative burden. The evaluation of the greening measure (Alliance Environnement and Thünen-Institut, 2017) estimated that farmers had incurred between €36m and €217m in administration costs.
- Greening – crop diversification. The evaluation of the greening measure noted the theoretical incoherence between this requirement and the sub-objective of farm income which arises since some farmers' crop choices may be constrained away from those which would best suit the market. That evaluation also noted, however, that such effects had not happened in practice except in a few localised areas, whereas in other areas farmers forced to diversify crops had actually benefited financially due to market swings;
- Greening – Permanent Grassland – the area where potential for conflict was identified was in relation to the permanent grassland ratio and the sub objectives of market stability (including food security), farmer income and agricultural competitiveness. It was noted that theoretically requirements to limit conversion of permanent grassland could restrict flexibility

in the sector. This in turn could slow price adjustments and exacerbate consequences of price changes impacting on farmer income and competitiveness and potentially food security. However, as noted in the evaluation of greening measures under the CAP, impacts are anticipated to be limited in practice given the flexibility of Member State implementation choices and that there is little evidence (for example in terms of refusals by managing authorities to allow farmers to convert land) of an impact in practice.

- M5 Disaster risk reduction and M17 risk management – it is noted that the use of these measures should in theory protect farmers from risks and the emphasis on preventative action under M5 should promote long term economic security. However, there is a potential to conflict with long term competitiveness and farm incomes if risk reduction measures are used to protect farmers, farming systems or practices that are in conflict with the long term needs or local environmental conditions. This is particularly important in light of the need for farming to adapt to climate change and the need to recognise risks and constraints associated with flooding events and water availability.
- M8 Forest Investment – this measure was considered to be potentially incoherent with market stability and food security dependent on implementation decisions. Afforestation has the potential to convert land from agricultural uses and there is a risk associated, in particular, if afforestation were to impact significantly on a specific sector or type of crop/livestock production. Moreover, afforestation is a long term land use change meaning that land is unlikely to be reconverted for agricultural uses, reducing land available for food production and to respond to market conditions. However, it should be noted that the likelihood of such impacts is low given the level of forest expansion anticipated.
- M10 – Agri-environment-climate – it was noted that some sub measures under ACEM could impact on market stability if change impacts on a specific farming system explicitly or specific crop types. Again, while this is a theoretical risk the likelihood of a significant impact on farmers' contribution to key markets or the flexibility to response to market conditions is limited by the breadth of choices available and that farmers enter into the scheme on a voluntary basis.

In terms of synergies between climate measures and objectives for the delivery of viable food production there are several common themes that run across measures. For example under competitiveness and farm income there is a strong theme around diversification both economically and in terms of climate focused management practices (i.e. promoting improvements in soil management, soil organic matter retention, water efficiency). This is considered to potentially boost farm income and support competitiveness into the long term in the sector by increasing the environment resilience to climate change, supporting both adaption and mitigation efforts. This trend is specifically linked to: crop diversification under greening, M4 regarding investment in more energy and resource efficiency techniques and technologies, M6 farm business development and M10 AECM measures. Opportunities are particularly noted in relation to promoting investment in schemes that may add market value linked to ecosystem services or promote marketing to deliver such schemes.

M8 and M15 focused on forest investment offer the potential to diversify farm income streams and so improve business viability. However if these measures were used with the sole purpose of maximising carbon sequestration the result could be sub-optimal farm income as a result of more limited extraction rate from forests and reduction in forest products. Moreover, investment in the environmental resilience of land and alternative farming systems more tailored to climate mitigation and adaption needs offers the potential of greater flexibility into the longer term and reductions in vulnerability to extreme events, also offering benefits for food security.

In relation to consumer expectations a key aspect noted of importance is the desire for healthy food. Most of the climate measures examined are considered to be neutral in relation to these sub-objectives; however, potential synergies were noted with M10, M15 and GAEC specifically. The potential for synergies is considered to be maximised if the concept of healthy food is linked to the reduction in diffuse pollution, reductions in erosion and the question of soil health – which M10 and GAEC in particular are focused upon.

M1, M2 and M16 on knowledge transfer, advisory services and cooperation were again noted to be coherent with all the sub objectives under viable food production (similar to under management of natural resources). In particular it has been noted in several case studies (i.e. Hungary and Croatia) the importance of these measures in maximising the benefits of other climate relevant measures and

in supporting farmers transitioning towards new climate responsible practices in a way that is coherent with good practices both for environmental protection and to ensure the retention of farm income, the promotion of competitiveness and the maximising of added value.

14.1.2.3 Coherence of climate measures with the CAP objective of balanced territorial development

As for the other two CAP objectives reviewed, no CAP climate measures were identified to be in conflict with the sub-objectives under balanced territorial development i.e. maintaining agricultural diversity across the EU, promoting socio-economic development of rural areas or fostering innovation. CAP climate measures were identified as being synergistic, neutral or synergistic/in conflict dependent on the nature of implementation. The CAP climate measures were, therefore, identified as being coherent with the CAP objective of balanced territorial development. The following section examines the circumstances under which potential conflicts may emerge depending on the implementation of relevant climate measures and then examines areas where important synergies are possible.

Climate measures that may result in conflict with CAP sub-objectives as a consequence of implementation were identified for balanced territorial development. It should be noted that for this objective fewer potential issues were noted than was the case for the CAP objectives of sustainable management of natural resources and viable food production. The instances identified relate to the following CAP measures.

- Greening – Permanent Pasture – As for market stability, farm incomes and competitiveness of the agricultural sector (examined under viable food production) this measures was identified as potentially in conflict specifically with the sub-objectives of socio-economic development in rural areas. If there is an impact on farm incomes, their competitiveness and their ability to respond to the market this is anticipated to have a knock on impact on the wider socio-economic conditions. However, as noted above the approach to the implementation of this measure allows national flexibility and the impact on socio-economic conditions is likely to be limited.
- M5 on Disaster Risk Reduction – This measure was noted to be potentially in conflict with maintaining agricultural diversity across the EU. As noted in the review of viable food production, there is a potential risk associated with the prevention of farm transformation associated with inappropriately designed schemes for disaster relief and response. While the preventative elements of this measure offer clear synergies with agricultural diversity, the promotion of socio-economic development of rural areas and in the dissemination of innovative practices; there is a risk that schemes reduce pressure for the farming sector to diversify, respond to local conditions and risk factors.

There are also important areas where CAP climate measures offer the possibility of delivering synergies with the objectives linked to balanced territorial development. For example in relation to the sub-objective of fostering innovation there are a number of different measures that have the ability to support both innovations in management and the diffusion of innovation amongst farmers. In particular M1 (knowledge transfer, in particular demonstration projects have been noted as important in innovation support and transfer within the iSQAPER H2020 project focus on agricultural soil quality), M2 (advisory services), M4 (Investment in physical assets with associated opportunities to promote new technologies which can be important for climate adaptation action in particular linked to soil management), M16 (Cooperation which is specifically focused on innovation support under the EIP groups and also in light of the ability for collective farmer action to promote dissemination of innovations), AECM and GAEC (both linked in particular to changes in soil and water management). In addition to promoting innovation M1, M2 and M16 were also noted as offering potential synergies across all the sub-objectives of balanced territorial development.

M4 was highlighted as important in terms of both innovation and promoting alternative socio-economic opportunities within rural areas. In relation to the latter M4 allows investment in marketing and processing activities. In particular this offers the opportunity for exploring added value products linked to local produce and bringing the added value within the rural economy. This is noted as being a particular opportunity when linked to AECM actions under M10. Changes in practices and approaches supported under AECM may offer the opportunity to differentiate local products and add value in terms of environmental and ecosystem service delivery. Perceived environmental quality or linked local differentiation, driven by M4 and AECM, can also promote diversification of economic activities, including eco-tourism.

An element of socio-economic development identified of interest for this evaluation question is afforestation. Afforestation can contribute to the diversity of farmer and rural incomes and socio-

economic development. It was noted environmental focus areas (EFA) under greening are potentially synergistic with afforestation; afforestation, forest edges and short rotation coppice are offered as EFA options. In addition, while not specifically afforestation, agro-forestry can also be promoted under the EFAs and within M10; in the latter action to increase tree cover can be promoted to support soil and water management. M8 on forest investment and M15 on forest-environment-climate offer the potential to manage forest systems more effectively, although support for new afforestation may be more limited given the emphasis on existing forest. M4 also offers potential synergies in relation to afforestation with support for adaptation in the forestry sector and non-productive investments may link to increasing trees on agricultural land for example for soil or water management.

The emphasis placed on forest measures and their use varies considerably across Member States, with some (for example Ireland) promoting afforestation outside of CAP support i.e. using state aids. In other Member States, for example, Spain the use of measures for forest management is limited in focus.

Box 24: The use of the forest management measure in Spain

In Spain, the forest measure M8 is mainly used for fire prevention through the sub measure M8.3. The national authority and producer organizations pointed out the fact that the budget allocated to this sub-measure usually goes to the public fire department to improve their capacity to respond to firebreaks while more budget should be allocated in finding appropriate tree species resilient to fire and other prevention practices. For the moment, no forest sub-measures are opened for new applicants.

In the German case study it was noted that measures are designed in a way that enables them to have multiple positive aspects. A key aspect of importance for all measures in Germany was noted to be the support for a more diverse landscape and hence agricultural diversity across the rural areas. In the case of the Czech Republic a particular issue linked to M17 was noted. Some farm risks are not insured against (e.g. impacts of drought) and mutual funds for alternative ways of insurance have not created (a consequence of institutional/legal obstacles). Insurance is an important route for securing confidence in investment and innovation, if well targeted. Hence, poor implementation may lead to risks particularly in terms of socio-economic development of rural areas and potentially in terms of fostering innovation, specifically the diffusion of innovative practices.

14.1.3 Conclusions

Overall the CAP climate measures are considered to be coherent with the CAP objectives of sustainable management of resources, viable food production and balanced territorial development. Apart from the additional administrative cost of the greening measure (which is in conflict with the objective of viable food production), no instances of conflict were identified; however, multiple instances where conflict might arise dependent on implementation were noted. This highlights the importance of implementation approach to avoiding conflicts, but crucially implementation is also central to securing synergies between CAP climate measures and wider CAP objectives. For example, in some case studies, it was noted that key measures, flagged as potentially highly synergistic, for example M2 on advisory services, are not made use of within RDPs (for example in Saxony-Anhalt and the Czech Republic). There is a wider question in terms of maximising the opportunity offered by these potential synergies. As noted in a number of case studies, including the Netherlands, Lithuania and Romania, the lack of incoherence is passive. It does not necessarily represent the active promotion of coherence and a drive to maximise synergies between climate mitigation and adaptation and wider goals.

14.2 Coherence with other EU policies related to climate change and contributing to the 2020 objective of -20% reduction in greenhouse gases (ESQ9b)

ESQ9b: To what extent have the CAP measures towards the objective of climate action been coherent and delivered synergies with other EU policies related to climate change and contributing to the 2020 objective of -20% reduction in greenhouse gases also in view of the long-term COP21

Paris Agreement envisaged for 2021.

14.2.1 UNDERSTANDING OF THE QUESTION ESQ9B

This question requires an evaluation of the external coherence of the CAP measures with intended effects on climate action with other EU policies related to climate action[128].

The CAP is one of the primary public funding mechanisms for climate action from land management and it is therefore frequently referenced in Member State commitments to climate action in rural areas. The question considers the coherence of CAP supported actions which might deliver on the 2020 target to reduce GHG emissions by 20% (and those that promote adaptation to climate as well) with actions supported through other EU policies. ESQ9b assesses whether synergies have been achieved through the use of climate-focussed CAP measures and other EU climate policies, or whether there have been conflicts.

14.2.2 PROCESS AND METHODOLOGICAL APPROACH

The first step was to identify the 'other' climate-related policies and strategies that are to be considered in this analysis and their relevance to climate action. These policies were categorised according to their interactions with the agriculture and forest sectors in relation to climate action, based on previous evaluations of the CAP (such as the forest measures evaluation) and other relevant studies. The second step considered how the climate-focussed CAP measures may influence the impact of these other policies. The analysis has been carried out using a two-entry matrix showing the key interactions between climate-focussed CAP measures and the policies identified.

There are limitations to this method especially around the lack of detailed information on the use of CAP climate-focussed measures. For instance, a recent review of the EU Member States' LULUCF Article 10 reports highlighted the lack of clear description of which and how CAP measures are being used, whilst at the same time referring to 'EAFRD' as a key policy to implement action on LULUCF.

14.2.3 ANALYSIS

EU policies dealing with climate adaptation and mitigation have been classified based on the nature of their interaction with the agriculture and forest sectors with respect to climate action, as follows:

- mitigation of non-CO_2 GHGs emissions;
- mitigation of CO_2 emissions through sequestration;
- mitigation through energy efficiency;
- mitigation through the development of renewable energy;
- adaptation, and,
- innovation for climate action.

Policies supporting innovation can be an important driver for the adoption of climate action.

The detail of the analysis is presented in Annex 7. For each of the six areas of interactions listed above, the analysis identifies relevant EU policies and assesses the extent to which the CAP climate measures make any explicit links to those and if they are likely to contribute to their objectives.

14.2.4 SUMMARY OF FINDINGS AND CONCLUSIONS

The table below summarises the analysis of the coherence of the climate measures with other EU policies tackling climate action. The analysis shows that there are no major cases of incoherence and overall the CAP climate-focussed measures are coherent with other EU policies related to climate change. However, there are instances where further opportunities for integration exist, in particular with the EU Soil Thematic Strategy and the Floods Directive. It is important to note therefore that although in principle CAP climate-focussed measures and other relevant EU policies do not conflict, some of the rules in place do not safeguard against conflicts happening in practice through the implementation of the measures.

[128] As described in the introduction, CAP measures considered in the framework of this evaluation as having intended effects are: the greening permanent grassland and EFA measures, cross-compliance GAEC 1, 2, 4, 5, 6, 7, RDPs measures M1, M2, M4, M7, M8, M10, M15, M16 for mitigation; and the greening crop diversification obligation and RDP measures 1, 2, 4, 5, 8, 10, 15, 16, 17 for adaptation.

Table 41: Internal coherence of the CAP climate measures

Policies/mechanisms/strategies aiming at:		Greening EFA	Greening PG	Greening crop diversify-cation	RDP soft measures (M1, M2, M16)	M4 Invest-ments in physical assets	M5 Disaster risk reduc-tion	M6 Farm business and develop-ment	M8 Invest-ment forest	M10 Agri-environm ent-climate	M15 Forest-environm ent-climate	M17 Risk Mana-gement	Cross-complian ce (GAEC standard s)
MITIGATION	Mitigation of non-CO_2 emissions • Nitrate Directive • Emission Trading System • Effort Sharing Decision • Low-carbon Economy roadmap • National Emissions Ceiling Directive												GAEC 1, 4
	Mitigation of CO_2 emissions • EU Soil Thematic Strategy, • Low-carbon Economy roadmap • LULUCF Decision • EU Forest Strategy • Circular Economy Package												GAEC 1, 4, 5, 6, 7
	Improved energy efficiency • Energy Efficiency Directive												GAEC 5
	Development of renewable energies • Renewable Energy Directive • ILUC Directive • EU Bioeconomy Strategy												
ADAPTATION • EU Forest Strategy • Floods Directive													GAEC 1, 4, 5, 6, 7

• Water Framework Directive												
INNOVATION • EU Bioeconomy Strategy • Life programme • Horizon 2020 • European Innovation Partnership												

Legend

	Contradictory
	Neutral
	Coherent
	Mixed

14.3 COHERENCE WITH RELEVANT MEMBER STATES NATIONAL POLICIES (ESQ9C)

ESQ9c: To what extent have the CAP measures towards the objective of climate action been coherent and delivered synergies with relevant Member States national policies?

14.3.1 UNDERSTANDING OF THE QUESTION ESQ9C

This question requires an evaluation of whether the climate-focussed measures of the CAP have contributed towards Member States' national policies on climate action. Put more simply, do the CAP climate measures support Member States in delivering climate action driven by international, EU or national policies within their territory? Member States' national policies on climate action often stem from their commitments under international agreements (such as the Kyoto or the Paris agreements) or from the requirements of EU policies in light of these international agreements (such as the 20% emission reduction target, the 20% share in renewable energy or 10% share of transport fuels from renewable sources). As part of the subsidiarity principle, Member States have some discretion within these policy frameworks to implement policies that work best within the context of their territories. This question identifies the relevant national policies relating to climate within the 10 case study countries and where CAP measures are used to deliver complementary contributions, thus demonstrating coherence.

14.3.2 METHODOLOGY

This analysis is based on the 10 case studies and the links identified between their national policies on climate change mitigation and adaption and the CAP measures towards the objective of climate action. The first step of the analysis is to identify the key national policies. These were identified on the basis of expert judgement of the study team and of the case study experts, based on a review of literature and discussions with national level experts. The objectives of the policies have been set out to show how they address both mitigation and adaptation actions and whether any explicit links is made to the role of agriculture or the CAP in their implementation.

Following the identification of the climate relevant policies, the linkages between the high-level policy goals and the implementation of the CAP was reviewed. This considered whether it is possible to make use of climate focused CAP measures to deliver the national policies for climate mitigation and adaptation, the types of CAP measures being noted as important, whether the link is implicit or explicit (i.e. whether the CAP measure is deliberately being used and coordinated with climate goals or not) and any limitations noted in terms of their coherence with climate policy delivery.

The main limitation to this methodology relates to the extent of the information available in Member States' national policies on climate change, and linked to this the likelihood that the CAP's climate measures might interact with these national policies. In a separate project to assess the policies and measures used by Member States to implement actions under their LULUCF Article 10 commitments, explicit links between climate policies and CAP support were found to not always be apparent. Coherence assessments require consideration of implementation on the ground, and therefore are limited to what information can be drawn from the 10 case study countries.

14.3.3 ANALYSIS

14.3.3.1 National Policies for Climate Mitigation and Adaptation

At the time of drafting the European Commission was reporting that 21 Member States have adaptation strategies in place[129]. Within the case studies adaptation strategies were noted as either having been adopted or under development (Croatia's draft adaptation strategy was published in 2017 and scheduled for adoption in 2018). It should be noted that both national and regional adaptation strategies are in place in some places. For example, Saxony-Anhalt was an early mover on adaptation issues following threats linked to soil and water management and it adopted its first

[129] European Commission website on the EU adaptation strategy accessed on 10 April 2018 - https://ec.europa.eu/clima/policies/adaptation/what_en##tab-0-1

regional adaptation strategy in 2004. Andalucía adopted a Program for Climate Change Adaptation in 2010. In the case of adaptation, policies are generally non-binding taking the form of a Strategy that sets goals which can be either broad or more specific. For example the German National Strategy for Climate Change Adaptation sets seven high-level goals focusing on both areas of intervention (e.g. promotion of water retention in drought risk farm and forestry landscapes) and types of intervention (e.g. focusing on knowledge transfer and monitoring). Several Member States (e.g. the Czech Republic) combine an adaptation strategy with a National Action Plan.

In contrast, the approach to climate mitigation policy differs, in part driven by the fact that binding targets are in place at the EU level. Most Member States have a strategic national climate policy that sets out the binding targets; several have strategic plans looking beyond existing commitments to 2030 (e.g. in Hungary, the National Energy Strategy) or 2050 (e.g. as in the Netherlands and Germany). Within the national policies for climate change, the approach to agricultural emissions varies considerably. For example, the Hungarian 'Domestic Decarbonisation Roadmap' concludes that 'the agriculture sector will only make a minor contribution to Hungary's decarbonisation effort' mainly through resource efficiency. In contrast the Czech Republic in its National Plan for Emissions Reduction specifically states that agriculture should contribute to reductions of NOx emissions (with a ceiling by 2020 of 34 kt/year from the agriculture, forestry and fishery sector), that measures will be implemented to decrease emissions from stationary sources by 2023 and to reduce emissions of ammonia from fertiliser use and animal products (by 2020-2023). In Germany and the Czech Republic, goals for agricultural climate mitigation are included in wider strategic climate policies. Meanwhile, other Member States have adopted more detailed policies and national action plans specifically promoting mitigation action in the agricultural sector. For example, Ireland has a National Mitigation Plan for Agriculture, Forestry and Land Use Sectors aimed at achieving carbon neutrality by 2050.

Within the case studies, it was noted that France and the Netherlands have detailed, legally binding policy actions aimed at delivering climate action via the agricultural sector. In the Netherlands sectoral targets allocated to relevant ministries have been in place since 2004. These are complemented by a dedicated strategy for the agri-food sector, which was signed by government and the key agricultural sectors. It also has specific programmes focused on delivering emission reductions in priority areas including greenhouses, sustainable feed use and fertiliser use and production of biogas from manure. In France, the delivery of agricultural climate commitments, both for adaptation and mitigation, is delivered through the 2014 'Law for the future of Agriculture, Agroindustry and Forest'[130] which sets the legal framework to deliver an agro-ecological approach in France including tools to respond to key environmental challenges in agriculture.

14.3.3.2 Climate goals and the CAP

Of the case studies analysed, 6 of the 10 have either a target specifically focused on emission reduction in the agriculture sector or a policy (or a series of policies) guiding delivery within the agriculture and agri-food sectors. Only the Croatian case study noted that they have no national policies in place requiring agriculture, forestry or other rural sectors to reduce their emissions or a comprehensive strategy. All Member States have adaption strategies in place which to some extent focus on the need for action within the agriculture and forestry.

The climate relevant measures within the CAP have the potential to address climate mitigation and adaptation. The question is to what extent the CAP measures are used in practice to deliver climate goals. Analysis in ESQ10 highlights that all case study countries/regions include climate relevant priorities within their needs assessment for their respective RDPs. In addition, analysis of LULUCF implementation highlighted that all Member States anticipated that CAP measures will be important in balancing carbon dioxide emissions and sinks. Several Member States note that climate plans and strategies were not used as a basis for determining their approach to implementation of the CAP measures in the 2014-2020 period. This was either due to, for example, RDPs needing to be developed before relevant climate policies were in place (e.g. Czech Republic and Croatia) or because climate was not the primary consideration during the policy development (e.g. as in Saxony-Anhalt and Hungary). Institutional limitations (e.g. Spain) and limits in knowledge (e.g. Czech Republic and Croatia) were also noted as factors limiting more explicit coordination of policy implementation. As

[130] This was superseded by a new agricultural policy adopted in June 2018.

noted in the Lithuanian case study, at present CAP rules do not impede proper climate actions; however, interviews felt that the Government took a passive role in this and that they did not seek to actively promote coherence or to maximise synergies. In contrast, France does have in place a mechanism for reviewing the RDPs of the regions and ensuring that climate goals are taken into account.

In some case studies, it was questioned whether the current implementation of the CAP support was coherent with the overarching goal of climate mitigation into the long term (see also section 0). For example analysis of Irish and Dutch policies noted that while use of CAP measures is not incoherent with climate goals, the approach to the use of CAP measures does not complement the areas of greatest need. For example Ireland has yet to define how CAP measures can be used to protect peatlands. As noted by agricultural experts, although Ireland's objective is to move towards carbon neutrality in agriculture, it is still to be planned what this will actually entail and the means to deliver it. In the Netherlands, CAP funding was noted to focus on renewable energy, biodiversity and manure management without addressing the broader challenges associated with the sector's climate footprint.

14.3.3.3 CAP implementation and use of CAP climate measures

This analysis has identified a wide range of CAP measures that are coherent with, or offer the potential to promote, climate mitigation and adaptation. All the case studies noted the importance of RDPs in delivering climate mitigation and adaptation strategies and goals. Some Member States noted that cross compliance and greening measures were less influential either due to limited changes in practice delivered (e.g. Czech Republic, Netherlands) or given that farmers do not understand the context or prioritise implementation choices based on climate (e.g. Croatia, Hungary, Romania).

Different strategies are employed across the case studies to bolster climate mitigation and adaptation within the RDPs. An example of differences is for example action on knowledge and knowledge sharing. In some case study examples, M1 and M2 under the RDP were not in use (e.g. Germany) while in others these are strongly highlighted as of importance to delivering change and linked to conditions associated with receipt of wider beneficial payments e.g. under M10, M11 (i.e. Hungary and Croatia). There are also examples of using such knowledge sharing measures to bolster wider coherence. For example in Ireland a Carbon Navigator has been developed to enable farmers to understand how their farms produce GHG emissions, to set mitigation targets and put in place specific measures.

A further example of the diversity of approach is M4. All case studies highlighted M4 as representing an important opportunity for climate mitigation; however, this was tailored differently in different Member States. For example in France M4 is focused on village development and landscape features, in the Netherlands on renewable energy; in contrast, in the Czech Republic investment options focused on renewable energy were removed due to low uptake.

Despite the differences in approach, the vast majority of actions is either coherent or synergistic with climate goals. However, some Member States noted that the scale of synergies is still unknown in some cases, with information about implementation decisions and uptake of measures unavailable (e.g. M8 in Hungary and wider implementation in Croatia). A limited number of instances were, however, highlighted where a lack of coherence occurred between the CAP implementation and national goals for climate mitigation and adaptation. In Ireland the use of M10 to support the Beef Data and Genomics Programme (under sub-measure 10.1) was questioned, in that, while it does seek to reduce GHG emissions per head of livestock, it does not address wider questions around climate proofing farming nor does it place Ireland on a trajectory towards its stated goal of climate neutrality by 2050.

There were several examples where incoherence was highlighted, not in relation to the CAP measures focused on climate action, but in relation to the implementation of other CAP measures. For example, M13 was noted in a number of instances as being inconsistent with climate mitigation and adaptation, specifically in Lithuania where payments were considered to be targeted in a way that was incoherent with sustainable land management. Concerns were also noted in relation to coupled payments to livestock, although, as noted in the French and Romanian case studies, it is possible to tailor eligibility criteria and payment scales to ensure limited emissions impacts. Several Member States flagged the lack of consideration of climate issues when determining Pillar I payments (e.g. Lithuania, Germany).

As noted in the Dutch case study,"no specific examples have been found where CAP measures in the Netherlands worked against each other from a climate perspective, however in the absence of any relevant climate conditionality of payments under Pillar I, they have most likely contributed to a continuation of the status quo in certain sectors/regions where more and earlier action would have been beneficial".

14.3.4 CONCLUSIONS

Analysis of the case studies has identified multiple approaches to national climate delivery both within national climate mitigation and adaptation policies, to the requirements placed on the agricultural sector and to the use of the CAP measures. The CAP, in particular the RDPs, is noted in all case studies' national climate policies as being an important policy through which to deliver climate goals at the national and regional level.

However, the choices made in relation to the implementation of the CAP at national level often do not aim to proactively pursue synergies in relation to climate action and delivery. For example this was identified in the Dutch and Lithuanian case studies. Moreover, in the Netherlands and Ireland there are questions about whether current use of the CAP is compatible with the action which will be needed on climate in the longer term. It was, however, noted in a number of case studies (i.e. Czech Republic, Germany, Romania, France) that key policies were not integrated into Pillar II and Pillar I implementation during the 2014-2020 period due to key climate policies still being under development. In the case study countries, climate issues are increasingly seen as important within the agricultural sector and climate goals are expected to be of increasing importance post 2020 (e.g. as in Germany, where the 2050 National Climate Protection Plan explicitly highlights the role of the CAP moving forwards).

15 EU ADDED VALUE (ESQ12)

ESQ12: To what extent have the CAP measures created EU added value with respect to climate change? (EU added value points at achievements as a result of EU action that would not have happened if Member States acted on their own).

15.1 UNDERSTANDING THE QUESTION

EU added value is defined in the Better Regulation Guidelines as the value resulting from applying policy measures at EU level which is additional to the value that would have resulted from public authorities applying similar measures solely at the regional or national level. It has both an economic aspect and a social or political one. Economically, action at EU level may be more efficient or effective than similar action taken at a sub-EU level. For example, if national or regional authorities as a whole would have under-provided public goods which are of interest at European level, or if different Member States provided them in ways whereby their disparate actions interacted to reduce the potential benefits at EU level. Even if Member States are willing to provide an optimal amount of such goods, coordinated action at EU level may be more effective than separate actions. Socially and politically, action at European rather than at national or regional level may create greater certainty (which is also of economic benefit) for stakeholders, since European law cannot be changed at the whim of individual governments. European rather than national action may also lead to greater acceptance and adherence by stakeholders to unpopular or unfamiliar measures where these apply across the EU rather than in a single Member State whose farmers may consider themselves disadvantaged as a result.

EU-level added value for climate change (mitigation and adaptation) through application of the CAP measures can potentially occur through:

- Member States' adoption of measures for climate action which are more ambitious than those that individual Member States would have adopted by themselves, provided that the CAP measures through which this ambition is channelled are efficient and effective;
- Increased effectiveness in relation to climate objectives, for example, those with a transboundary dimension (e.g. in the resilience of forests to storms and pest/diseases) or the

need for a 'critical mass' of action or of certain types land cover (e.g. in relation to protecting soils from erosion, or reducing flood risk);

- Gains from coordination, for example in developing and applying approaches to climate protection and adaptation which can be more effective when introduced on an EU scale than via isolated Member State initiatives, or where pooling experience can improve design and implementation of measures;
- Gains in efficiency, where greater environmental progress can be achieved at lower cost through an EU intervention, for example if CAP support for climate mitigation actions in rural areas across all Member States can reduce the costs of investment required, reduce levels of administration, and/or increase the response of farmers, compared to Member States acting alone;
- Greater certainty for farmers, foresters and other beneficiaries (including those in the supply chain) because the CAP provides a common legal and policy framework;
- By promoting complementarity and synergy with existing funding instruments/programmes at EU and national/regional levels of governance, thereby seeking to fill gaps and avoid duplications.

15.2 PROCESS AND METHODOLOGICAL APPROACH

The four categories of CAP measures defined in the earlier analysis – viable food production, land management, capital investment and soft measures - are assessed against the counterfactual for EU added value in terms of climate mitigation and adaptation. Where appropriate the agricultural and forest sectors are considered separately.

It is usual for such an analysis to consider a counterfactual in which the identical measure is taken (or attempted) by Member States acting without the EU. This is not feasible for the CAP which, over its lengthy evolution, has had a cumulative effect that has helped to shape current EU agricultural structures, incomes, markets and land uses. Therefore, to assess the added value of climate action under the CAP, we consider a hypothetical counterfactual in which there are no EU funded direct payments and no EU co-financed rural development measures. National or regional governments would be free to incentivise climate action by rural land managers and businesses in ways of their choosing and using their own funds. Member States have shared competence with the EU to require farmers to meet environmental requirements or provide environmental services. They can exercise these powers to the extent that the EU has not done so, provided that they remain consistent with Single Market principles and the rules on State Aids. They are also free to impose higher environmental standards than those required by the EU in their own territory if they wish.

Therefore, for the purposes of this analysis, the counterfactual is assumed to be:

1. In the absence of Pillar I direct payments most national governments would choose to implement some form of decoupled direct support, for at least some of their farmers, but the current CAP conditionalities and eligibility rules would not apply;
2. There would be no EAFRD funding for climate action and the national/regional budgets that had been used for co-funding their RDPs would not necessarily be used for similar purposes, in the absence of the CAP; if MS/regions chose to incentivise climate action, current EAFRD rules would no longer apply (but for some land management payments MS would have to demonstrate compliance with WTO green box requirements);
3. Transposed EU Directives and other national/regional legislative requirements applicable to rural land managers would remain part of the baseline for incentive payments.
4. Current EU climate and energy targets would remain.

Some secondary effects of CAP withdrawal have not been taken into account in the definition of the counterfactual or the assessment of added value, because they are beyond the scope of this study. These include any consequential amendments to other EU environmental Directives and policies, which now rely in part on the CAP to fund or otherwise support their implementation[131].

[131] For example, the Natura 2000 Directives, the Water Framework Directive, the Nitrates Directive and the EU Forest Strategy.

15.3 ANALYSIS

15.3.1 MEMBER STATE AMBITION IN THE ABSENCE OF THE CAP

Member State ambitions are influenced by the current level of climate ambition agreed at EU level, their individual ESD obligations and the recent decision to include LULUCF within the 2030 climate and energy framework[132]. The existence of the CAP no doubt had, to some extent, a positive influence on the level of EU climate ambition Member States were prepared to agree to, but the scale of this effect is impossible to quantify.

The counterfactual would leave Member States free to determine the level of ambition for the contribution of their agricultural and forest sectors to meeting EU climate and energy targets, and the size of any financial incentives. The evidence of MS implementation choices within the revised GAEC framework and greening requirements for crop diversification, EFAs and permanent grassland does not suggest any increase in ambition on the part of most MS or farmers to use these measures to improve protection of water resources and soils generally, or the carbon stores in soils and woody vegetation. Most of the choices have prioritised farmer interests over those of the environment, and although the prevalence of N-fixing crops in EFA implementation has both adaptation and mitigation benefits these do not seem to have driven the choices made. Although GAEC and greening have done little to raise climate ambition, compared to the counterfactual (where there may be no environmental conditions attached to direct payments) they have had a passive effect in preventing further deterioration of soil carbon and quality, and removal of woody landscape features. There is some evidence that use of VCS for beef and dairy systems has contributed to an increase in cattle numbers and enteric emissions. This, together with a lack of focus of RDP measures on reducing emissions from ruminant livestock and manure handling/storage suggests a lack of ambition on the part of MS to address non-carbon GHG emissions, particularly methane.

Evidence from the case studies suggests that the introduction in 2013 of specific EAFRD priorities linked to climate action has stimulated some Member States to bring forward the development of climate policies (CZ), or refocused debates on the CAP to encompass climate action (DE-SA and HR). In others, the government had done more than would have otherwise been the case (ES-A, RO, IE), in one example offering more support for adaptation (DE-SA). This effect on raising ambition is not EU-wide – the Netherlands had already chosen to both develop and implement climate policies largely without using CAP funds, and in Lithuania there has so far been limited impact on an agriculture sector that is focused on other priorities. Of the EAFRD measures used, the most significant impact on GHG reduction (mostly CO_2) is from land management supported by the agri-environment-climate measure. Capital investments contributed little to GHG reduction (and suffered from low uptake) suggesting that they have not raised Member States' ambitions.

It is more difficult to judge what effect the CAP has had on adaptation ambitions in the agriculture sector. The process of preparing strategic plans for the ESI-Funds and ex-ante analysis for their RDP has probably stimulated a number of managing authorities to analyse their climate risks and adaptation needs as part of their policy planning and programming earlier than they would have done in the absence of the CAP. This may also have raised ambition to use the CAP to support adaptive actions. Analysis of Member States' adaptation plans for this evaluation has shown that they have seldom budgeted for, and even less often funded, the actions proposed in their plans. This highlights the potential role of the CAP (and other sectoral policies) to support adaptation, for example through RDP support for preventive actions.

However, the cushioning effect of decoupled direct payments on fluctuations in farm incomes from the market and weather events may have masked both Member States' and farmers' perceptions of the need for adaptation, and possibly depressed ambition. On the other hand, for those farmers wishing to take adaptive action, the security of decoupled CAP payments may have helped them to increase their ambitions. Use of EAFRD measures for climate adaptation seems to be driven by negative experience of the effects (drought, floods, forest fires) rather than the need for pre-emptive action (although the forest sector, which is not supported by direct payments, and has a much longer

[132] Regulation of the European Parliament and of the Council on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU.

harvest cycle, seems to be more aware of the need for adaptation action now). As the counterfactual assumes the existence of national direct payments there may be little change in adaptation ambition in the absence of the CAP – but this may depend on the extent to which the most vulnerable production systems and areas continue to be supported by national direct payments.

Overall, we judge that the presence of CAP decoupled direct payments, GAEC and greening is likely to have increased mitigation ambitions for CO_2 to some extent but have had little effect on (apparently low) ambitions of Member States to reduce CH_4 emissions from agriculture. The availability of EAFRD funds, the focus provided by the ESI-Fund plans and the EU priorities and implementation rules for the EAFRD has clearly hastened the development of climate ambition and policies in those MS where there has been a significant impact of EAFRD. The scale of this impact at EU level is difficult to judge against the counterfactual because it depends entirely on the extent to which these, and other MS would, in the absence of the CAP, choose to replace EAFRD funds and possibly change some of the administrative rules (e.g. to make it easier to achieve uptake).

15.3.2 Increased effectiveness as a result of EU-wide action

Increased effectiveness may be achieved where the benefits from climate actions being carried out in all Member States are greater than the benefits of separate actions. The EAFRD priorities for climate action and the requirement to use 30% of the EAFRD for seven environmental and climate measures, (including the compulsory agri-environment-climate measure) have clear potential to increase the scale and effectiveness of implementation of land management for carbon protection at EU level. In the absence of the CAP there would be no equivalent obligations on Member States. Analysis of the impact of the CAP measures (ESQ4) indicates that the most significant impact on GHG reductions has come from land management measures which, even if not focused on GHG reduction, may have secondary climate benefits (for example from biodiversity management that protects or increases soil carbon). In practice the actual effect depends on the choice of measures and the extent to which they are designed to benefit climate objectives and are targeted effectively.

Increased effectiveness of climate adaptation at EU level could also occur, for example, if RDP measures were used to support land management to reduce flood risk in neighbouring Member States that share a river basin, or to mitigate fire risk in trans-boundary forests. No examples have been found, but this may simply be a factor of the location of case study RDPs. It is possible that such transboundary action funded by the EAFRD may also be linked to Member State implementation of other EU policies (e.g. Water Framework Directive, Nitrates Directive, Natura 2000 Directives), such as the conversion of arable to grassland or afforestation in 'shared' catchments and flood plains.

It is judged that the requirements of EAFRD funding and the use of the agri-environment-climate measure has increased the effectiveness of GHG mitigation at EU-level, and that EAFRD support has clear potential to support trans-boundary land management for climate action, but the data is not available to assess the extent to which this has been realised.

15.3.3 Coordination gains

The CAP has considerable potential to foster EU-scale approaches to climate action, for example in improving the knowledge and skills of land managers, and sharing best practice, which are important catalysts for effective uptake and implementation of the CAP land management and investment measures. The preceding analysis has not identified any instances of EU-level coordination gains linked to climate action from the CAP funded Farm Advisory Services, possibly because the availability and accessibility of farm advisory services, both generally and those specifically related to climate action, is highly variable across the EU. Both the ENRD and EIP-Agri networks have undertaken work to promote and share good practice of land management for climate action among RDP managing authorities and other stakeholders, and to provide forums for discussion between Member States and regions. EIP-AGRI bridges a gap between research and practice, supports farmers to play a role in innovation and helps to share lessons across borders (EC, 2017). It is still too early to assess the cumulative effect of this work on the development of Operational Groups or the design of land management measures at the RDP level.

15.3.4 Efficiency

One case study pointed out that an EU-wide requirement is more acceptable to stakeholders than single country action would be (FR), suggesting potential gains in efficiency for some CAP measures (but not necessarily for those where Member States can choose to opt out, as shown by the extremely low uptake of ESPG outside Natura 2000 areas). The climate benefits of greening requirements (mainly for soils) come at a very significant cost (ESQ7). Compared to direct payments, MS/regions have scope to design and target their RDP budgets for climate action more precisely, and therefore more efficiently, but there is still scope for efficiency gains in the programming, design, targeting and implementation/uptake of EAFRD measures for climate action. Two case studies commented on the absence of sufficiently targeted CAP measures to address specific problems - CH_4 reduction (NL) and carbon in peat soils (NL, IE).

15.3.5 LEGAL CERTAINTY AND POLICY FRAMEWORK

EAFRD 5-7 year contracts for environmental land management provide individual beneficiaries with greater legal certainty than would necessarily be the case under separate national measures (were they to be enacted, in the absence of EAFRD). However, there is a degree of uncertainty in the CAP, given that Member States may, from one year to the next, close schemes to new applicants or reallocate budgets. In the absence of the CAP, national schemes would not be tied to the 7-year EU programming cycle and could commit funding to much longer land management contracts, for example to protect and increase soil carbon. However, the potential variability of different national schemes reduces the certainty for the sector as whole at EU level, particularly in the absence of a requirement for MS to implement agri-environment-climate schemes across their whole territory.

15.3.6 COMPLEMENTARITY

The CAP measures are designed to complement each other and national/regional support with similar climate objectives. Through their Partnership Agreements under the common rules for EAFRD and the other ESI-Funds Member States/regions are required to promote climate mitigation and adaptation within a wider sustainability framework, and provide information on support for climate objectives, in line with the ambition to devote 20% of the EU budget to climate action. Evidence from the case studies demonstrates that RDP measures have been used in synergy with other funds.

15.4 CONCLUSIONS

Comparison with the counterfactual shows EU added value, particularly of the RDP measures. Table 42 summarises this analysis. The EAFRD requirements to address climate priorities has provided EU added value by stimulating a higher level of climate ambition in those Member States which had not yet developed climate action plans for agriculture and forestry. The EAFRD environmental land management measures (principally agri-environment-climate contracts but also some forest measures) have increased the effectiveness of climate action. By contrast, voluntary coupled support payments in Pillar I may have contributed 'negative EU added value' to GHG mitigation where they have slowed down a decline in ruminant livestock production, although they serve other CAP objectives.

EAFRD measures are more efficient in terms of targeted climate action than direct payments but there is still scope for improved efficiency, at RDP and cumulatively at EU level. The CAP has provided a significant degree of legal certainty, but only for the duration of each programming period. EU funding rules have provided opportunities for synergy between EAFRD and other funds.

It is possible, however, that Member States acting alone could have devised more efficient and effective means of achieving the levels of ambition currently agreed at EU level, or those that they chose individually. For example, the more ambitious might: target support at areas or production systems where the greatest mitigation or adaptation benefits can be achieved; make any income support payments conditional upon more demanding, targeted requirements for soil management, particularly for carbon-rich (peaty) and wetland soils and to combat soil erosion and improve soil functionality; limit investment support to projects that meet threshold criteria for GHG reduction and medium-term adaptation benefits; and support investments in water efficiency in agriculture only if these implement an adaptation plan for all uses of the resource concerned. However, there would be other Member States where, in the absence of the CAP (particularly the EAFRD), ambition would be low and climate action would be less of a priority.

Table 42: EU added value

Potential	CAP measures	Counterfactual	EU added value
A higher level of ambition for climate action at EU level	**Mitigation:** of the four categories of CAP measures only EAFRD has been shown to foster a higher level of ambition for climate action. The implementation choices of the other measures show little evidence of increased ambition overall, yet GAEC and greening may have prevented a decline in ambition. There is an evident lack of ambition in addressing CH_4 reductions across all the CAP measures. **Adaptation:** the strategic planning process required for programming EAFRD may have stimulated integration of adaptation in RDPs.	MS would not necessarily attach environmental conditions to their national direct payments, or replace EAFRD measures with incentives to address EU climate mitigation or adaptation, through land management and investment support, or through 'soft' measures such as knowledge transfer and advice	Yes, for mitigation strong evidence of added value of EAFRD (but not in all MS) and evidence of 'damage limitation' value of GAEC and greening requirements. The CAP does not appear to have raised ambitions for reducing CH_4 emissions, and use of VCS for ruminant livestock is likely to have contributed to increasing enteric emissions. To a limited extent for adaptation ambition, but only for EAFRD where the planning process has hastened risk analysis and planning. But Member States' implementation choices for Pillar I show no evidence of changed ambitions.
Increased effectiveness through EU action	Mitigation: EAFRD funding rules promote the use of agri-environment-climate contracts of benefit for both mitigation and adaptation (particularly for soil and carbon protection). These, and some of the forest measures also contribute to adaptation. Theoretically EAFRD has considerable potential for transboundary adaptation actions in both agriculture and forests, but data is lacking on the extent to which this has occurred. Adaptation: FAS and RDP measures also strengthen the AKIS in many MS, such support to soft measure is an essential complement to other measures (e.g. M4, M10), improving their effectiveness		Yes, strong evidence for agri-environment-climate land management contracts. Theoretical potential of EAFRD to support trans-boundary land management for climate action in both agriculture and forests.
Co-ordination gains	Work of ENRD and EIP-Agri has promoted sharing of good practice relevant to climate action using RDP funding	None	Yes, in theory, but too early to judge impacts at the RDP level.
Efficiency gains	The flexibility available in the design and targeting of EAFRD allows managing authorities to achieve high levels of environmental efficiency, but this potential has not yet been fully realised.	None	Yes, for EAFRD, but potential for environmental efficiency not yet fully realised.
Legal certainty	EAFRD environmental land	MS could choose to provide	Yes, to some extent, for

and policy framework	management contracts for 5-7 years provide certainty for contract holders but not necessarily for potential applicants, or between programming periods.	an improved level of certainty if they wished (for example longer contracts for soil management).	EAFRD land management contracts
Promoting complementarity and synergy	CAP measures are designed to complement each other and to be used coherently, although the extent to which synergies are achieved depends on MS implementation choices. EAFRD and other ESI-Funds are used synergistically	More risk of double funding under combinations of national schemes and other EU funds	Yes

16 PRODUCTION EFFECT (ESQ13)

ESQ13: To what extent have the combined CAP measures addressing climate action affected agricultural production?

16.1 UNDERSTANDING OF THE QUESTION

ESQ13 asks for an assessment of the effects on agricultural production of the CAP measures addressing climate action. According to the previous analysis, the CAP measures that address climate action (i.e., for which climate adaptation and/or mitigation is an intended objective) and that should be analysed in this ESQ are the following: Greening measures, cross-compliance measures, soft measures (M2, M6, M16, M19 and Farm Advisory Services), investment measures (M4), forest measures (M8 and M15), AECM (M10) and risk management measures (M5 and M17).

These CAP measures are mostly designed with the intention not to hamper agricultural production (Ignaciuk and Boonstra, 2017; Ignaciuk, Coger and Dameron, 2017). But when implemented, some measures can involve a trade-off between agricultural production and climate objectives. Moreover, the various mitigation and adaptation actions supported through CAP measures may have synergetic or antagonistic effects on some types of production. Therefore, the combined effect of the CAP measures addressing climate action should be analysed.

More generally, there is potential for CAP measures which lack climate objectives to affect emissions via production effects. For instance, the livestock sector is both an important source of GHGs and frequently the custodian of significant soil carbon stocks. It is also an important sector in terms of adaptation since it will be impacted by climate change and can help reducing the vulnerability of wider society, for example due to its role in the nutrient management cycle or improving resilience to fire. Hence the analysis also considered the combined effects of Pillar I and II measures on the production of intensive and extensive livestock systems.

16.2 PROCESS AND METHODOLOGICAL APPROACH

This analysis is mostly based on the literature review and on results from previous ESQs. When possible, additional analysis has been performed based on FADN and/or Eurostat data. Results are also triangulated with information from the case study interviews.

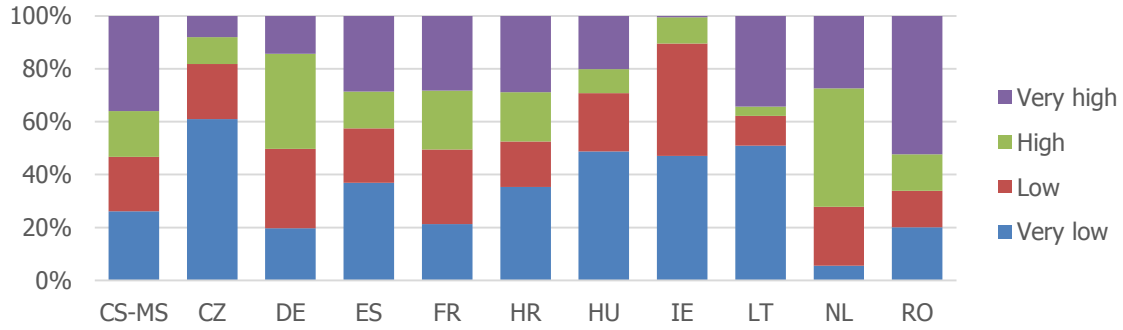
The impact on production of the measures addressing climate action is assessed first. Then, a brief analysis of the overall impact of the CAP on production and climate objectives is provided. Finally, an in-depth analysis of the effect of CAP measures as a whole on the livestock sectors is included, as an example of how some CAP measures affect production in a way that has unintended consequential effects on climate objectives.

This analysis mostly focuses on the effects of the CAP on production in terms of quantity produced per sector (i.e., cereals, oilseeds, dry pulses and legumes, livestock and forest biomass). In addition,

when analysing livestock production, the impact of the CAP measures is assessed for different levels of intensification, because measures may affect intensive and extensive farms differently and consequently have differing effects on climate objectives. Intensification has been assessed based on the area of grassland, fodder and fallow available to each farm since this is important both for carbon storage and for feed autonomy. Hence pig and poultry production has been considered to be intensive. Indeed, feed imports (and especially protein imports) can lead to emission leakage and farmers relying on imports are vulnerable to price volatility that is expected to increase as a result of climate change. Moreover, carbon storage is a key point to reduce emissions with the protection of permanent grasslands playing a key role. The level of intensification for grazing systems is thus calculated based on the area of grassland, fodder and fallow per livestock unit (LU). Based on FADN data, two indicators have been used: the number of grazing livestock units per hectare of permanent and rough grazing to account for carbon storage; and the number of grazing livestock units per hectare of permanent and temporary grassland plus rough grazing, fodder and fallow to account for feed autonomy. Because results obtained with these two indicators are similar, only the results of the first indicator are presented here[133]. It should be noted that results would have been slightly different if based on the percentage of LU instead of the percentage of farms per category.

Based on these definitions, the FADN analysis shows that in NL and RO most of the grazing livestock systems are relatively intensive while in CZ, HU and IE grazing livestock systems are mostly extensive (see Figure 35). However, these results should be interpreted with care due to the general limitations with the use of FADN data which apply to this analysis (see Box 2 in section 3.4 for details). In particular, extensive livestock farms which fall below the FADN threshold economic size for that country will not be captured by this analysis. This last point might explain why the level of intensification is quite high in Romania (many small extensive farms are not considered in FADN data).

Figure 35: Percentage of grazing-livestock farms per category of level of intensification in 2015 (in 10 case study Member States)



Source: Alliance Environment from FADN – DG Agri **Notes:** The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and rough grazing.

16.3 Analysis

16.3.1 Effect on production of CAP measures addressing climate action

The impact of the different CAP measures is analysed below.

16.3.1.1 Impact of greening measures on production

Several studies have assessed the impact of the greening measures on production through modelling with the IFM-CAP and CAPRI models (Gocht et al, 2016; Louhichi et al, 2017) or through analysis of

[133] The results obtained with the second indicator are in Annex 8.

FADN and Eurostat data (Alliance Environnement and Thünen-Institut, 2017). The main results of the latter are presented in Box 25.

Box 25: Summary of the findings of the greening evaluation on the impact of the greening measures on different types of production

Concerning cereals, greening measures led to only a slight decrease in the area under production compared to changes in total areas cultivated for cereals. However, depending on the Member States and crop type, the effect of the crop diversification measure looks as if it has also led to some increases in the area under cereal production. For example, the effect of the crop diversification measure on the decrease of soft wheat area was limited at the EU level but significant in Spain (-6% of the 2014 area). Results available for the case study Member States show that the crop diversification measure may have led to a decrease of the barley area at the EU level: barley areas decreased in Spain and to a lower extent in Poland and the overall decrease resulting from the measure accounts for about 65% of the total EU decrease in area. However, this decrease may have been compensated by area increases in other Member States where farmers chose to introduce barley to diversify their cropping patterns. For maize and durum wheat, no significant changes due to the crop diversification measure were identified in the case study Member States. The analysis at NUTS2 level confirmed that the high level of exemption did not prevent the increase in major crops in areas that were already insufficiently diversified (soft wheat in PL, maize in RO, HU, and PL).

For these four cereals, there were no significant changes in the geographical distribution of areas and no significant effect from greening was identified on prices. For these crops, the market is highly influenced by global market fluctuations, even though one cannot exclude the fact that greening measures might have slightly contributed to slowing down the price decrease.

Concerning oilseeds, overall it looks as if the greening measures have led to a slight increase in the total area cultivated, although there is no significant effect on prices and geographical distribution. The crop diversification measure helped mitigate decreases in the area of rapeseed and sunflower (especially in Romania). The crop diversification and EFA measures also contributed to increases in soybean but only to a limited extent, the soybean area being mainly driven by the market and the availability of VCS.

Concerning dry pulses and leguminous (mainly fodder) crops, greening measures seem to have encouraged significant increases in the areas cultivated against a declining trend. In particular, the crop diversification measure prevented likely decreases in the area of dry pulses in Spain, France and Poland and in the area of leguminous crops in Spain (an impact is also likely in Italy but it was not possible to verify it due to data availability). Together with the EFA measure, these measures also appear to have initiated changes in the geographical distribution of dry pulses areas, with significant increases in the EU share in Poland and Lithuania. It was not possible to analyse the impact on prices due to data unavailability.

Source: (Alliance Environnement and Thünen-Institut, 2017)

The results of these studies are generally coherent, especially concerning the limited effect on production of the maintenance of permanent grassland measure, and the role of the greening measures in the slight decrease in cereal production and as one of the drivers of increased production of dry pulses between 2014 and 2015. The results mainly diverge with regard to oilseeds, where modelling suggested that production would decrease due to the greening measures, but in practice increased slightly according to analysis based on FADN data (Alliance Environnement and Thünen-Institut, 2017). Finally, although the effect of the permanent grassland measure is difficult to assess due to the change in definition between the 2007-2013 period and the current one, and also the lack of data, an indirect positive effect on extensive livestock production at the expense of crop production can be expected. These limited effects might be because: many farms were exempted from or already compliant with the greening measures; the effects of the EFA measure were not as large as expected due to widespread use of productive EFA options; and almost all Member States chose to apply the PG ratio at national level, with only a few implementing an authorisation system for conversion of permanent grassland (AT, DE, FR LV, NL).

These studies focused on the impact of the greening measures on cropping areas. However, it should be noted that by forcing farmers to diversify their cropping system or to maintain mixed farming systems (in the case of the permanent grassland measure), the measures may promote the use of less productive crops or the continuation of relatively less productive livestock farming in the short term. However, in the longer term, the diversification of crops or activities might be positive in terms of climate adaptation and might lead to more secure production.

16.3.1.2 Impact of cross-compliance measures on production

Neither of the two criteria used by the Commission – number of hectares covered by cross-compliance and the share of CAP payments subject to it – measures its effects. The effect of the measure on production is consequently even more difficult to assess.

The large area covered by the measure - all holdings receiving Pillar I direct payments or environmental land management payments under Pillar II - attests to its potential. But since the 2014 shift of some requirements from GAEC to greening, the direct impact of the GAEC measures on production is expected to be limited, although the GAEC standards aimed at limiting soil erosion (GAEC 4, 5 and 6) can also enhance soil fertility and thus improve yields. Despite the percentage of cross-compliance infringements observed during controls was high at 29%, farmers most frequently cited the complexity of the rules rather than any constraining effect they had on production as the reason for infringement (European Court of Auditors, 2016).

16.3.1.3 Impact of Pillar II forest measures (M8 and M15) on production

Forestry production has to be appraised on a long-term perspective, as the rotation of EU stands ranges from 50 to 70 years or more for most conifers, and to up to a century or more for broadleaved trees. Hence, estimating the effects of the measures over a short period inevitably leads to figures showing little effect. This is the reason why the evaluation of the forest measures by Alliance Environnement and EFI (2017) mostly analysed results from the previous programming period. Based on the results of the implementation of the measures over that period and on the assumption that the situation now would be similar, the effects of the measures of the current programming period were estimated. The main results of the effect of forest measure on production from the forest evaluation are presented below (Alliance Environnement and EFI, 2017). They show that only measures 8.1 and 8.2 and their equivalent in the previous programming period (221, 222 and 223) had a significant positive effect on forest area. It should be noted that these afforested areas can sometimes be developed at the expense of cropland with consequent impacts on food and feed production as discussed in ESQ14.

Box 26: Summary of results of the evaluation of the forestry measures on the effect on production

At the EU level, measures 221 and 223 on **afforestation** (equivalent of M8.1) were implemented in 53 RDPs in 19 MS in the last programming period. If compared to the increase of forested area over the period, M221 (equivalent to M8.1) proved to be a key measure affecting land-use change, as it supported one third of the increase of 924,000 ha of forest area between 2007 and 2013 (287,490 ha), even though programmed in only half of the RDPs. In terms of geographical distribution, Spain is by far the MS in which afforestation was the most implemented (77,873 ha), followed by the UK (61,112 ha), PL (36,763 ha) and, to a lesser extent, Hungary (26,737 ha) and Lithuania (25,991 ha). Over the 2014-2010 period, 565,277 ha is expected to be afforested.

At the EU level, for measure 222 on **agroforestry** (equivalent of M8.2), only 5 RDPs out of 28 in which measure 222 was planned contributed to establish agroforestry systems. As a result, the RDP monitoring data showed that measure 222 led to the establishment of 2,900 ha of agroforestry and that M8.2 is expected to support the creation of 71,906 ha of agroforestry. The evaluation concluded that agroforestry corresponds to a very significant change in the agricultural system of farms, and that the level of support is not high enough to push land managers to make the change. The small proportion of RDPs that programmed the measure during the previous period and the places in which the measure was implemented (18 % of the RDPs) confirms the difficulty in finding farmers ready to make this significant change.

Measures impacting on **management practices** (8.3, 8.4, 8.5, 8.6, 15.1) are among those that could lead to changes in production. The RDP analysis shows that a wide range of operations are supported, allowing forest owners to choose the type of management they want, from production to conservation. The impact of these measures is therefore difficult to assess. However, two measures can be highlighted for their potential impacts on forest area preservation: M8.3 (M226) on disaster prevention (8.6 Million ha concerned by actions to protect forests from fire, and about 1 Million ha from natural disasters, which is about 5% of the total EU forest area); and M8.4 (M226) supporting restoration of damaged forests (557,000 ha reforested between 2007-2013).

Source: (Alliance Environnement and EFI, 2017)

Finally, the forest evaluation concluded that the set of forest measures have a generally positive effect on forest production and on the maintenance of the productive capacity of forests.

16.3.1.4 Impact of the Pillar II AECM measures on production

The agri-environment-climate measure (M10) can promote various actions which can have an impact on cropped area and livestock production. For instance, in the case study Member States it has been used to promote diversification (e.g. in DE, ES, FR, LT and NL), legume production (e.g. in DE, ES, FR, HU and LT) or extensive livestock production (e.g. in CZ, DE, FR, HU, IE, LT and RO). Extensive livestock production can, for instance, be promoted by requiring farmers under AECM to produce all or much of their feed on farm or to limit stocking density. On this last point FADN analysis shows that in general AECM preferentially supports extensive or very extensive livestock systems (e.g. CZ, DE, FR, IE and NL) even if in some Member States the support can favour more intensive livestock farms[134] (e.g. HU) (see Figure 43 and the section below on the impact of the CAP measures on intensive and extensive livestock for more details).

In some Member States, the AECM supports maintenance or creation of non-productive areas such as fallow land (e.g. in FR, HU or IE) or buffer strips and hedgerows (e.g. in DE, ES, FR, HR, IE, LT and NL) with potential negative impacts on production. The measure can also support some actions that have no direct impact on production area but can have an impact on yields in the longer-term (e.g., catch or cover crops or no tillage practices). Finally, by promoting practices that are better adapted to the changing climate (e.g. diversification, soil carbon conservation, etc.), the AECM can induce a decrease in production on the short term, but are expected to help limit the impacts of climate change on yields and thus on production variability in the long-term.

The AECM measure has been implemented to different extents in different Member States. The area under contract in 2016 ranges from 0 ha (in MT and HR) to 12,900 ha in the UK[135]. However, lack of data on the level of implementation of different schemes within an RDP agri-environment-climate programme makes it difficult to assess to what extent M10 supports actions that have an impact on production. Moreover, according to some interviewees, some payments support actions that would have been taken even without support and, if this is the case, any deadweight would have limited production impact.

16.3.1.5 Impact of Pillar II investment measures (M4, M7) on production

In the answers to ESQs 1 to 5 it has been shown that M4 can support a broad range of actions for mitigation and adaptation which are, in most cases, also positive in terms of production. For instance, support under M4 can help farmers to modernise their production systems, potentially leading to a decrease in GHG emissions in absolute terms, for example from improved livestock housing, and also per unit of meat or milk, as a result of consequent improvements in productivity. Capital investments in infrastructure and technologies aiming at climate action can also support some specific types of production. For instance, the production of irrigated crops can be improved, with M4 support for drip irrigation or increased storage capacity. The budget allocated to M4 is relatively significant (more than a fifth of the total public expenditure for RDP measures in the EU) and the measure has considerable potential. Finally, anaerobic digesters can also be supported under M4 with potential positive effects on the production of energy crops at the expense of other crops. However, due to lack of data in the AIRs on the type and level of technical operations supported, it is difficult to assess quantitatively the direct impact of the measure on production. Finally, the measure might, to some extent, lead to a specialisation and intensification of the farming systems. Indeed, this might be needed by farmers to provide a reasonable return on their investment. However, this effect is limited in some Member States where the measure has been designed to preferentially support collective investments.

The other investment measure considered here, M7.2 supporting investment in small scale infrastructure, is also important in terms of mitigation since it can, for example, provide support for the establishment of renewable energy infrastructure. This could help to reduce reliance on fossil fuels in remote rural areas and reduce emissions from farms. However, in the case of support linked to bioenergy production and use, it can lead to competition between land used to produce feed and

[134] The level of intensification is defined as the number of LU per area of grassland and rough grazing on farms.

[135] Information derived from the Annual Implementation Reports in 2017 – and explained further in ESQ5.

food and land used to produce energy crops, with potential impacts on food security and carbon leakage (see ESQ 14 for more information).

16.3.1.6 Impact of Pillar II soft measures (M1, M2, M16, M19) and of Farm Advisory Services (horizontal regulation) on production

As established in the introduction (section 2), soft measures addressing climate action are M2, M16, M19 and the Farm Advisory Services. These offer an opportunity to improve farmers' capacity and uptake of climate friendly actions through knowledge sharing, advice, training, cooperation, etc. These measures can affect production (by enhancing competitiveness), but such effects are likely to be limited and difficult to measure (Charatsari, Folinas and Lioutas, 2010). Moreover, as shown in ESQ5, the measures have been little programmed, with delays in implementation in some Member States. Impact of Pillar II risk management measures (M5, M8 and M17) on production

M5, M8 and M17 help farmers and foresters to build resilience to the effects of climate change by supporting preventive actions (M5.1 and M8.3), restoration after damage (M5.2 and M8.4); and in the case of farmers, by supporting insurance, mutual funds and income stabilisation tools (M17). These measures can thus be considered as production system conservation tools. However, these measures can also support maladapted systems with negative impacts in terms on production (see ESQ5).

16.3.1.7 Combined effects of the measures addressing climate action on production

Many factors affect EU production and the CAP measures under consideration have rarely been mentioned as key factors to explain production levels. However, even if the individual effect of each measure is weak, the multiplicity of incentives for the production of specific crops or livestock (e.g. dry pulses or legumes or extensive livestock products) can act in synergy to maintain or even increase certain types of production, according to interviews in the case study Member States. Results show that the measures partly drove the increase in the area planted with dry pulses and leguminous crops, slightly limited the decrease of permanent grassland area, boosted the increase in forest area and led to a slight reduction in cereal production. Many measures addressing climate action also have a positive effect on land and labour productivity, for example when measures to protect soil also result in increases in yield. However, some measures can reduce a farm's productivity and profitability. For instance, the permanent grassland measure is in some areas limiting the ability of farmers to switch grassland areas to more productive uses (Alliance Environnement and Thünen-Institut, 2017). To meet diversification requirements, some farmers may have to introduce less productive crops in the rotation which can hinder productivity in the short term. However, in the longer term, by promoting practices such as diversification which make systems more resilient, the CAP measures under consideration increase the expected stability of production over time.

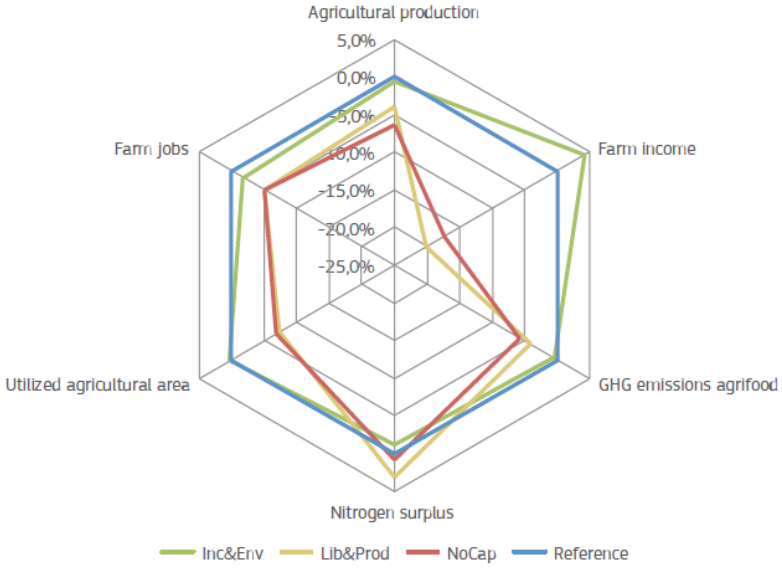
16.3.2 Overall impact of the CAP on climate objectives and production

This ESQ asks about the impact of the CAP measures addressing climate action on production. In order to supplement that analysis, we also look at the impact of CAP measures as a whole on production and at the implications of such changes for climate action. As an example, a focus has been made on the livestock sector. Livestock is a key sector for climate mitigation for several reasons (see ESQ1-4), particularly as it is one of the main sources of non-CO_2 GHG emissions, linked to manure management and enteric emissions. Livestock farmers also play a key role in managing large areas of land which are (or potential) carbon sinks (especially when managing large areas of permanent grassland and rough grazing). Concerning adaptation, the sector may also be affected by climate change (see ESQ5), through impacts on animal welfare and health, on yield variability (although grass yields are less likely to impacted than those of other crops (INRA, 2014) and on price volatility of animal feed. The livestock sector is of interest because of the relationship between feed self-sufficiency, carbon leakage (since 95% of soymeal is imported (see ESQ14)) and resilience. Since these relationships vary greatly according to the intensiveness of the farming system used, the analysis looks at the impact of the CAP on livestock farms with differing levels of intensity (calculated based on the area of grassland, fodder and fallow per LU to account for feed autonomy and carbon storage potential). This analysis relies on FADN data and the SCENAR 2030 simulation.

16.3.2.1 Overall link between impact of the CAP on production and climate

Within SCENAR 2030, (M'barek et al, 2017) the JRC analysed how different scenarios for the CAP (including a no-CAP scenario) would impact on the various objectives of the CAP (including production and climate action). Results of the SCENAR 2030 study show that without the CAP, agricultural production would decrease in the EU (mostly at the expense of small farms in EU marginal areas) along with GHG emissions (see Figure 36). Moreover, the analysis shows that the decrease in production in the EU will be compensated by an increase in imports, leading to increased production in other parts of the world (especially in the Mercosur countries[136]). Thus, overall the impact on GHG emissions is very uncertain. In terms of adaptation, a decrease in production will be accompanied by increased specialisation of farms with potential negative effects on adaptive capacity at farm level, but also on the vulnerability of the EU as a whole in terms of food security (due to increased reliance on imports). Finally, farm labour and income are expected to decrease in the EU without CAP support.

Figure 36: Overview of scenario impacts of SCENAR 2030

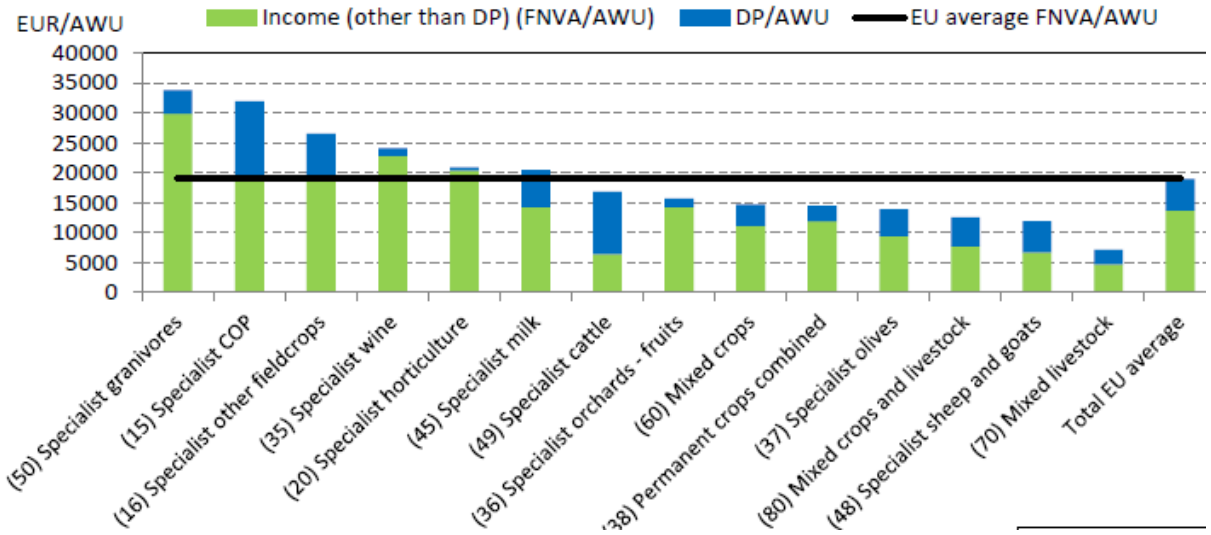


Source: (M'barek et al, 2017)
Notes: Inc&Env: restrictive compliance with agri-environmental objectives is required for direct payment eligibility, while the EU's CAP budget is maintained at its current nominal level; Lib&Prod: severe reduction in support payments with the removal of Pillar I direct payments (which are returned to tax payers) and a shift of Pillar II payments to productivity-increasing measures and further trade liberalization; NoCap: without the CAP; Reference: the current CAP

EU level FADN data analysis makes it possible to assess the level of support provided by direct payments by type of farm. Figure 37 compares income per labour unit for different types of farm, and also shows the relative importance of CAP direct payments and other sources of income. This shows that direct payments for specialist milk and specialist cattle farms help to bring these farms up to near the EU average income per labour unit, but this is not the case for other types of farm that have relatively low income per labour unit from other sources (mixed livestock or specialized sheep and goats). These results show that even though grazing livestock farms are supported by the CAP, their average income per working unit remains lower than the EU average and much lower than for many other types of farms. As a result, it can be expected that direct payments help to prevent some farm abandonment and thus prevent to some extent a decrease in livestock production. Thus, effects on production might be positive, with an increase in GHG emissions (as described in ESQs 1-4). This is consistent with the result of the SCENAR modelling study.

[136] Argentina, Brazil, Paraguay and Uruguay

Figure 37: Income per labour unit from direct payments and other sources, by type of farm (estimated 2019)

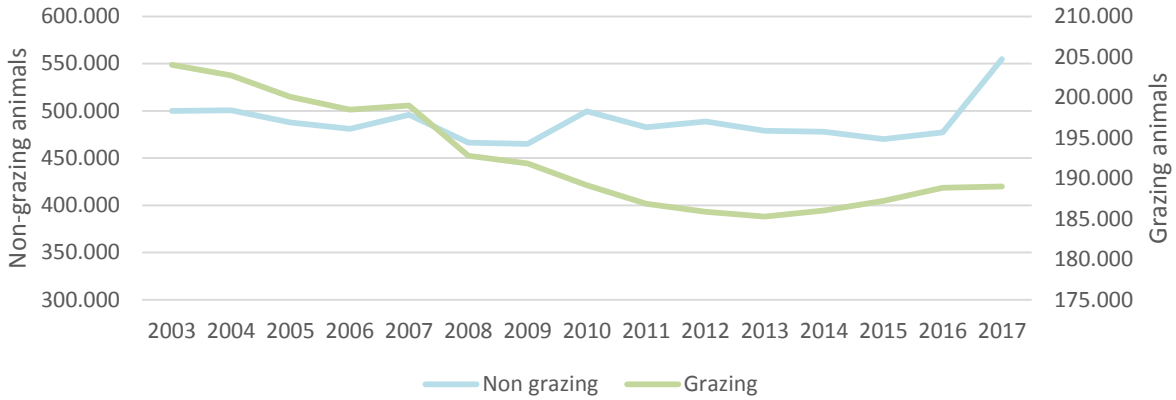


Source: FADN data – DG Agri

16.3.2.2 Main factors impacting on production in the livestock sector

The structure of European agriculture and more specifically the livestock sector has changed dramatically over the last fifty years towards an intensification of livestock systems (Huygue et al, 2014). On the one hand, due to the low price of imported soybean, it became more profitable to feed livestock with imported feed than with feed produced in the EU. On the other hand, green maize and other annual crops have contributed to the reduction in grasslands, with green maize playing an important role in animal feed, to complement soybean.

Figure 38: Grazing and non-grazing population change since 2003 (in thousand head)

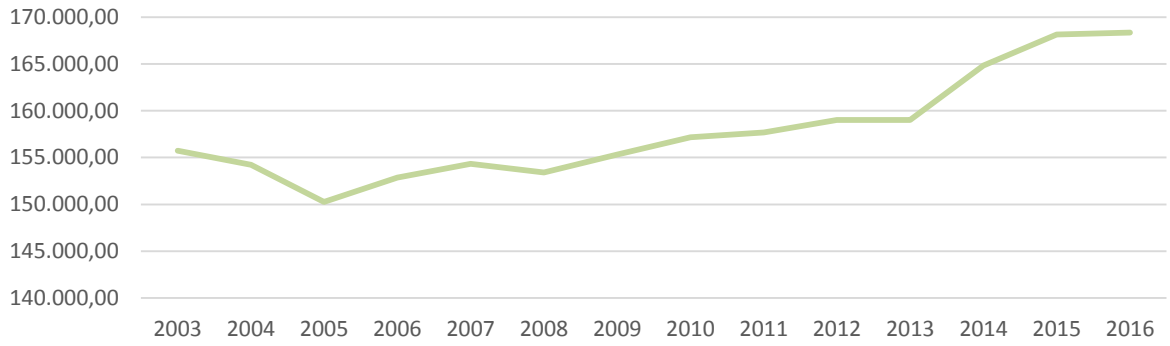


Source: Eurostat data

The grazing livestock population has decreased over the last 20 years but since 2013, an increase in the area grazed has been observed (Figure 38). The end of milk quotas can partly explain why the grazing animal population have been increasing since 2013 (together with the supportive demand). In fact, the sharper increase in milk production observed since 2013 (Figure 39) could be partly explained by an increase in the dairy cattle population which had been indirectly restricted by the quotas, but also by an increase in productivity due to reorganisation of the sector. In some Member States the fall in milk prices following the end of the milk quotas forced some farms to close. In Germany for example, the milk price dropped from 0.390€/kg on average for 2013/2014 down to 0.317€/kg for 2014/2015 (MULE, 2016) If in some areas this might have led to a decrease in cattle numbers, some of the surplus dairy herds were absorbed by the remaining farms resulting in an average increase in productivity. For instance, it has been shown that, in Ireland, the end of the EU

milk quota in 2015 was the driver for a 6% increase in milk production in the same year (Zeng and Gould, 2016).

Figure 39: Production and utilisation on the farm of milk in EU-28 (1000 t)



Source: Eurostat data

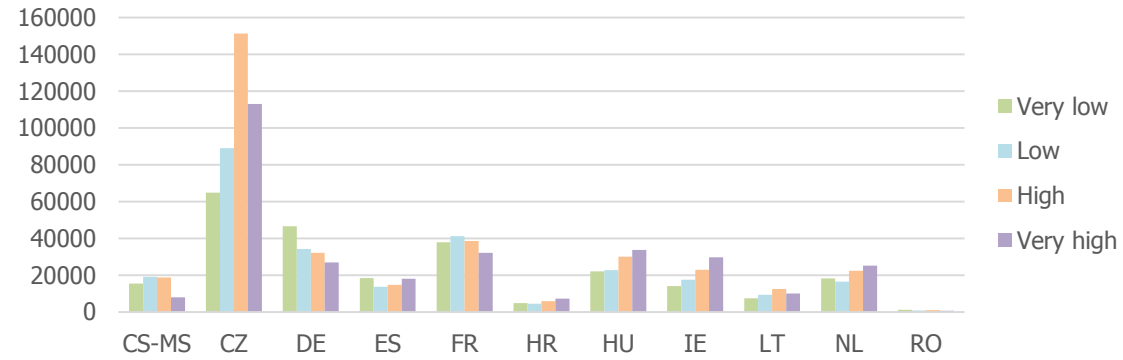
Finally, as explained below, the decrease in grazing animal numbers until 2013 (Figure 38) might have been limited by the various CAP support for grazing livestock production leading (together with the supportive demand) to a positive trend after 2013 (Huygue et al, 2014).

16.3.2.3 Impact of the CAP measures on grazing livestock production

Various CAP measures have the potential to support livestock farmers. This analysis mostly assesses the effects of CAP support on intensive and extensive production based on analysis of FADN and implementation data. Results from the previous analysis of greening are also referred to.

When focusing on the distribution of the support among grazing livestock producers based on their level of intensification, it can be seen that on average in case study Member States, CAP support increases in line with the level of intensification (defined based on the number of grazing LU per hectare of permanent grassland and rough grazing). However, the picture is quite varied across Member States. On average the level of CAP support is higher for farms with high or very high levels of intensification in CZ, HR, HU, IR, LT and NL while it is lower in DE, FR and RO. In the case of ES, the level of support is higher for very intensive and very extensive farms than for other farms. Thus, the CAP preferentially supports extensive grazing livestock systems in DE, FR and RO. As results were similar when using the second indicator of intensification that considers food autonomy (area of fodder crop and grassland per LU), it can be said that these three Member States also mostly favour food autonomy at the expense of systems dependent on bought in feed. The following analysis assesses the level of support of some specific measures per farm by level of intensification in order to investigate further these results.

Figure 40: Average CAP support per farm (in EUR) received by farms with grazing livestock in 2015, by intensity of management, in the 10 case study Member States

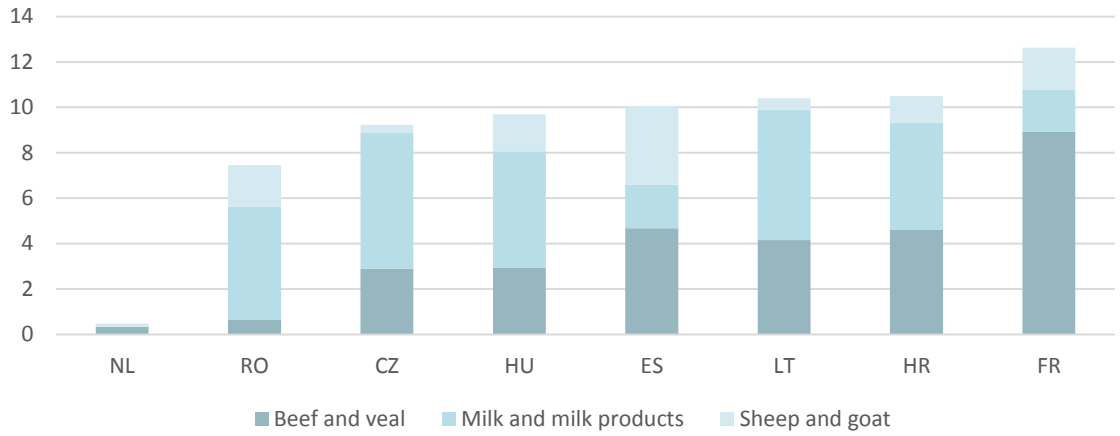


Source: Alliance Environment from FADN – DG Agri

Notes: The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and rough grazing. CS-MS: case study Member States.

Voluntary coupled Pillar I payments were established in both of the two previous programming periods to maintain a level of coupling for certain sectors deemed vulnerable[137]. In the CAP 2014-2020, around 10.1% of the Pillar I budget has been earmarked for the VCS measure, with this support going mainly to livestock sectors (beef and veal, milk and milk products, and sheep and goats) which account for 74% of the VCS budget (DG Agri from ISAMM data). At the EU level, an impact assessment carried out by the European Commission estimates that without VCS, beef production would reduce by 2.5% and milk production by 0.7%, evidence that this measure clearly supports ruminant livestock production at the EU level. In most of the case study Member States (all except DE where VCS has not been used and NL where VCS only supports very extensive farms), the share of direct payments dedicated to VCS support for livestock sectors is important (see Figure 41), especially for the beef, veal, milk and milk products sectors. It can be concluded that VCS also has a positive impact on livestock production in these Member States. As discussed in section 6.1.1, this increased production increases GHG emissions.

Figure 41: Share of 2015-2020 direct payment budget dedicated to VCS for livestock in 8 case study Member States

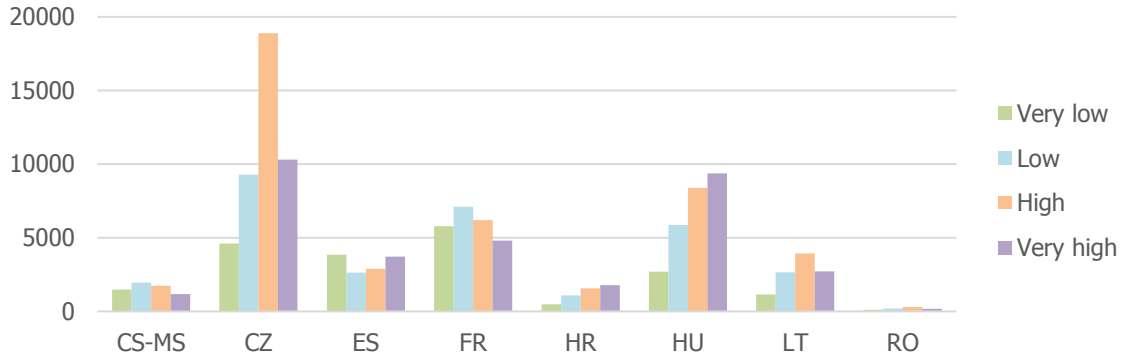


Source: Member State notifications

Regarding the level of intensification of the livestock systems supported, the analysis of the FADN data for 2015 shows that, in most case study Member States where VCS for grazing livestock are used (excluding DE and IE but also NL where no farmer in the FADN survey received VCS support), the level of VCS support for livestock per farm increases with the number of animals up to a point and then decreases with the level of intensification. This can be explained by the fact that FR and RO have set eligibility rules for VCS that limit the number of ruminant animals per farmer which VCS may support. However, in HR and HU, the level of VCS support per farm increases with the level of intensification. The case of Spain is specific, since farmers with very low or very high levels of intensification are preferentially supported (see Figure 42). Finally, it should be noted that the expected impact of the measures depends on the level of the support to farms which are on average quite high per farm in CZ, FR, and HU and to a lesser extent in ES and LT but quite low in HR and RO.

[137] See Articles 68 and 69 of Regulations 73/2009 and 1782/2003, respectively.

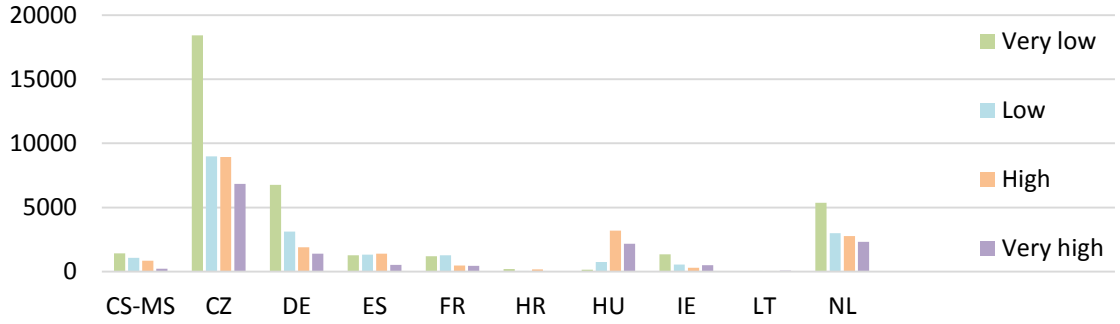
Figure 42: Average VCS support per farm (in EUR) received by farms with grazing livestock in 2015, by intensity of management, in 8 case study Member States



Source: Alliance Environment from FADN – DG Agri
Notes: The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and rough grazing. CS-MS: case study Member States. DE, IE and NL are not represented because no budget was dedicated to this measure in these Member States.

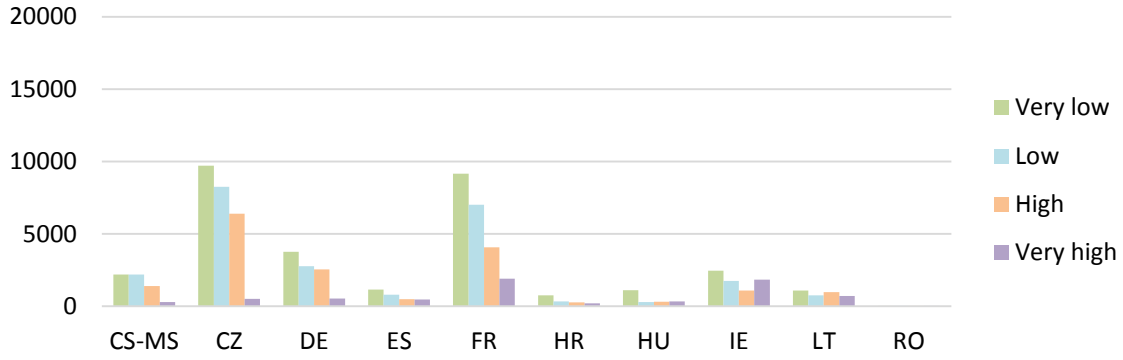
Many other CAP measures under both Pillars can also have an impact on livestock farming especially those related to permanent grassland including the greening permanent grassland measure (part of which was formerly linked to cross-compliance requirements), some AECM (M10) schemes, the Natura 2000 area compensation payments in agricultural areas (M12.1) but also specific supports in ANC (ex-LFA) areas (M13) (Huyghe et al, 2014). The impact of Pillar II greening requirements on extensive livestock production is limited, since these only partially prevent the conversion of permanent grassland into arable land (Alliance Environnement and Thünen-Institut, 2017). As regards Pillar II, results from 2015 FADN analysis show in those case study Member States where specific measures were implemented (IE, LT and NL for M13 and DE, FR, HR and RO for Natura 2000 compensation) that supports under M10, M12.1 and M13 are quite variable between Member States and that they preferentially support extensive livestock systems (see Figure 43, Figure 44 and Figure 45). This support per farm is quite low on average in HR, LT or RO while they are more important in CZ, DE, FR, HU and NL and to a lesser extent in ES and IE. This is at least partly due to differences in labour costs. M12.1 has been programmed by few of the case study Member States and the level of support under this measure is quite low (€800 per farm in Hungary for very extensive farms). Support under this measure is represented in Figure 45 which shows the distribution of M12.1 between livestock farms with differing levels of intensiveness as a proportion of total M12.1 support to livestock farming in each of the four Member States in which it is offered. This support is more favourable to (i.e. are more targeted towards) extensive livestock systems in almost all the case study Member States. Only some cases are observed where these measures favour intensive farms such as the AECM support in HU and M13 support in IE and RO. For RO, this is likely to be the result of the FADN sampling. The implications for climate action of supporting extensive livestock farming than more intensive farming are, in the case of adaptation, that environmental services (such as fire protection, effective functioning of nutrient cycles) and resilience (due to feed autonomy and resilience of grassland systems when compared to rain fed crop systems) are increased. Given the fact that the level of intensity of livestock farming is calculated based on the area of permanent grassland and rough grazing per LU, an increase in support to extensive livestock farming is linked with an increase in support to rough grazing and permanent grassland, which have an important potential in terms of carbon storage, although the potential of sequestration vary with soil, climate and grassland management. The implications for mitigation should thus be positive. The results obtained when considering the second definition of extensive livestock that considered feed autonomy (fodder production and temporary grassland) in addition to carbon storage (permanent grassland and rough grassland area) are similar (see Annex 8). It can also be concluded that these measures are less favourable to farmers with low feed autonomy and that they promote a decrease in feed imports and limit farmer vulnerability to feed prices volatility.

Figure 43: Average AECM support per farm (in EUR) received by farms with grazing livestock in 2015, by intensity of management, in 9 case study Member States



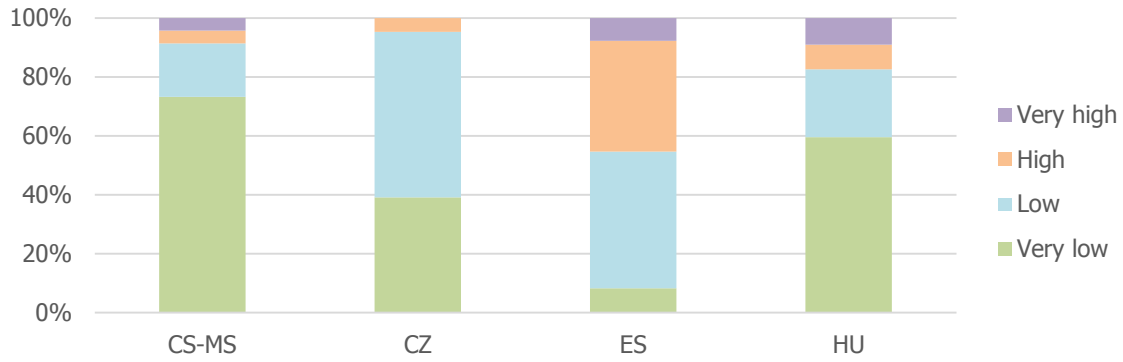
Source: Alliance Environment based on FADN data – DG Agri
Notes: The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and rough grazing. CS-MS: case study Member States. RO is not represented (less than 15 unweighted farmers with AECM support).

Figure 44: Average M13 support per farm (in EUR) received by farms with grazing livestock in 2015, by intensity of management, in 9 case study Member States



Source: Alliance Environment from FADN – DG Agri
Notes: The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and rough grazing. CS-MS: case study Member States. NL is not represented because no budget was dedicated to this measure in these Member States.

Figure 45: Percentage of M12.1 support received by farms with grazing livestock in 2015, by intensity of management



Source: Alliance Environment from FADN – DG Agri
Notes: The 4 levels of intensification are defined as: Very low: less than 1.2 LU/ha of permanent grassland and rough grazing; Low: between 1.2 and 2.44 LU/ha of permanent grassland and rough grazing; High: between 2.4 and 6.8 LU/ha of permanent grassland and rough grazing; Very high: > 6.8 LU/ha of permanent grassland and

rough grazing. CS-MS: case study Member States. DE, FR, HR and RO are not represented because no budget was dedicated to this measure in these Member States.

16.4 CONCLUSIONS

ESQ13 first assessed the effects on production of the CAP measures addressing climate action (greening, M2, 4, 5, 6, 8, 10, 15, 16, 19, GAECs 4, 5 and 6 and the Farm Advisory Service). The individual effect of any of these measures is limited in terms of area and/or quantity of agricultural commodities produced. Still there is a small positive effect overall (largely from the greening and forest measures) on the area on which legumes are grown, the area of permanent grassland and the forest area, and a negative impact on the area cultivated with cereals.

Forced diversification of crops can make production more stable in the long term even if productivity suffers some short-term damage.

CAP measures addressing climate change can have either positive – in the case of investment measures – or negative impacts on productivity. The scope for productivity improvements is greater in the EU-13 than in the EU-15.

Finally, it has been assessed that the CAP measures supporting adaptation of the farming system (e.g. by encouraging diversification or increasing soil carbon) can also help to secure production in the longer term, thus addressing an important challenge in the context of climate change.

The livestock sector is of interest because of the relationship between feed self-sufficiency, carbon leakage and resilience. It is also vulnerable to climate change through impacts on animal welfare, variability in the yields of feed crops and variability in the price of feed.

A comparison of agricultural income per worker between different sectors of agriculture shows that extensive livestock farming is on average only generating the EU average level of income per farm worker. The average level of CAP support per farm is higher for farms with high or very high levels of intensification in CZ, HR, HU, IE, LT and NL while it is lower in DE, FR and RO. More specifically, the support provided per farm under M10, M12.1 and M13 are in most cases higher for extensive than for intensive producers. In the case of VCS, the level of support per farm increases in line with the degree of intensiveness of farm systems before decreasing for the most intensive systems. This can be explained by the fact that some Member States (FR and RO) are applying degressive payment rates per head as the number of supported animals increases.

By increasing livestock farmer incomes the CAP as a whole increases livestock production and thus direct GHG emissions, although this impact cannot be quantified for lack of a suitable counterfactual. Where aid is routed preferentially to extensive livestock, however, there are adaptation benefits in the form of increased feed self-sufficiency, retention of farm system diversity, and other environmental services such as the protection of biodiversity and more effective functioning of the nutrient cycle. Feed self-sufficiency could also reduce associated land use change emissions. Any mitigation benefits from the management of soil carbon are site-specific.

17 FOOD, FEED AND THE BIO ECONOMY (ESQ14)

ESQ14: To what extent does a change in EU food, feed and biofuel production and the development of bio-economy affect greenhouse gas emissions?

17.1 UNDERSTANDING OF THE QUESTION

The Paris Agreement provides new ambition to climate mitigation efforts globally. These ambitions will require net-zero emissions from the economy as a whole by around mid-century. It is recognised that some sectors, including agriculture, will not be able to reduce emissions to zero, which requires negative emissions to play a role. ESQ14 provides information on some of the factors influencing the CAP-supported sectors' abilities to contribute to the EU's GHG emission targets in the context of changing food, feed and bio economy developments.

Before exploring these factors, it should be noted that the CAP is only one of the tools available to support and drive change in these areas, with a wide range of other policies and strategies (such as the Renewable Energy Directive) influencing the decisions of land managers, as well as wider drivers of change including dietary preferences and choices (such as the reduction of meat and animal products in diets) and technological changes (such as digitisation, feeding and breeding strategies and novel ways of processing). The flexibility of the CAP measures and instruments allows it to support action on these other policies as well as supporting farmers and foresters in adapting to other drivers, such as changing diets. For example, EAFRD forest measure 8.6 can support the development of new value chains for forest products in the bio economy.

The term "bio economy" covers the main elements of this question. It is defined in the EU bio economy strategy (*COM(2012) 60 final*) as the "production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy". The CAP and the bio economy are strongly connected as they share and address similar objectives, such as food security, rural development, European self-sufficiency, while being complementary (Allen et al, 2015). The concept of the bio economy is intended to integrate and consider more holistically the use of biomass as a raw material, yet is neither sustainable or climate positive by default. One challenge for the growing bio economy is how to ensure that the production of biomass to meet a growing suite of demands can be met sustainably and in a way that continues to drive down GHG emissions in the agriculture and forest sectors whilst contributing to greater GHG efficiency in the economy as a whole. The production practices employed, choices made regarding end use, efficiency of use and use of waste materials will all be important in determining how the development of the bio economy interacts with GHG emissions and mitigation.

Technological changes, research and innovation, and their potential impacts on GHG emissions (assessed in ESQ6) are essential in supporting the development of the agricultural component of the bio economy to reach its mitigation and adaptation goals in a way that does not compromise the potential of the sector to contribute towards the CAP's strategic objectives as a whole.

Considering the breadth of the bio economy as a topic, the analysis is focussed on three elements impacting food, feed and the bio economy as a means of exploring the CAP's role in addressing climate action. These are:

(1) livestock production and consumption in the EU;
(2) feed production within the EU, and;
(3) the bioeconomy as seen through developments in biofuel production.

In order to answer ESQ14 and reflect the different needs and interactions associated with the bio economy, each element is analysed separately followed by an analysis of interactions. In a second step, the role of current CAP instruments in those changes is assessed. The authors are aware that there are other important interactions and end uses within the bio economy that can be influenced by the CAP including the development of biogas, support of solid biomass energy and production of biomaterials through forestry measures and supply chain measures possible within the RDP framework.

17.2 Process and methodological approach

The Steering Group agreed to a forward-looking approach to this ESQ, therefore the methodology used includes the analysis of prospective scenarios focusing on the three potential changes identified and how they are expected to affect GHG emissions by sources and removals by sinks in the EU. The results of previous ESQs were also used to complement the analysis.

- **Assessment of current trends** based on a review of relevant literature.
- **Synthesis of prospective studies focusing on the three components of this question:** changes in food (animal products), feed, biofuel production and consumption that could support climate mitigation. A description of the method used for the comparison of scenarios for GHG emissions is provided in Annex 9. The field of analysis has been the EU-28 and third countries when relevant and feasible. As far as possible, a common date for forecasts has been used. When elements of the literature review provided prospective results concerning GHG emissions, these have been synthesised (see Annex 9). When this was not the case, the analysis carried out in the previous ESQs was used to estimate the impact of expected changes in food, feed and biofuels.
- **Identification of main policy drivers** affecting the food/feed/and bioeconomy sectors and their emissions, based on a literature review, case studies and analysis of previous ESQs.

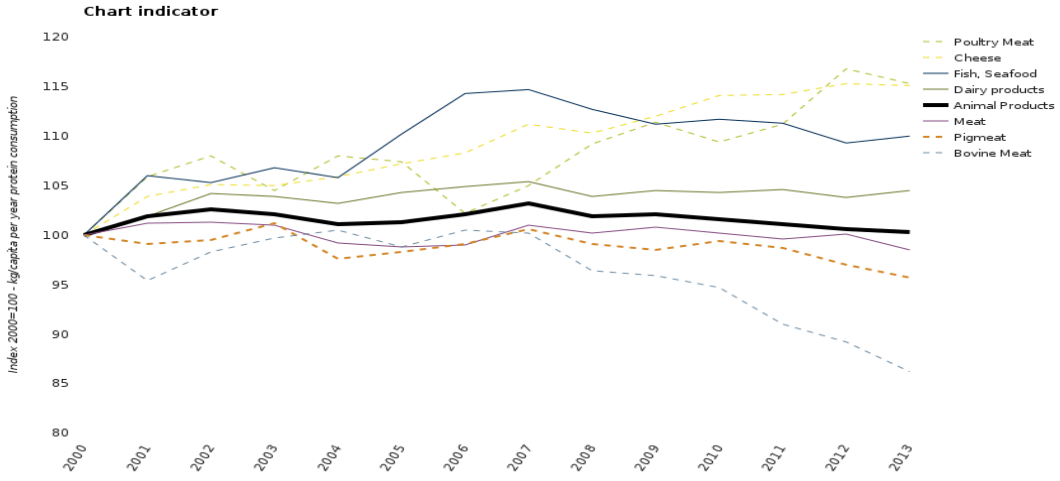
17.3 Analysis

17.3.1 Consumption and production of livestock products

Some studies suggest that feasible dietary changes in richer parts of the world such as Europe could bring about reductions in per capita emissions of more than 25 % (FCRN 2015). These involve a lower level of meat and dairy consumption than at present (Baldock and Mottershead, 2017; Garnett et al, 2017). The current daily calorie intake in the EU is approximately 20% higher than the world average (2,596 kcal/person compared to 2,180 kcal/person) (FAO, 2016). Figures on the level of meat consumption in the EU vary depending on the source consulted but are generally accepted to be higher than the WHO recommended level of meat protein consumption as part of a healthy and low-carbon diet (EEA, 2017d). The WHO suggests that if industrialized countries reduce their meat consumption from the current 224 g/person/day (~82 kg/person/year) to 90 g/person/day (~33 kg/person/year) (convergence globally) there would be a significant effect on carbon levels and health (World Health Organization, 2008).

From 1995 to 2011, the EU consumption of dairy products and meat increased respectively by 6% and 2% (EEA, 2017d). This general trend, however, masks a change in the types of meat consumed. Within the meat category, consumption of beef has fallen by 13 %, while consumption of poultry products has increased by 23 %.

Figure 46: Trends in EU per capita animal based protein consumption. Total and by selected animal product category



Source: (EEA, 2017d)

Livestock are one of the main sources of GHG emissions in the agriculture sector in the EU. If emissions due to land use change are included, livestock production is estimated to release 9.3% of all human-induced emissions (Weiss and Leip, 2012) and currently accounts for around 60% of agricultural GHG emissions in the EU[138]. The consumption of livestock products (in general, but with intra livestock variation) will continue to have a detrimental impact on agricultural GHG emissions, unless emissions in these sectors are addressed through: reducing production and consumption of animal products; mitigation approaches based on improved livestock system management (i.e. considering land, feed management, nutritional and manure management mitigation strategies); or by a combination of the two (Gerber et al, 2013).

The link between meat protein consumption and GHG emissions and environmental impacts varies depending on the type of meat consumed and does not provide for a direct relationship. For example, the current average EU consumption of meat ranges from 1.9 kg/capita for sheep up to 32.5 kg/capita of pork meat[139], with beef and veal consumption at 11 kg/capita (OECD, 2018). The GHG impacts of these different livestock products varies considerably depending on their primary diet in conventional systems (e.g. grain fed versus grass fed) and the management conditions in which they are raised (see also section 17.3.2.1).

The CAP can play a supporting role in addressing some of the production-related emissions from livestock where they (and the feed) are produced in the EU, but has a more limited role in addressing consumption patterns, which derive from a much broader set of external drivers.

17.3.1.1 Reducing the production and consumption of livestock products

Reducing production in the EU would not necessarily lead to a reduction in GHG emissions if this is compensated wholly or in part by a concurrent increase of production in other parts of the world to meet EU demand (see 3.2). However prospective studies reviewed here are generally based on hypotheses such as the maintenance of a close link between consumption and production at the EU level, which is probable when considering the current and projected level of production costs compared with other main livestock producers (e.g. Brazil, US, etc.), and the trading environment, at least for meat. It is therefore necessary to consider which parts of production should be reduced to achieve emission reductions and the impacts those reductions may have on broader environmental, social and economic agendas[140].

Livestock farming has multiple impacts and (particularly in the case of extensive livestock grazing) can be beneficial to a number of broader EU objectives including economic[141] and environmental ones, such as biodiversity conservation, or in supporting climate adaptation through grazing for vegetation management. Extensive grazing can enable production on areas that could not otherwise be used for production (Garnett et al, 2017) (see ESQ5).

The main factors influencing changes in livestock production in the EU are demand (i.e. EU internal and external food demand), productivity (e.g. the decrease in dairy cattle in Spain is partly explained by improved productivity), feed prices (mainly the price of imported soybean) and CAP instruments concerning ruminant livestock (e.g. the end of milk quotas in 2014 made farmers more responsive to the global demand). Other CAP measures may also have had a role as discussed in ESQ13 and further in this ESQ[142].

---

[138] Including ~16% for manure management and 43% for enteric fermentation. Source: EEA (aei_pr_ghg)

[139] 24.2 kg/capita poultry

[140] Economic impacts of dietary changes have also been assessed and their outputs rely mainly on how trade and trading policies are modelled: strong regional effects are expected in areas with lower quality arable land. Economic effects are lowered if citizens mainly consume products with higher added value that comes from livestock systems with higher welfare levels and positive effects on biodiversity (Westhoek et al, 2014).

[141] The livestock sector accounts for up to 40% of the EU's agricultural production value with an estimated €130bn output value annually and creates employment for almost 30 million people (Animal Task Animal Task Force, 2017).

[142] Concerning current trends in livestock numbers, in 2013, the total livestock population in the EU-28 accounted 130 million livestock units (LSU), of which cattle made up 48 %, followed by pigs (26 %), poultry (15 %) and sheep (7 %) (Eurostat). Ruminant livestock numbers (cattle, sheep and goats) decreased between 2003 and 2013 and have slightly increased since 2013 (by 12.5%) (see ESQ13). Non-grazing animals (poultry and pigs)

Concerning food demand evolution, we can distinguish two types of scenarios in the EU:

- ***Scenarios considering relatively stable or slowly increasing demand, with current dietary patterns.*** In this case, technological progress in agricultural production including increases in crop yields and livestock feed conversion efficiency is expected to continue whereas the concrete effects of technological changes on climate mitigation and on their dissemination rate are varied in the different scenarios (Fischer et al, 2010) (Bryngelsson et al, 2016). If dietary patterns remain stable and there is no major technological progress toward mitigation, CH_4 and N_2O emissions are expected to increase by about 40% by 2050 (in comparison with 2010 levels), to over 1.7 metric tonnes CO_2eq per capita per year. If there is significant technological progress, emissions could be cut by nearly 50% respectively, down to about 600–900 kg CO_2eq per capita per year. Although, this reduction remains still insufficient for meeting the EU 2050 targets (Bryngelsson et al, 2016).
- ***Scenarios considering alternative diets in the EU.*** These studies focus on GHG emissions assessment of radical changes in dietary patterns such as much greater uptake of vegan or vegetarian diets; partial replacement of different types of meat; or partial reduction of meat consumption (e.g. flexitarianism,) (Aleksandrowicz et al, 2016) and reduction of sugar intake. In fact, dietary changes most often considered are reductions in calories, reductions in the quantity of meat and the type of meat consumed. Some studies evaluate the impact of alternative diets without compensating for the decrease in energy intake. For example, with a lower consumption of meat, dairy and eggs, the average consumption of cereals could increase by 10 to 49 % while the protein intake in the alternative diets could still be up to about 10% lower than under baseline scenarios. The level of protein intake would still remain in the EU average of at least 50% higher than the dietary requirements set out by the WHO (Westhoek et al, 2014).
- The results of such studies generally show that reductions in environmental footprints (and GHG impact) are generally proportional to the magnitude of restrictions in livestock-based food consumption. Analysis of 14 dietary patterns suggest that a possible reduction of between 20 to 30% of GHG emissions (median figures) could be achieved in Europe by shifting diets in this way (Aleksandrowicz et al, 2016). Other positive effects that are expected for such scenarios are improved animal welfare and public health.

Some scenarios test the potential to shift from ruminant to monogastric meat, showing a decrease of GHG emissions (Bryngelsson et al, 2016). However, such scenarios are based on intensive breeding systems, where animals are raised in battery cages with an optimised diet. Intensification of livestock production is often presented as a way to reduce GHG emissions ((Havlík et al, 2014), (Dolfing, 2017), (Weiss and Leip, 2012)) but indirect GHG emissions, carbon storage and other sustainability and environmental effects are often not taken into account. Agricultural intensification can moreover cause significant environmental pressures on soil, water resources, biodiversity and potentially human health (risk of maladaptation) and GHG emissions if not addressed sustainably.

Prospective studies often assume that a reduction in the consumption of meat protein would mean a lower demand for feed, including forage. As a result, therefore, alternative diets would result in opportunities to change the use of some land that is currently needed for feeding animals. For example, replacing 50% of current meat and dairy in diets could lead to a 75% reduction in soymeal use, 46% reduction in energy-rich feed imports and a 52% reduction in feed cereal use (Westhoek et al, 2014). A significant question that arises from this is what the resulting freed-up land would be used for. Uncertainties over these land-use decisions lead to significant uncertainties over the estimated GHG mitigation potential of reduced livestock consumption.

17.3.1.2 Technology approaches to livestock-related GHG mitigation

There are a number of technologies addressing emissions from enteric fermentation and manure (mis)management including feed additives, feeding management, animal breeding and new approaches to manure storage, processing and application. In many cases, however, their cost-effectiveness remains a major challenge requiring further research and development (EIP-Agri Focus Group, 2017). In addition there are uncertain impacts on production associated with these measures

---

were rather stable between 2013 and 2015 (with year-to-year fluctuations), but have increased sharply since 2016.

(FAO, 2013). Barriers to uptake include a perception that reducing GHGs brings no commercial benefit ("there is no money in reducing methane" (BusinessGreen, 2017)) and constraints on affordability in the livestock sector. These challenges can be addressed through cost reduction as technology and techniques are refined, as well as through better information around their commercial benefits and support for adoption and implementation.

Whilst technologies enabling highly-controlled and more precise and efficient production might be able to address many climate adaptation and mitigation challenges in the agriculture sector, in practice they can face strong public opposition. One example is large-scale dairies that farm thousands of cows using controlled or zero-grazed feeding. Improved manure capture and processing has seen relative success through the development of anaerobic digestion technology, capped and covered manure storage and the potential to generate renewable energy and digestate as a means of diversifying income streams on farms. Such technologies are already available and some have been supported through the CAP[143].

17.3.2 TRENDS IN FEED PRODUCTION

Animal feed in the EU comprises mainly grain fodder legumes and oilseed by-products. Today, the EU produces 38% of the co-products used for feed, but the situation varies greatly when disaggregated by co-product[144]. Fodder (i.e. grass and silage) are mainly produced in the EU and used most often on-farm, and grain legumes (i.e. lupin, peas, etc.) are primarily produced in the EU (~93% of demand). The notable exception to this self-sufficiency in feed products is soya bean meals. Only 5% of soybean meals used in the EU are produced here, with the other 95% imported mainly from South America (Argentina and Brazil) and the United States.

The import of soya into the EU has been declining since its peak in 2007-2008 due to the price of the meal. In 2013 an estimated 28 million tonnes of soya was imported, representing approximately 12.8 million hectares of land[145] (De Visser, Schreuder and Stoddard, 2014). The use of soya bean meal in animal production varies depending on the animals in question. Beef, pork and poultry use 232g/kg, 648g/kg and 967 g/kg of production respectively illustrating the greater dependence of monogastric livestock on soya meal compared to ruminants (Bues et al, 2013; De Visser, Schreuder and Stoddard, 2014). As noted above, the total consumption of poultry protein has increased in recent years, whereas consumption of both beef and porcine protein has decreased. These changes increased the EU's demand for soya meal.

17.3.2.1 Projected feed production changes and their effects on GHG emissions

The main GHG emissions associated with feed production are related to production, land use changes and transport. Generally, the carbon footprint of animal products fed with mostly European-grown protein crops is lower than those using imported soybean (Bues et al, 2013). In addition, the cultivation of protein crops has agronomic and other climate benefits, primarily from the leguminous nature of 'protein crops' enabling them to fix atmospheric nitrogen and thus mitigate GHG emissions by potentially reducing the use of Nitrogen fertilisers. It should be noted that forage legumes (such as clover) also have these benefits, but are a grassland plant, rather than a grain legume.

The significance of feed crop production as a contributor to the life-cycle effects of animal products on GHG emissions is high. In the life-cycle of livestock commodity products (carcass meat, milk etc.), feed production accounts for 47% to 88% of the GHG emitted. In many studies, the inclusion of pea in feed formulas is proposed to replace partially both soya and cereals, since pea contains large amounts of starch as well as protein (Bues et al, 2013). Local protein feed production presents a good opportunity to reduce GHG emissions, assessed for example in Sweden as having achieved a reduction of about 4.5% and 12% of GHG emissions respectively for pig and dairy cows fed with locally produced feed. However, such scenarios have a cost of increasing land occupation for feed production if demand stays constant (Sasu-Boakye, Cederberg and Wirsenius, 2014).

[143] For example the generation of renewable energy and reduction of ammonia emissions on a dairy farm in Romania (ENRD, 2013a)

[144] The EU produces 42% of sunflower meals and 79% of rapeseed meals used.

[145] Assuming a yield of 2.7 tons of soya bean per ha

One key option to address the impacts of feed production on livestock-related GHG emissions and reduce dependency on imports, is to increase the share of pasture in certain animal diets (Weiss and Leip, 2012). Whilst this is unlikely to be suitable for chicken or potentially porcine animals, it would be relevant for most ruminant livestock. This could support wider environmental benefits beyond climate mitigation by targeting support to low intensity grazing systems which provide environmental services such as maintaining species-rich grasslands (Rosenthal, Schrautzer and Eichberg, 2012), protect carbon stocks, and improve resilience to climate change at wider scale (e.g. resilience to fires). These systems may also be the only types of production possible in some areas such as in arid or mountainous areas.

17.3.2.2 Technology approaches to feed/crop-related GHG mitigation

While product innovation and technological development are two drivers of incremental changes of agricultural production systems (Box 27), more systemic changes could be needed to get to a net-zero emission agricultural sector by 2050 (Lóránt et al, 2017).

Box 27: Technology as a driver of reducing GHG emissions from production

The availability of increasingly affordable digital technologies – such as sensors and satellite navigation– has contributed to recent technological developments in agriculture through inter-sectoral spill-overs[146]. Precision technologies are moving the sector towards 'smart approaches' producing more with less by applying the right treatment in the right place at the right time. However, uptake remains below initial expectations, which is often linked to cultural perception, lack of local technical expertise, infrastructure and institutional constrains, high start-up costs sometimes coupled with risk of insufficient return on investment (Zarco-Tejada, Hubbard and Loudjani, 2014). In addition, while precision technologies can potentially also contribute to the reduction of GHG emissions (e.g. reduced fuel consumption and improved N-use efficiency), these benefits together with the broader environmental impacts are yet to be adequately assessed (Zarco-Tejada, Hubbard and Loudjani, 2014) along with the potential availability to farmers from a financial and technological accessibility (skills) perspective.

Technologies and technological development have played a key role in advancing productivity and thereby help keep pace with population growth and rising demand for the quantity and diversity of food and other agricultural commodities to feed growing food, feed and bioeconomy markets. While increased efficiency can certainly improve the relative environmental performance of agricultural production (e.g. less water consumed per irrigated hectare; lower GHG emissions per tonne of crop produced), there is a risk that the availability of new technologies will lead to the increase in production and therefore the overall mitigation benefits arising from technological development might remain below its potential (i.e. when efficiency savings are not counterbalanced/eliminated by increased production/consumption levels). This phenomenon is referred to by some as 'rebound effect' that refers to the reduction in expected gains from technological efficiency improvements (technical changes and productivity) due to behavioural or other systemic responses (Banuri et al, 2001; Perry and Karajeh, 2017).

Source: Lóránt et al (2017)

One reason for requiring more systemic changes is that the adoption of innovative and new approaches by farmers does not only rely on their availability and affordability but by a range of cultural and institutional factors. Equally agriculture systems have stabilised over time and have locked actors into their past choices. Unlocking such systems or fostering a widespread adoption of any new practices thus frequently require system innovations, defined as large scale transformations in the way a societal function (here providing food, fibre and fuel to people) is fulfilled. System innovations rely not only on technical / technological advances but also on organisational, institutional and market changes (Barbier, 2011). In other words, system scale innovations are not only about adoption of new technological processes, but about setting the whole environment of farming systems right (Box 28). The bio-economy strategy (exemplified by the FACCE SURPLUS Era-net) is an example of system scale innovation where innovative processes for bio-refineries need to be considered in the framework of a regional network of supply chains interrelated with one another for their co-product and by products, aiming at a circular economy and improved resource efficiency (Lóránt et al, 2017).

Box 28: Drivers for system innovations and their role in net-zero transition

A key driver of such systemic change is what some call "coupled innovations" (Meynard et al, 2017). This idea

[146] Inter-sectoral spill-over is a source of technological development through the transfer of knowledge / approaches from one sector to another.

refers to a recoupling between innovation in several sub-sectors of the food system that are often though of separately: genetics, agronomy and food processing for example. Analysing how to foster crop diversification, they show that several changes would be needed simultaneously regarding plant breeding / genetic, crop collection logistics, processing firms strategy, consumption patterns and institutional arrangements for better coordination between actors (Magrini et al, 2016)

Source: Lorant et al, 2017

17.3.3 CURRENT BIOFUEL PRODUCTION AND RECENT TRENDS

Here, the production of biofuel feedstocks is used to illustrate trends and impacts of using crops or dedicated biomass production to feed the bioeconomy. Whilst it is noted that the potential inputs to the bioeconomy are highly variable from wastes and residues from agricultural production to dedicated crops and forest biomass, biofuel crops are well studied and provide a basis on which to explore GHG mitigation potential.

The EU is currently the largest producer of biodiesel worldwide, but also the largest consumer and importer. Its production accounts for around 40 % of the annual global biodiesel production, with Germany and France being the top European producers. Global biodiesel production is expected to increase from 776 petajoules (PJ)[147] in 2011 to almost 1,400 PJ by 2021 (Marelli et al, 2015)[148]. The EU is also a considerable importer of bioethanol, which is produced mainly by USA and Brazil.

The vast majority of biofuels currently being produced are conventional biofuels i.e. produced from food and feed crops cultivated on arable land (e.g. oilseed rape or wheat). The EU's renewable transport fuels target (RES-T) to 2020 has driven the use of conventional biofuels and led to controversy around the displacement impact they may have on food production resulting in Indirect Land Use Change (ILUC) and thus increasing the emissions associated with such fuels. To address ILUC, and wider questions of sustainability, the focus of support through the Renewable Energy Directive (RED) has been modified through the adoption of the ILUC Directive (Directive 2015/1513 EU) to place a focus on so called 'advanced' biofuels that are produced using feed stocks based on agricultural and forestry wastes and residues and dedicated energy crops. These same feed stocks are an important source of material for the bioeconomy more broadly.

The production of some biofuels (from wheat, maize and rapeseed) yields protein-rich co-products such as rape meal, dried distillers' grains and solubles as they follow a relatively simple process of crushing or distillation extracting the oil or ethanol and leaving the fibrous and protein-rich residue. These co-products can be used as animal feed and have the potential to reduce the demand (and thus GHG emissions) for imported protein-rich crops and their associated land use. Protein-rich crops generally require a relatively large amount of land for a given output compared with cereal crops. Some estimates suggest that the use of co-products generated from rapeseed, soy, wheat and maize can reduce net land use by 11 to 25% (Croezen, Kampman and Schepers, 2008). However, it should be noted that during the debate on ILUC, co-products were argued to address ILUC emissions and thus as a basis for continued support for conventional food and feed-based biofuels. These same co-products would be produced if, for example, the resulting oils were used in the food sector (e.g. vegetable oil production which has since been substituted for palm oil) or other areas in the bioeconomy.

17.3.3.1 Projected feedstock production changes and their effects on GHG emissions

In most of the scenarios reviewed in this study, considering food, feed and biofuel demand, availability of land for biofuel feedstock production is dependent on the arable land no longer being required for animal feed and food crop production, but also from potential poor quality or 'spare' land that could be utilised for dedicated energy crops.

The question of the extent of 'spare land' for the production of energy crops for biofuel production has been under debate. Figures often fail to take into account that land may not be cultivated in Europe for many different reasons. These include: economic and market forces; topographic, bioclimatic and edaphic conditions; contamination or pollution factors; and a variety of institutional factors. Recent assessments of the land areas for dedicated biofuel energy crop production vary

[147] 1 PJ (petajoule) = 10 [15] joule.

[148] In 2012, global bioethanol production reached 83.1 billion litres, for biodiesel it was 22.5 billion litres.

considerably. An assessment, based on existing demand for food and feed and taking into account environmental and agronomic criteria, identified that only between 1 and 1.5 million hectares of land can be investigated for energy crops cultivation. This suggests that, under current conditions, the overall energy potential from dedicated energy crops on 'spare' land in Europe is relatively low (Allen et al, 2014).

The availability of land and the potential for biomass to supplement energy production illustrates the challenges associated with developing a low-carbon bioeconomy and its links to agriculture and forestry. Substituting fossil resources for renewable bio resources has many benefits, not least the potential reduction of GHG emissions in those sectors where the substitution takes place. However, these benefits need to be taken in light of the potential impacts (positive and negative) on the sectors that produce the biomass. For example, demand for biomass to feed a growing bioeconomy could lead to increased emissions from the agriculture or forest sectors through increased production intensity that is not balanced with increased efficiency[149], or displacement and leakage impacts. However, where the bioeconomy derives from wastes, co- or by-products then there is potential to reduce emissions in both the producing and consuming sectors through mitigating emissions and reducing waste.

17.3.4 SYNTHESIS OF PROSPECTIVE STUDIES CONCERNING FOOD, FEED AND BIOFUELS

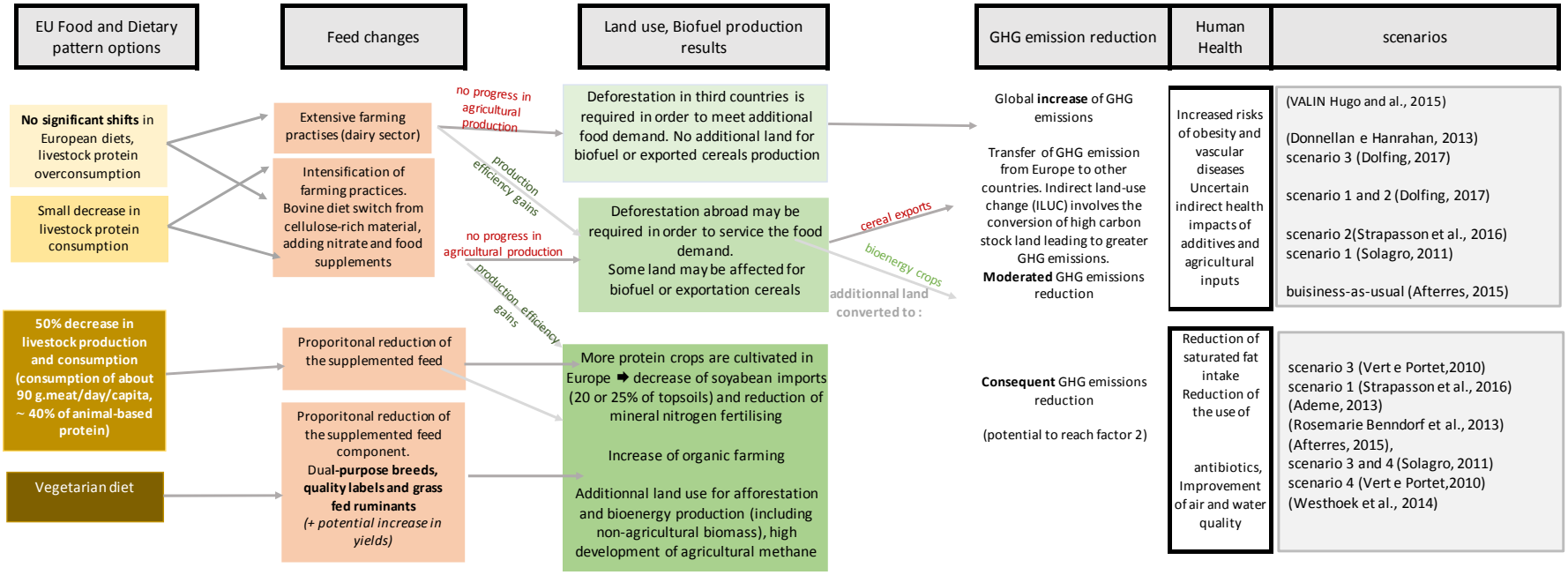
Figure 47 presents a summary of the results of the nine studies for 2030 and 2050. The scenarios which have the best results in terms of GHG emissions reduction imply significant changes in production systems and land use, and in dietary patterns.

At the European level, the greatest decrease of GHG emissions shown in the scenarios are obtained through a ~50% decrease in meat consumption (compensated by higher intake of cereals and pulses), involving a proportional reduction in the feed components and a higher production of protein crops. Amongst these scenarios, the reduction is higher when released land is used for bioenergy production, including biofuel production, and not for exports (Westhoek et al, 2014). Bellarby et al (2013) identified a reduction potential of 12-61% in EU livestock-related GHG emissions by reducing meat production/consumption, avoiding food waste and also increasing beef production on grasslands instead of intensive grain-feeding.

It should however be noted that across the models, the social and economic impacts of the selected trajectories are rarely detailed. Nor are the types of changes that would be required, or the drivers or mechanisms for delivering these changes specified. Moreover, the scenarios studied do not take into account contextual factors. In particular, when looking at economic aspects, the reality of global markets has to be factored in to consider whether a decrease in internal consumption would necessarily translate into a decrease in production. For instance, domestic production may respond to external demand (e.g. as is the case for milk). GHG reduction efforts through changes in dietary and production patterns would need to be supported also beyond the EU.

[149] i.e. greater emission through the increased use of fertilisers and mechanical inputs, as illustrated for biofuels - (Valin et al, 2015).

Figure 47: Trajectories of scenarios involving changes in food, feed and biofuel production and impacting EU GHG emissions reduction potential



Source: Own compilation

17.4 IMPACTS OF THE CAP ON FOOD, FEED AND BIOFUEL PRODUCTION

This section focuses on the impacts of EU policies, including the CAP, on the current or expected trend in the reduction of livestock meat consumption, protein crop production (for both human and animal feed) and biofuel production.

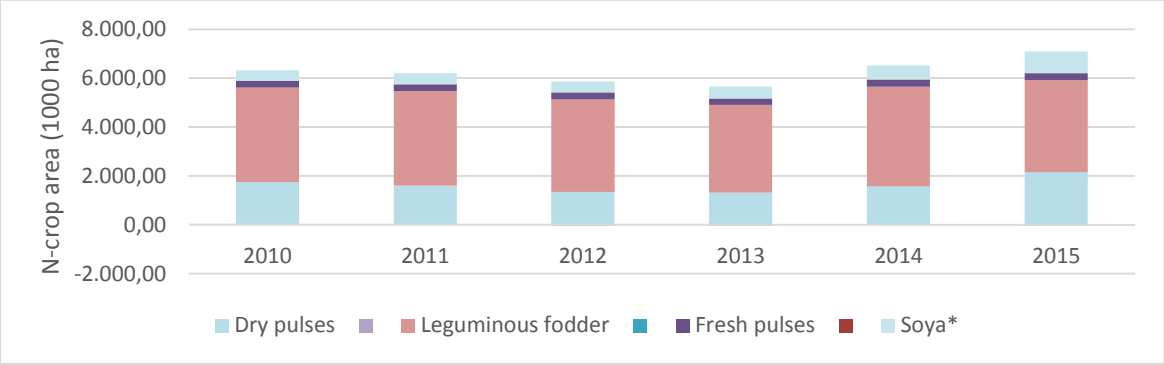
17.4.1 EFFECTS OF CAP MEASURES ON FOOD AND FEED

Meat consumption is currently influenced by an over-proportional CAP support for livestock production, especially through direct payments, which account for 7% of the income of horticultural farmers, versus 70% of the income on 'other grazing livestock' (Matthews, Salvati and Scoppola, 2017) Most Voluntary coupled support (VCS) is provided to the animal farming sector.[150] Moreover, within the EU-15 ruminant livestock sector, more intensive producers have been the main beneficiaries of direct payments due to the link of payments to historical reference levels (Baldock and Mottershead, 2017), which remains the case, despite the convergence enabled through the current CAP. The convergence principle that applies to direct payments in the current CAP is implemented differently across MS and some, such as Spain, still maintain a strong link with historical references and hence levels of productivity.

The milk quota regime has been the most important CAP-related driver for past herd reductions in the dairy sector, while general decoupling has supported this effect (EEA, 2017). However, the recent abolishment of the milk quota regime in 2015 could result in increased livestock production (Kirchner, Schönhart and Schmid, 2016) and in the concentration and increase of feed-based systems.

The reduction in protein crop cultivation in recent decades is part of a wider change to more specialised production systems. The production, use and trade in protein crops have been impacted by CAP measures since the 1970s, with reduced support under recent reforms. However, the trend of the area planted with protein crops has been reversed since 2014 with the slight increase of area planted with pulses, soybean and green fodder thanks to 2014-2020 CAP measures (i.e. the EFA and crop diversification greening measures and VCS for protein crops) as well as market development (Figure 48) (Alliance-Environment, 2018). Today, legumes can be supported through various ways under the CAP, through VCS, the greening obligations of crop diversification and EFA nitrogen-fixing crops, M10 AECM and M11.

Figure 48: Changes of areas planted with nitrogen fixing crops in the EU-20 from 2010 to 2015



Source: Alliance Environnement, 2018 based on Eurostat data

The CAP focuses on agricultural production therefore it does not explicitly support diet changes. To date, there is limited reference to food or dietary patterns in the CAP, apart from the School Fruit, Vegetables and Milk Scheme that aims to increase the share of these products in children's diets (EEB, 2017). The consumption of more environment and climate friendly products may be influenced through the RDP measure M3 'quality schemes' and also indirectly by the support to more sustainable

[150] beef and veal sector (24 MS, 42% of total, €1.7 billion in 2015); followed by milk and dairy products (19 MS, 20% of total, €0.8 billion), and sheep and goat meat (22 MS, 12% of total, €0.5 billion).

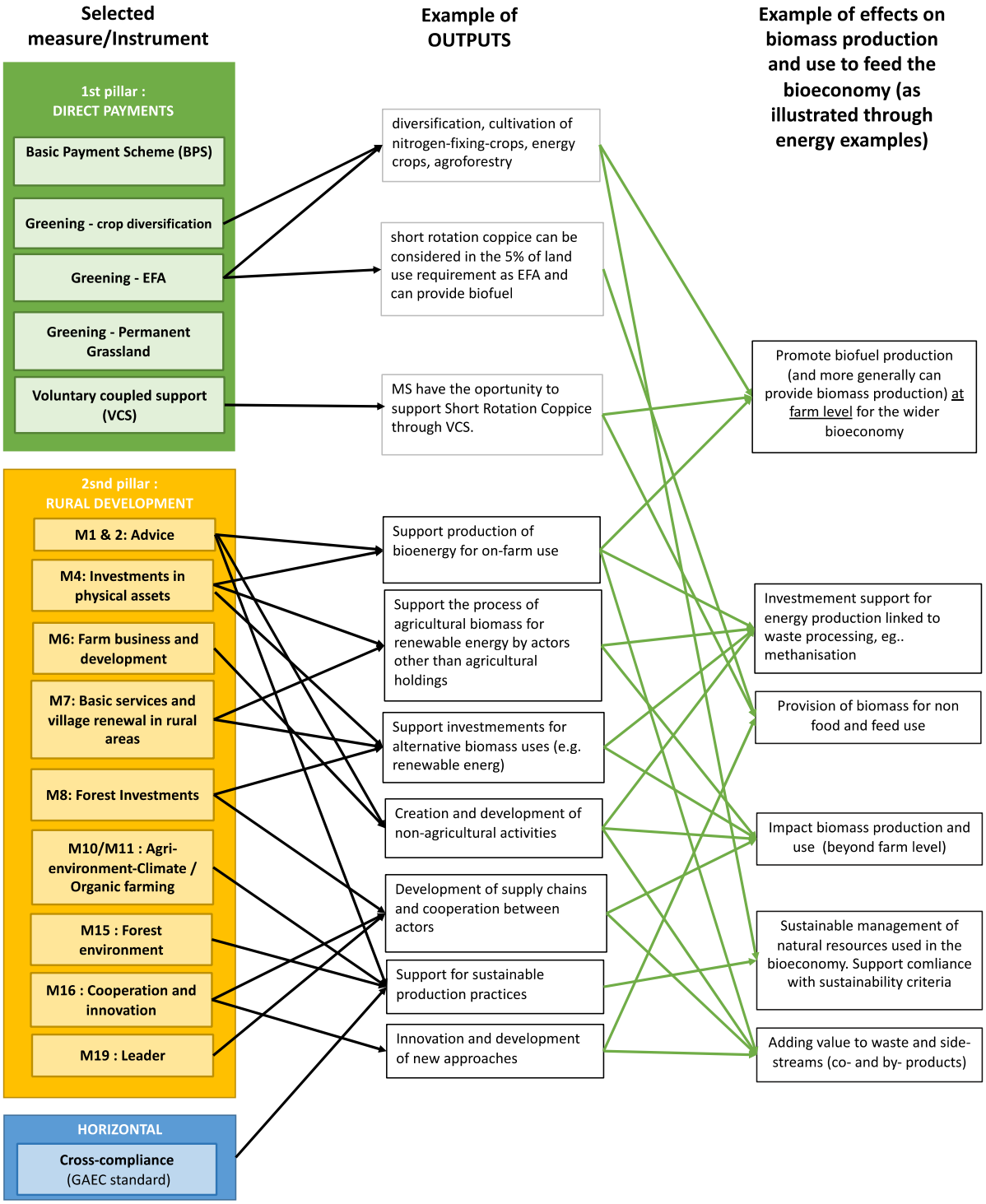
production systems (e.g. M11 organic farming and M10 AECM). However, a major component of the GHG impact of food production is that of food waste. The most efficient GHG emission reductions scenarios reviewed, suggest that food waste should be reduced by 50% to have a meaningful impact on GHG emissions. The EU Court of Auditors (2017) pointed out that the CAP can be contradictory to addressing food waste through its support (even though decoupled) to production. The problem of food waste could be addressed through the CAP, such as promoting more efficient processing and production of food crops, meaning less wastage on farm; improved and shorter supply chains to reduce storage and spoiling times; and the valorisation of waste streams for the wider bioeconomy, utilising food waste. Whilst the latter would not avoid the GHG impacts of producing such wastes (in production and decomposition of the biomass) it could be used to replace other purpose-grown biomass for use in the bioeconomy or fossil resources.

17.4.2 THE EFFECT OF CAP ON BIOMASS PRODUCTION WITH A FOCUS ON ENERGY

Historically the CAP supported biomass production for energy in two ways. Production of non-food crops on land receiving the CAP set-aside premium began in 1993, and primarily supported production of industrial crops for biofuel production. In addition, energy crop aid of €45 per hectare with a ceiling of 1.5 million hectares was introduced in the 2003 CAP reform. The ceiling was raised to 2 million hectares when the scheme was extended to the 15 new Member States in 2006. The CAP 'Health Check' reform (November 2008), abolished both set-aside and the energy crop payments.

Today, the CAP only supports energy crops indirectly (outside of forest biomass). For instance, short rotation coppice plantations are eligible as EFAs and can be supported through VCS. The main policy influencing energy crops remains the RED (Miyake et al, 2012). Figure 49 illustrates the possible impacts of CAP or other policies on biomass production as illustrated in part through examples of bioenergy and biofuels.

Figure 49: Potential effects of CAP on biomass production for the bioeconomy



Source: Own compilation

17.5 CONCLUSIONS

The consumption of livestock products, changes in feed production and developments in the bioeconomy (including energy and material uses) all have a bearing on GHG emissions through the production of crops and livestock and as a result of land use and management decisions. These drivers are all interrelated and need to be addressed through both changes in consumption and production.

The consumption of livestock products is a major determinant of GHG emissions from the agriculture sector in which those products are produced and as a result of interlinked feed production and imports. Overall the studies reviewed suggest that a reduction in calorific intake in line with WHO guidelines and a reduction in meat-protein intake would likely lead to a reduction in GHG emissions in agriculture and public health benefits. This would need to be combined with efficiency measures to address issues such as food waste which interrelate with developments in the bioeconomy, and broader considerations around the environmental, economic and social importance of certain livestock production systems and the impacts on the structure of the agriculture sector in the EU. Leakage of production and emissions to third countries must also be addressed, particularly where production systems may be less GHG efficient or have lower animal welfare and environmental challenges.

The current CAP measures offer limited scope to address consumption patterns other than indirectly through, for example, the development and marketing of products. However, it is clear that dietary choices have a major impact on production decisions and resultant GHG emissions. Strengthening the link between agricultural production and the objective of promoting a healthy diet could help to address the major emitting sectors in agriculture today (livestock-related emissions and cropland management). Within this frame, public support for livestock production could be approached from a longer-term perspective of what are and are likely to be sustainable markets. However, there is room for a more careful consideration of how far agricultural policy drives dietary patterns and whether interventions in agricultural production, which encourage more sustainable diets, are feasible and desirable

The CAP can, however, have a significant impact on production side changes to improve GHG emission reductions through food and feed production. Feed crop production accounts for a high proportion of the life-cycle GHG emissions of animal products. Livestock systems based on locally produced feed may lead to a 4.5% to 12% reduction in GHG emissions. This could help to address the heavy dependence on non-EU markets (and thus lack of security) for commodities such as soymeal, of which 95% is imported[151]. The CAP has already several instruments in place which can support or encourage the development of protein crops production in the EU (i.e. VCS, M10, M11 and greening) which have led to a slight increase in domestic production in recent years. However, there is also a need for more research and value chain development in the field of protein crops to achieve production on a larger scale, such as that undertaken by the EIP-AGRI Focus Group on protein crops[152].

Technological innovation will play an important role in addressing production side emission challenges in the agriculture and forestry sectors. At present the technologies available are unevenly distributed between animal production, where they are developing in line with approaches to increase production efficiency and yields (such as improved breeding and feed strategies), and those for manure management that are more established (such as anaerobic digestion). Increases in production and GHG efficiency need to develop in the context of associated changes in consumption and export developments so that there is no resulting 'rebound effect' if consumption and/or exports were to increase commensurately. It is not simply technological innovation which is needed. Social systems which support greater uptake of existing technologies (such as anaerobic digestion) are required, along with policies which connect different types of farm (livestock, arable) in ways which optimise GHG-critical systems such as nutrient management.

[151] It should be noted that prospective scenarios often rely on hypotheses and do not factor in contextual elements such as trade policy, environmental issues (water, soil resources, biodiversity, adaptation to climate change issues) or food security issues. These are important elements to keep in mind when making decisions about how best to achieve mitigation objectives by adjusting a range of potential levers.

[152] https://ec.europa.eu/eip/agriculture/en/publications/eip-agri-focus-group-protein-crops-final-report

Beyond food and feed production, the development of the wider EU bioeconomy offers opportunities and challenges to the reduction of emissions in the CAP supported sectors and in the economy as a whole. Development of new supply and value chains that utilise wastes, co- and by-products as substitutes for GHG intensive products can lead to synergistic emission reductions both within and outside the agriculture and forestry sectors. However, care needs to be taken where the demands of the bioeconomy stimulate an increase in primary production, leading to unsustainable intensification of production or cropland area expansion (in the EU or in third countries). If expansion leads to land use and management changes, there is a risk of increased GHG emissions, as demonstrated through the ILUC impacts of food and feed-based biofuels. The CAP has multiple roles to play in these developments. Supporting the production and development of value chains to feed a growing bioeconomy based on wastes can and should be facilitated through the available rural development measures. The environment and climate measures available in the CAP also have an important role to play in ensuring that bioeconomy feed stocks are produced sustainably, in the same way biofuel feed stocks have to comply with sustainability criteria set out in the RED.

18 SYNTHESIS (ESQ15)

ESQ15: Which factors have decreased or increased the potential impact of the CAP on climate change and greenhouse gas emissions, and to what extent?

18.1 UNDERSTANDING OF THE QUESTION

This is a synthesis question which uses the results of all previous ESQs to provide a strategic picture of the factors which have increased or decreased the potential impact of the CAP on emissions, removals and its contribution to climate adaptation goals. Where necessary, the information has been supplemented with further review of the literature on the strategic context.

18.2 PROCESS AND METHODOLOGICAL APPROACH

The factors considered include those internal to the CAP – such as the rules requiring certain percentages of budget share to be devoted to climate measures, the eligibility rules which help to determine which parts of the economy and types of land use can be reached using CAP measures, and the extent to which administrative cost and complexity influences Member States' perception of the desirability of using CAP levers to achieve climate objectives as compared to actions they could take using other means and/or in other sectors of the economy.

The second kind of factor considered is the extent to which the external environment in which the CAP operates has potentiated or diminished the effectiveness of the CAP as a tool for climate action. For instance, a long period of relative stability in international markets may have contributed to EU farmers' longstanding willingness to tolerate a high degree of dependency on foreign feed in certain markets. These factors are however very much interlinked. This question therefore jointly discusses which external and internal factors are likely to have had a role in the potential impact the CAP has had on climate change and greenhouse gas emissions. It also discusses the extent to which they have helped or hindered this potential.

The results of the analysis lead to conclusions about how the CAP might be modified in order to optimise its climate performance in a range of external scenarios.

18.3 ANALYSIS

The policy framework for action on climate change, as given effect by the Kyoto Protocol, Paris Agreement and the LULUCF and Effort Sharing Decisions, does not set a target specifically for agricultural emissions. Perhaps as a consequence, Member States do not prioritise reductions in agricultural emissions as a means through which to achieve their overall ESD targets, with only five of the ten case study Member States having set a sector-specific target. The relevance analysis (ESQ10) shows that where targets are set, they often lack ambition. There is a perception at EU level that agricultural emissions are a special case. When the Climate and Energy Framework to 2030 was adopted in 2014, the Council Conclusions noted 'the multiple objectives of the agricultural and land use sector, with their lower mitigation potential'. This suggests that the Council did not expect

agriculture to make a proportional contribution to GHG mitigation Analysis of Member States' individual targets under the (at the time proposed) ESR has suggested that for most Member States, significant reductions in agricultural emissions below a reference scenario based on current policy trends will not be required (Matthews, 2016).

The lack of a strong external driver (such as more stringent ESD targets which cannot be met largely by other sectors) for further reductions in agricultural GHG emissions affects the CAP's potential through the design of the measures and their implementation. As has been shown in ESQs 8 and 10, significant opportunities have been missed to design the CAP in a way that would contribute more coherently and with greater relevance to climate objectives. The potential has not been realised due to the choices made by MS in implementing the CAP 2014-20 and by farmers.

For Member States, a number of reasons explain this. The case study work highlighted the complexity of the issue, which is the outcome of there being many site-specific local impacts. Whilst there are actions – such as soil protection – which are beneficial in a variety of different contexts, there are others where benefits are site specific and/or where the right thing to do may depend on an interpretation of the system boundaries. This is a challenge to the expertise of managing authorities, which is sometimes limited in this regard. Our work in setting up the case studies and contacting advisers to participate in the survey questionnaire was hampered by the difficulty of identifying Government officials, farmer representatives or advisers with significant climate expertise or who understood how the CAP could be used to further climate objectives. This suggests strongly that the CAP's potential for climate action is currently limited by the availability of expertise.

The greening study (Alliance Environnement and Thünen-Institut, 2017) showed that keeping administrative burden and financial risk to a minimum were key considerations driving the choices of Member States when implementing greening. Time proved to be a limiting factor too: managing authorities and farmers had a relatively short time window to implement the new obligations, which also partly explained why choices made were often not as ambitious as they could have been. The case studies for this evaluation also showed that a number of Member States had developed their adaptation strategies either in parallel with, or after, implementing the 2013 CAP reforms, thereby missing opportunities to increase synergies and relevance. Timing factors have therefore reduced the current CAP's potential to deliver climate benefits.

Box 29: Factors impacting the implementation choices of Member States and farmers for the greening payment

The case study work undertaken for the evaluation of the greening payments shows that environmental considerations have not been amongst the key criteria for farmers when making their decisions about how to implement greening on their farms. Different reasons may explain this, in particular that information and advice provided to farmers has not focussed on the potential environmental benefits of different ways of complying. In many of the case study countries examined this is the result of the limited time available to put in place the measures as well as the complexity of the rules. This situation could therefore change over time as authorities, farmers and advisers become more familiar with the implementation of greening. […]In a few cases in the case study countries, some farm advisers suggested greening may have not contributed to increasing farmers' environmental awareness because its national implementation had low environmental ambition or resulted in agronomic incoherence. Stakeholders in some case studies (ES, FR) said more time was needed to assess whether environmental awareness has changed or not. Other factors like generational change was seen as more powerful than greening in raising farmers' awareness about environmental issues. Stakeholders in a number of case study countries (FR, AT, NL, PL, UK-En, UK- Sc) also suggested that farmers' environmental awareness could increase if/when the positive effects of greening become more visible and more tailored advice becomes available.

Source: (Alliance Environnement and Thünen-Institut, 2017)

Finally, the case studies in this evaluation found that there is generally limited political will to demand more from the agricultural sector in relation to climate as this is perceived as potentially damaging to the economic performance of farms. This echoes the statement accompanying the Council Conclusions referred to above. Adaptation pressures on rural areas appear to be a stronger driver of CAP implementation by Member States but in the absence of sufficient policy debate at EU level on the nature of adaptation and an appropriate level of ambition, adaptation actions funded by Member States using CAP measures are sometimes lacking in focus.

The case studies identified a lack of understanding of the problem of mitigation and the solutions available. This, along with a perception among farmers that climate interventions would reduce their production was seen as having caused a low uptake of some measures. In this context, the lack of knowledge sharing and advice observed in some case studies is particularly important. For example, the case study in Romania points out the lack of a functioning Farm Advisory System and the implications for small farmers seeking free and independent advice. Lack of advice again is shown to have an impact (e.g. in HR and RO), while issues of different types may exist too such as in CZ where regulatory issues have been a deterrent for the uptake of the M6 measure in respect of biogas plants; and in DE-ST, where the 5 year long commitment is seen as an issue affecting M10.1 uptake; while in FR, payment delays and lack of budget impacted uptake.

The uptake of RDP measures is determined by a variety of factors, including the budget available. Payment rates are an important factor and the case studies in HR, HU, IE, LT and FR reported that payments based on income foregone or extra cost were not always seen by farmers as attractive. This limited appetite for participation at current payment rates limits the ambition Member States can set themselves for uptake. We note that the Commission has proposed for the next CAP, a Pillar I-based environmental scheme to which this payment restriction would not apply.

The CAP's internal rules could provide greater stimulus to climate action than they do currently. Although sustainable management of natural resources and climate action is one of the three strategic objectives of the CAP, no specific targets are set by the legislation. No targets at all are set for Pillar I and Member States are not required to exercise their implementation options according to any strategy (such as maximising climate and other benefits). The Rural Development Programme is a strategic tool with some elements which increase its potential impact on climate action. These are:

- the requirement to spend a minimum 30% of programme funds on measures contributing to climate action;
- the existence of a "cross cutting" objective of climate action alongside the RDP's six Priorities;
- and, the availability of a financial incentive towards climate action in the form of higher EAFRD co-financing rates for certain measures.

While these rules are helpful, they do not maximise the extent to which the CAP might contribute to climate action. The effectiveness of the 30% spending requirement to potentiate climate action is weakened by the inclusion of payments to Areas of Natural Constraint which account for by far the largest share of the 30% requirement programmed by Member States. As ESQs 5, 8 and 11 have shown, payments to ANCs are of limited relevance or effectiveness as climate measures.

Whereas all of the CAP's measures can potentially be used successfully in an adaptation context, as shown by ESQ5, the absence of any requirement to consider their implementation through an adaptation lens means that their potential is not realised.

In addition to these policy factors which limit the incentive for MSs and farmers to undertake climate action in the CAP, the trade and economic situation faced by certain agricultural sectors, in particular the EU beef and dairy sectors, was regularly invoked by interviewees during the case studies as a reason for limiting the contribution these sectors could make to the CAP's climate objectives. The economic context in which cattle farmers, in particular, operate has presented a serious obstacle to engagement with climate mitigation. Imports of beef to the EU are subject to very high tariffs, which has enabled a cost structure to survive in that industry which would be especially vulnerable to any liberalisation in terms of trade (Baldock and Mottershead, 2017). Meanwhile, intensive meat farming – predominantly of pigs and poultry but also cattle – has benefitted from the absence of tariffs on protein feed such as soya, where the EU is not self-sufficient (Table 43). Because of these factors, the beef sector – and especially extensive beef farming – is seen as especially vulnerable.

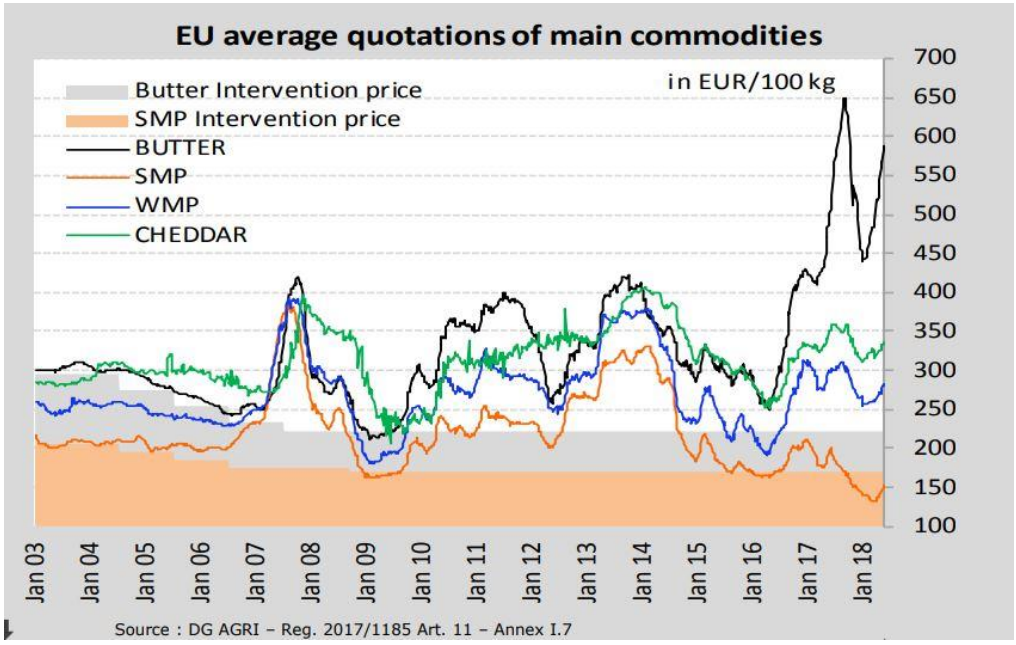
Table 43: EU production and consumption of protein feed

	EU Production	EU Consumption	Self-Sufficiency
Soya beans/ meal	344	14,280	2%
Rapeseed/ sunflower seeds/meal	5,022	6,795	74%
Pulses	424	450	94%
Dried forage	623	589	106%
Miscellaneous	743	1,336	56%
Sub-total	7,156	23,450	31%
Fish meal	235	350	67%
Total	7,391	23,800	31%

Source: FEFAC Statistical Yearbook 2014

Similarly, the EU dairy industry has faced severe economic conditions since 2015. Russia's decision to ban imports of fresh EU foodstuffs taken in August 2014 coincided with the end of milk quotas on 31 March 2015, provoking a major crisis in the EU dairy sector. In response, the Commission provided over €1 billion in aid, which was initially used to buy up surpluses and fund their private storage. The existence of these stocks has however had a dramatic and ongoing impact on EU Skimmed Milk Powder (SMP) prices which fell from €3,240 a tonne before the crisis to €1,400 in Jan 2018[153]. In July 2016, the Commission also introduced a scheme offering payments to farmers for voluntary reductions in their milk production, which appears to have been more successful in helping the dairy market to recover since the end of 2016. This being said, the sector remains in an economically vulnerable position.

Figure 50: EU average quotations for main dairy commodities, between 2003 and 2018 (in EUR/100kg)



Source: DG AGRI Dashboard: Dairy products, 2018[154].

[153] https://www.politico.eu/article/europes-hidden-milk-price-lake-threatens-fragile-market-eu-commission/

[154] https://ec.europa.eu/agriculture/sites/agriculture/files/market-observatory/milk/pdf/dashboard-dairy_en.pdf

These factors affecting the beef and dairy industry have affected the CAP's potential for climate action in a number of ways. Firstly, because of the vulnerabilities referred to, Member States have tended to view the policy agenda for cattle farming as the ensuring of its survival, with environmental or climate improvement a secondary consideration. This was evident in a number of the case studies. This concern with the economic viability of the cattle sector has led Member States to make generous use of VCS for livestock as noted in ESQ1. Secondly, Member States have been reluctant to impose costs – including those which might arise from certain mitigation measures – on cattle farmers, as the case studies showed.

The relevance analysis shows that the suite of CAP measures is partially relevant to the EU's climate needs, but constrained in particular by the lack of measures aimed at tackling emissions from livestock farming. This limits the CAP's potential usefulness in reducing emissions from this sector. Where the available measures are used, this may be in a context where GHG emissions will increase overall. For example, Ireland has set out quite ambitious growth plans for its dairy sector even though agriculture accounts for 26% of that country's GHG emissions with livestock responsible for two thirds of that figure. Even though the planned growth in Ireland's dairy sector is accompanied by measures seeking to move farms towards more GHG efficient systems, gains in efficiency are not expected by the Irish authorities to fully compensate for additional emissions from an increased number of animals.

The presence or absence of other EU legislation relevant to climate action in rural areas has affected the CAP's potential. As discussed in ESQ1 the CAP has strengthened but not broadened the contributions to emissions reduction made by the Nitrates Directive and the Habitats Directive which established Natura 2000 sites. As discussed in ESQ1, cross-compliance reinforces the delivery of both whilst the ESPG component of the greening measure strengthens the protection of grassland under the latter. However, in neither case does the CAP address the issue from the perspective of climate action. This would, for example, require of the inclusion of further rules for the management of manures outside Nitrate Vulnerable Zones.

In 2006 the Commission adopted a Soil Thematic Strategy including a proposal for a Soil Framework Directive. The proposed Directive included, amongst other things, the following requirements:

- The establishment of a common framework to protect soil on the basis of the principles of preservation of soil functions, prevention of soil degradation, mitigation of its effects, restoration of degraded soils and integration in other sectoral policies;
- The requirement to identify, describe and assess the impact of some sectoral policies on soil degradation processes with a view to protect soil functions;
- The requirement for land users to take precautionary measures when their use of the soil can be expected to significantly hamper soil functions;
- The identification of areas at risk of erosion, organic matter decline, salinization, compaction and landslides, and establishment of national programmes of measures. To ensure a coherent and comparable approach, the identification of risk must be carried out on the basis of common elements. These elements include parameters which are known to be driving forces for the different threat. Risk reduction targets and programmes of measures to reach those targets will have to be adopted. Programmes can build on standards and measures already identified and implemented in national and Community contexts.

However, while the EP adopted its first-reading opinion in 2007, a blocking minority at the Council led to the proposal being withdrawn by the Commission, after almost eight years without reaching a qualified majority in the Council. The proposal recognised that some soil protection requirements can be found in environmental legislation dealing with water, waste, chemicals, industrial pollution prevention, nature protection and pesticides as well as in cross-compliance. However, "due to their different objectives and scopes, and to the fact that they often aim to safeguard other environmental media, existing provisions, even if fully implemented, yield a fragmented and incomplete protection to soil [leading to continued] soil degradation." (COM 2006, 232 Final).

The requirements of the proposed Soils Framework Directive would have enabled a more comprehensive geographical coverage of agricultural soils and a more holistic approach to soil protection than has been achieved by the cross-compliance GAEC requirements set by Member States to date. For example, we judge that had Spain been required to use cross-compliance rules to

implement the requirements of a holistic approach to soils, it would not have chosen criteria which limited the incidence of one of the relevant GAECs to around 3% of its arable land (see section 9.1.2). The absence of a Soils Framework has therefore limited the CAP's potential to deliver benefits to soils.

The adoption of the Bioeconomy Strategy Plan in 2012 provided the policy framework for the production of renewable biological resources and their conversion into products and bio-energy. These Plans have played a positive role in supporting the development of the bioeconomy in rural areas notably through forestry but also in agriculture and other rural sectors. In turn, there are important interactions and end uses within the bioeconomy that can be influenced by the CAP including the development of biogas, support of solid biomass energy and production of biomaterials. In particular the production of biogas can result in both better management and capture of manure emissions (where manure is used as a feedstock) and the production of renewable energy. The contribution of biofuels to GHG emissions however remains highly uncertain and their sustainability is debated. In this context, some negative examples were identified in the case study e.g. German incentives to bioenergy greatly incentivise maize production with detrimental effects on soils and N_2O emissions. With regard to biomass used for bioenergy, a recent study (Matthews, Hogan and Mackie, 2018) shows that "there are significant risks of increases in GHG emissions associated with greater bioenergy use, in particular forest bioenergy use, unless appropriate checks and balances on the supply and consumption of bioenergy sources [are in place] with regard to associated GHG emissions". However, overall drivers external to the CAP in support of the bioeconomy are likely to have positively influenced the extent to which the CAP has been used to develop this sector in rural areas, with potential positive effects on fulfilling its climate objectives.

18.4 Conclusions

A number of factors have determined the extent to which Member States have used the CAP to secure climate action. The first of these is the absence of any strong external driver encouraging Member States to make the most of the CAP's potential to secure climate action in the agriculture or forestry sectors. This is because targets at EU level for the non-ETS sectors can be achieved by most Member States without a significant contribution from agriculture beyond what is already being achieved. The proposed Soils Framework which could have been expected to drive more ambitious GAEC rules for the protection of soils was abandoned.

Secondly, the CAP's strategic objective for climate action is not accompanied by specific targets or a requirement that they be set.

Finally, there is evidence from the case studies that Member States are reluctant to tackle climate emissions in the livestock sector because of its perceived economic difficulties. Timing issues and lack of expertise in climate issues relating to agriculture have also contributed to the limited ambition of Member States' CAP implementation in respect of climate action.

19 Conclusions and Recommendations

19.1 Conclusions

19.1.1 Relevance (ESQs 10 & 11)

The CAP has objectives which are broad enough to encompass the necessary climate action, and which correspond closely to the needs identified by Member States and at holding level. However, it does not provide Member States with the tools they would need to require farmers to reduce the two most significant categories of emissions (enteric emissions and emissions of N_2O from soil management), even if within the RDP Member States have the possibility to define more tailored but voluntary measures. Depending on how Member States have implemented the greening measure and the RDP, farmers may have a choice of measures available with which to tackle these emissions. However, Member States cannot compel them to do so through the current CAP.

Most CAP measures are relevant to adaptation but few have been designed with adaptation in mind. Moreover, the focus areas to which RDP measures are targeted do not bring together the different

elements of farm and forest adaptation in a single focus area. In addition, expenditure on adaptation is not tracked separately from other climate-related expenditure, making it challenging to assess adaptation improvements.

The 'climate and environment ring-fence' whereby Member States are required to devote 30% of their RDP budget to certain measures would be more relevant to climate needs and objectives were spending on measure M13 to be excluded. ANC is not a climate measure and it can have both positive and negative impacts on climate action.

19.1.2 EFFECTIVENESS (ESQS 1-5)

Our assessment of effectiveness has been limited by the available data. A key limitation has been the absence of data to show whether permanent grassland has been kept unploughed, ploughed then reseeded or converted and ploughed.

19.1.2.1 Effectiveness for mitigation

Overall, we have identified quantifiable reductions in GHG emissions totalling 26.2 Mt CO_2eq annually as assessed using 2016 data which can be attributed to the operation of the CAP. Whilst these reductions have helped agriculture to reduce emissions in line with its share of the emissions reduction required under the Kyoto Protocol, they do not offer a full picture of the CAP's impact which includes both positive and negative (albeit unquantifiable) other impacts.

These quantified estimates were obtained using a simulation model which uses uptake data for CAP measures alongside relevant emissions factors. The model suggests that the greening ESPG and EFA measures are leading to a reduction of emissions compared to what they would otherwise have been by approximately 19.8 Mt CO_2eq/year, and RDP measures are having an impact of ~ 6.4 Mt CO_2eq/year. These figures need to be treated with caution as they do not allow for policy overlap and accurate emissions factors were not always available.

The permanent grassland ratio applied to over 36 million hectares in 2016 is designed to protect soil carbon. Anecdotal evidence collected during the evaluation of the greening measure confirms that it is deterring some farmers from ploughing and is thus very likely to be having the intended impact on the protection of soils. However the extent of this impact cannot be estimated using available data. Whether or not permanent grassland is ploughed, converted or left unploughed results in very different impacts on soil carbon, but cannot be established from existing data. For each 1% of declared permanent grassland, the impact on annualised net carbon emissions, if it remains unploughed for 20 years, is estimated to be between 1.1 and 4.5 Mt CO_2eq/year lower (depending on soil type and climate) than if it had been ploughed and converted.

Cross-compliance is another measure which can be used to protect soil carbon and biomass over millions of hectares. However, almost all GAEC rules are set individually by Member States and there is wide variation. Estimating the incidence of the specific rules set is extremely challenging but an analysis of Poland's soil protection GAECs, which are both targeted to sloping land, suggests that these particular rules may not be well targeted since areas of sloping ground do not appear to coincide well with high carbon soils. Data with much finer resolution would be needed to make a final assessment, but there are grounds to conclude that not all Member States may be targeting their GAEC rules in the best way for soil carbon protection.

Assessment of the impact on GHG emissions of direct payments and voluntary coupled support has been challenging. However both theory and results from modelling studies suggest that VCS has a significant impact on maintaining ruminant livestock production. Additional animals will result in additional direct emissions. It is sometimes argued that in the absence of VCS, livestock production would simply shift elsewhere; that it would be carried out more intensively; and that GHG emissions from the land on which farming had previously been supported by VCS would increase. Whilst we acknowledge that each or all of these things could occur in specific cases, VCS is used so widely by Member States to support livestock and with so few restrictions, that we can judge that its overall impact on emissions is negative. Direct payments maintain or increase the area of land used for farming but land use change can be positive or negative for GHG emissions.

For Pillar II, the simulation model estimates that reductions of ~6.4Mt CO_2eq were achieved in 2016 through the use of RDP measures M4, M8.1 and 8.2, M10.1, M11 and M12.1. Over half of the reduction is estimated to come from measure M12.1 which funds compensation payments to farmers who must comply with the requirements of a Natura 2000 management plan or of the Water Framework Directive. As with ESPG, these benefits represent emissions avoided as a result of the protection of soils (using a carbon rich soil proxy), and also reflect the contribution of other measures. M10.1 (Agri-Environment Climate) and M11 (Organic Farming) are the other two RDP measures with a significant impact on simulated emissions.

The quantified reductions in emissions have largely been achieved through land management which protects soil carbon stocks and changes in N_2O emissions from soils and manures. Protection of high carbon soils in predominantly extensively-farmed Natura 2000 areas is particularly important. The CAP has achieved fewer reductions in intensive grassland or arable farms. EFA contributed just over 4Mt CO_2eq in 2016, with 92% of this coming from N-fixing crops and a further 7% from catch crops.

Table 44: High-level ranking of CAP measures according to their impact on GHG emissions

CAP measures	Impact on GHG emissions
Income support	A significant impact on the extent of agricultural area. This can have both positive and negative consequences for emissions and quantification of the overall net impact is not possible.
VCS	Negative impact when used to support ruminant livestock but not quantifiable. Positive impact when used to support leguminous crops but the measure is used to provide much greater support to ruminant production.
Land management practices	Positive impact with potential to deliver more
Capital investments	Positive impact with potential to deliver more
Soft measures	Usually indirect impact but fundamental to delivery of mitigation actions

Source: own analysis

There is no evidence to assess the impact of "soft" measures such as the provision of advice. The most commonly accessed measures include the Farm Advisory System, and the knowledge and advisory service measures under Pillar II. Advisory Services are an important mechanism for policy implementation and although they are not a mitigation activity per se, they may be used (on a voluntary basis for MS) to inform farmers about climate action. More generally, they can also be used to increase uptake of other measures such as land management contracts.

19.1.2.2 Effectiveness for climate adaptation

The vulnerability of farm holdings to climate change is highly site-specific and context-dependent. Sound planning of adaptation strategies in the agriculture and forestry sectors needs information and knowledge which is still being developed in many Member States, as well as specific expertise which can be in short supply.

There is a need for better appreciation by Member States of how CAP measures can be used to achieve adaptation objectives at farm, forest and higher levels. Although adaptation is a cross-cutting objective in the RDP, the fact that so few individual measures are identified in the regulations as having an adaptation purpose is hindering systematic use of the measures to achieve the cross-cutting objective.

The planning of climate adaptation at the EU level has improved over the last decade but this is so far not reflected in the way Member States have implemented the CAP. Although the ESI-Fund planning process required Member States to gather information, draw up strategies and commit to policy actions in respect of adaptation, links between national risk assessments, adaptation plans and relevant CAP measures have rarely been made. This is the case even though the CAP is for most Member States the main or sole source of funding for adaptation in the farm and forestry sectors.

Member States have used Pillar I funding to respond to economic drivers and in some cases, broad (although still important) environmental issues such as biodiversity. Support for farm incomes can be a means of sustaining diversity among farming systems at territorial level, which can be beneficial to

adaptation. However, the CAP's market orientation enables a degree of specialisation to persist which may weaken the resilience of individual farms or entire farming areas. Positive impacts on adaptation come from Pillar I spending on biodiversity (ESPG, EFA) and soil protection measures (GAEC).

Successful adaptation requires the development of new knowledge and the spread of existing best practice, as well as a readiness to change practices and systems in reaction to or in anticipation of climate change. Generational renewal can indirectly contribute to this but Member States have devoted limited proportions of their budget shares to the Young Farmers Scheme. Soft measures are essential to support adaptation but M1 and M2 have not been programmed widely, and the same is true of the risk prevention measure M17. These measures have also suffered from delayed implementation (M16) or from low uptake (M5, M17). Measures which have been more widely programmed and taken up, such as M10 and M11, have been used to meet broader environmental goals than adaptation to climate change, although with some benefits to the latter.

Adaptation of EU farm holdings and forest will require in some cases transformational changes, for example changes to farming systems and land use. Such changes should be supported through policy incentives and financial support especially when they improve resilience to climate change beyond the farm (e.g. flood protection). Such support would need measures dedicated to supporting the transformational changes needed for the long-term adaptation and resilience to climate change.

The evaluation identified some instances where CAP measures had contributed to practices which were actually or potentially maladaptive. For instance in the Guadalquivir and Jaen basins in Andalucía, RDP funding had been used to increase the area of irrigated farming despite water scarcity. The identification of actual or potential maladaptation requires information about agricultural and societal needs to be brought together in innovative ways.

19.1.3 EFFECTIVENESS AT STIMULATING INNOVATION (ESQ6)

Technological and social innovations in the agricultural sector have a high potential to contribute to the reduction of emissions and to adaptation. Their impact depends on local factors such as pedoclimatic conditions, farm systems and how they are put into practice in specific circumstances. Surveys and interviews in the ten case study Member States suggest that technological innovation is more likely to be adopted than social innovation. Some innovations are more extensively used than others, with genetically improved seeds or animals and participation in water management groups being the most widely adopted technological and social innovations. The case studies showed that the use of these innovations appears to be highly heterogeneous both across and within Member States.

Technological innovation carries a number of risks. These can be technical, linked with data ownership, responsibility (e.g. in the case of robotic failure) and security and consumers' information.

At the EU level, 'fostering innovation' is a cross-cutting objective of the CAP and many CAP measures can affect the rate of innovation and its adoption. However, the use of these measures to specifically target innovations which impact on climate objectives depends on Management Authorities' implementation choices and few data are available to assess their effects. Also, many other policies (outside the CAP) can enhance climate related innovation development in the agricultural sector such as economic and societal drivers. Within the CAP, having a strong Agricultural Knowledge and Information System (AKIS) in place can greatly influence and facilitate the uptake of technological and social innovation.

19.1.4 EFFICIENCY (ESQ7)

The absence of complete and quantified information about the benefits of the CAP's climate measures complicates the assessment of efficiency. However, using the ESI-Fund tracking methodology and the simulation of mitigation benefits carried out for the analysis of effectiveness, we estimate that around €6.1bn of expenditure on the greening payment in 2016 may have secured a simulated 19.8 Mt CO_2eq reduction in emissions at a cost of €278 per tonne of CO2eq. This ignores substantial but unquantifiable reductions in GHG emissions attributable to the permanent grassland ratio measure and cross-compliance which would reduce the cost per tonne. It also ignores benefits in the form of adaptation, which cannot be quantified, as well as other co-benefits of climate spending.

Using the same methodology, the cost per tonne of RDP spending is estimated at €194. Again, this ignores unquantifiable benefits including those in the form of adaptation, and non-climate co-benefits. The analysis also highlighted limitations in the tracking methodology which counts expenditure programmed to certain focus areas. This is imperfect because the allocation of spending to focus areas by Member States itself involves a degree of subjectivity.

With respect to adaptation, actions taken to adapt to climate change usually benefit private interests more than the public interest. Mitigation schemes may also have private co-benefits (e.g. avoided nutrient losses). Despite this, Member States have made only limited use of measures to limit deadweight such as the use of loans and well-designed risk management measures, and opportunities to target policies towards high value climate objectives (such as the protection of peatland in Sachsen-Anhalt) have been missed.

Flexibility and better targeting are needed in respect of climate action given the site-specific nature of many benefits.

There has been some simplification of the greening measure but the administration of RDPs became more complex in the current programming period and managing authorities in the case study Member States found the additional requirements related to strategic planning burdensome. Member State unwillingness to engage fully with the system of priorities and focus areas has contributed in some cases (e.g. France) to potential misallocation of expenditure with implications for the way climate spending is currently tracked.

Changes introduced in the 2017 Omnibus Regulation have corrected problems with measures M1 and M2 (requirement for tender; restricted scope of beneficiaries; requirement for full national coverage) which contributed to the low uptake of these measures in a number of Member States. It is particularly important that CAP support to advisory services is effective since many climate-related measures need supporting advice at farm level yet advisory services are still poorly developed for example in our case-study country, Romania.

19.1.5 COHERENCE (ESQS 8 & 9)

We made an assessment of the coherence of the CAP measures as a whole with respect to climate action, followed by an assessment of the coherence between those CAP measures which particularly address climate action and the CAP's other objectives, other EU policies and national climate plans.

19.1.5.1 Coherence of CAP measures as a whole with respect to climate action

The majority of the CAP measures under study were not designed as climate measures and have no impact – either positive or negative – on the performance of other measures in respect of climate action. There are, however, some exceptions. Cases of incoherence or inconsistencies include:

- M13 which is designed as a means of providing additional income support to farmers who operate in challenging conditions. It is not a climate measure and in practice, it was found that M13 can lead to both positive and negative impacts on climate action. It is incoherent therefore for it to count towards the 30% spending target on environment and climate. If Member States so choose, they may grant M13 support to areas facing challenging climatic conditions. This may benefit climate objectives (if abandonment would result in vulnerable soils losing their protection from erosion, for instance) but a measure more coherent with adaptation would fund adaptation actions, rather than simply providing a compensation payment.
- The existence of VCS support for livestock within the set of CAP measures is incoherent in respect of climate, since it is judged to increase direct emissions without necessarily leading to better management of soil carbon than would otherwise occur.
- There is some evidence to suggest a conflict between direct payments and the objective of afforestation, with farmers preferring to receive the former rather than afforest.

There are a number of instances where Member States have used CAP measures in ways which achieved significant synergies in respect of climate. Romania has used GAEC and EFA together to protect terraces and landscape features, and both of these measures in conjunction with the AECM to promote the use of catch crops. Ireland has used M1, M4 and M10 in conjunction to encourage better nutrient management alongside the protection of landscape features and soil carbon stocks. It has

cited climate mitigation and adaptation as the explicit target of these measures. France has aligned its use of VCS, greening rules and M10 with its strategy for protein crops and particularly, legumes. French regions such as Basse-Normandie are using M4 to fund the planting of new hedges[155] which are then protected under GAEC 7.

Instances of incoherent use by Member States of CAP measures occur when action at the local scale is not compatible with the wider climate picture. For example, in Andalucía, VCS provided to fruit and vegetables, cotton and rice is incoherent with measures aimed at enhancing climate adaptation because it increases water scarcity. Direct payments are granted to agricultural activities taking place on peatland/wetland (e.g. NL, LT) with no conditions preventing these areas from being damaged (which can result in high GHG emissions). In Hungary direct payments are being used to support cultivation of land which has been recently drained, which increases the risk of flooding and emissions losses from soil management.

The design of the CAP measures which protect soil carbon does not take sufficient account of the differing carbon contents of different soils, the long timeframe needed for carbon sequestration in soil, and the fact that most benefits are lost if the soil is ploughed. Whilst the rules of cross-compliance allow Member States to target soil protection GAEC according to soil type, very few Member States have done so. Protecting carbon rich soils from ploughing is an effective mitigation strategy, provided the protection is in place long term.

19.1.5.2 Coherence of the CAP's climate measures with the wider objectives of the CAP, other EU policies related to climate change and with relevant national policies

Overall the CAP climate measures are coherent with the objectives of sustainable management of resources, viable food production and balanced territorial development. No instances of conflict were identified. However, multiple instances where conflict might arise as a result of implementation were noted.

Similarly, there are no major cases of incoherence between the CAP climate measures and other EU policies related to climate change. There are however instances where further opportunities for integration exist in particular with the EU Soil Thematic Strategy and the Floods Directive. It is important to note that although there is no conflict in theory, some of the rules in place do not safeguard against conflicts happening in practice through the implementation of the measures.

With respect to relevant national policies, the CAP (and particularly Pillar II) is seen by all case study Member States as a key means of achieving national climate goals. It was, however, noted in a number of case studies (CZ, DE, FR & RO) that national climate policies were not fully integrated into Pillar II and Pillar I implementation for the 2014-2020 period due to climate policies still being under development. In the case study Member States, climate issues are increasingly seen as important within the agricultural sector, and climate goals are expected to be of increasing importance post 2020 (as in Germany, where the 2050 National Climate Protection Plan explicitly highlights the role of the CAP moving forwards).

19.1.6 EU ADDED VALUE (ESQ12)

The EAFRD requirements to address climate priorities have provided EU added value by stimulating a higher level of climate ambition in those Member States which had not yet developed climate action plans for agriculture and forestry. The EAFRD environmental land management measures (principally agri-environment-climate contracts but also some forest measures) have increased the effectiveness of climate action. By contrast, voluntary coupled payments in Pillar I may have contributed 'negative' EU added value in respect of GHG mitigation in cases where Member States have felt it necessary to match support provided by their neighbours.

The CAP has provided a significant degree of legal certainty, but only for the duration of each programming period. EU funding rules have provided opportunities for synergy between EAFRD and other funds.

[155] 'Bocage' which is a traditional type and system of hedges.

It is possible, however, that Member States acting alone could have devised more efficient and effective means of achieving the levels of ambition currently agreed at EU level, or those that they chose individually. For example, the more ambitious might: target support at areas or production systems where greatest mitigation or adaptation benefits can be achieved; make any income support payments conditional upon more demanding, targeted requirements for soil management, particularly for carbon-rich (peaty) and wetland soils and to combat soil erosion and improve soil functionality; limit investment support to projects that meet threshold criteria for GHG reduction and medium-term adaptation benefits; and support investments in water efficiency in agriculture only if these implement an adaptation plan for all uses of the resource concerned. However, without an overarching driver for climate mitigation in agriculture specifically we can conclude that this is not guaranteed to be the case and thus the CAP provided added (although limited) value in this respect. There would be other Member States where, in the absence of the CAP (particularly the EAFRD), ambition would be low and climate action would be seen as less of a priority.

19.1.7 IMPACT OF THE CAP'S CLIMATE MEASURES ON PRODUCTION (ESQ13)

The CAP measures specifically aimed at climate objectives (greening, M2, M4, M5, M6, M8, M10, M15, M16, M17) have a small positive impact on the area of land used to grow leguminous crops, as permanent grassland and on forest area at the expense of the area cultivated with cereals. This is largely attributable to the crop diversification and EFA measures supported by the availability of VCS for leguminous crops. Diversification can have a short term impact on production but in the longer term may help to stabilise it by spreading risk and reducing volatility.

The livestock sector is one of the most significant sources of GHG emissions, and livestock farmers also manage a high proportion of land with carbon sinks and the potential to act as carbon sinks. An analysis of how CAP aid is distributed between less- and more-intensive livestock farmers in the ten case study countries showed that the average level of CAP support is higher for farms with high or very high levels of intensification in HR, the CZ, HU, IE, LT and the NL, and lower in FR, DE and RO. At the measure level, support under M10, M12.1 and M13 is on average higher the more extensive the farm, whilst VCS per farm rises in line with increasing intensiveness before falling for the most intensive farms. This analysis suggests that aid intensity for the CAP as a whole is higher for the more intensive livestock farms, but lower in the case of M10, M12.1 and M13.

The limited positive effect of CAP measures on livestock production (with implications for CH_4 emissions) could be partly offset if aid is routed preferentially to extensive livestock farming, which brings adaptation benefits in terms of feed self-sufficiency and landscape diversity. Feed self-sufficiency could also reduce associated land use change emissions. Extensive livestock management may reduce or increase soil carbon emissions depending on site specific factors. This suggests that the measures which support it should also be site specific rather than general in nature.

19.1.8 FOOD, FEED AND THE BIOECONOMY (ESQ14)

The consumption of livestock products, changes in feed production and developments in the bioeconomy (including energy and material uses) all have a bearing on GHG emissions through the production of crops and livestock and as a result of land use and management decisions. These drivers are all interrelated and need to be addressed through both changes in consumption and production.

The consumption of livestock products is a major determinant of GHG emissions from the agriculture sectors in which those products are produced and as a result of interlinked feed production and imports. Overall the studies reviewed suggest that a reduction in calorific intake in line with WHO guidelines and a reduction in meat-protein intake would likely lead to a reduction in GHG emissions from agricultural production in the EU and associated public health benefits. This would need to be combined with efficiency measures to address issues such as food waste which interrelate with developments in the bioeconomy, and broader considerations around the environmental, economic and social importance of certain livestock production systems and the impacts on the structure of the agriculture sector in the EU. Production leakage and emissions to third countries must also be addressed, particularly where production systems may be less GHG efficient or have lower animal welfare and environmental standards.

The current CAP measures offer limited scope to address consumption patterns other than indirectly through, for example, the development and marketing of products. However, it is clear that dietary choices have a major impact on production decisions and resultant GHG emissions. Strengthening the link between agricultural production and the objective of promoting a healthy diet could help to address the major emitting sectors in agriculture today (livestock-related emissions and cropland management). Within this frame, public support for livestock production could be approached from a longer-term perspective of what are and are likely to be sustainable markets. However, there is room for a more careful consideration of how far agricultural policy drives dietary patterns and whether interventions in agricultural production, which encourage more sustainable diets are feasible and desirable

The CAP can, however, have a significant impact on production side changes to improve GHG emission reductions through food and feed production. Feed-crop production accounts for a high proportion of the life-cycle GHG emissions of animal products. Livestock systems based on locally produced feed may lead to a 4.5% to 12% reduction in GHG emissions. The CAP has already several instruments in place which can support or encourage the development of protein crop production in the EU (i.e. VCS, M10, M11 and greening) which have led to a slight increase in domestic production in recent years. However, there is also a need for more research and value chain development in the field of protein crops to achieve production on a larger scale, such as that undertaken by the EIP-AGRI Focus Group on protein crops[156].

Technological innovation will play an important role in addressing production side emission challenges in the agriculture and forestry sectors. At present the technologies available are unevenly distributed between animal production where they are developing in line with approaches to increase production efficiency and yields (such as improved breeding and feed strategies) and those for manure management that are more established (such as anaerobic digestion). Increases in production and GHG efficiency need to develop in the context of associated changes in consumption and export developments so that there is no resulting 'rebound effect' if consumption and/or exports were to increase commensurately. It is not simply technological innovation which is needed. Social systems which support greater uptake of existing technologies (such as anaerobic digestion) are required, along with policies (such as the encouragement of mixed farming or cooperation between livestock and arable farmers) which enable nutrient management to be optimised.

Beyond food and feed production, the development of the wider EU bioeconomy offers opportunities and challenges to the reduction of emissions in the CAP supported sectors and in the economy as a whole. Development of new supply and value chains that utilise wastes, co- and by-products as substitutes for GHG intensive products can lead to synergistic emission reductions both within and outside the agriculture and forestry sectors. However, care needs to be taken where the demands of the bioeconomy stimulate an increase in primary production, leading to unsustainable intensification of production or cropland area expansion (in the EU or in third countries). If expansion leads to land use and management changes, there is a risk of increased GHG emissions, as demonstrated through the ILUC impacts of food and feed-based biofuels. The CAP has multiple roles to play in these developments. Supporting the production and development of value chains to feed a growing bioeconomy based on wastes can and should be facilitated through the available rural development measures. The environment and climate measures available in the CAP also have an important role to play in ensuring that bioeconomy feed stocks are produced sustainably, in the same way biofuel feed stocks have to comply with sustainability criteria set out in the RED.

19.1.9 FACTORS WHICH HAVE AFFECTED THE CAP'S ABILITY TO SECURE CLIMATE ACTION

A number of factors have determined the extent to which Member States have used the CAP to secure climate action in the agriculture or forestry sectors. The first of these is the absence of any strong external driver encouraging Member States to make the most of the CAP's potential to secure climate action. This is because targets at EU level for the non-ETS sectors can be achieved by most Member States without a significant contribution from agriculture beyond what is already being achieved. The proposed Soils Framework which could have been expected to drive more ambitious

[156] https://ec.europa.eu/eip/agriculture/en/publications/eip-agri-focus-group-protein-crops-final-report

GAEC rules for the protection of soils was abandoned. Secondly, although the CAP has a strategic objective in respect of climate action it lacks specific targets or requirements that they be set. Thirdly, evidence from the case studies is that many Member States have been influenced by recent harsh economic conditions facing the livestock industry in particular, which has deterred them from seeking greater reductions in emissions from ruminants. Timing issues and lack of expertise in climate issues relating to agriculture have also contributed to the limited ambition of Member States' CAP implementation in respect of climate action.

19.2 RECOMMENDATIONS

This section contains the policy and data recommendations arising from the analysis in this study.

19.2.1 POLICY RECOMMENDATIONS

The design of the current CAP makes it difficult for Member States to require reductions in emissions from farmers (although cross-compliance does strengthen the requirements set under the Nitrates Directive). **The "enhanced conditionality" provisions in the draft CAP legislation currently under discussion need to require Member States to set a suitable regulatory baseline, including for GHG emissions, for all sectors covered by the CAP.**

In order to ensure that MS decisions on the CAP are properly coordinated with their national climate and adaptation strategies, **we recommend that the proposed CAP Plans should require Member States to demonstrate how their decisions will contribute to both mitigation and adaptation.** The impact of choices made in the distribution of CAP funds for both Pillars on GHG emissions and removals should be assessed by Member States along with the implication for adaptation in the short and longer term.

Member States should be required to demonstrate, before support is granted, that VCS for ruminant livestock is not leading to an increase in net GHG emissions. This should be by reference to specific attributes of the land on which it is claimed and the management practices it supports.

The current measures and instruments available to Member States and beneficiaries are limited in areas that address some of the largest sources of emissions from agriculture, namely those related to livestock. **We recommend that guidance is provided to Member States in the form of measure fiches elaborating the potential of different CAP measures and instruments to effect GHG emission reductions from livestock. This could be supported through dedicated work of the ENRD Contact Point on dissemination and advice.**

In order for climate adaptation to be addressed through the CAP in a systematic way, several things need to change. Better knowledge of adaptation issues and strategies is needed and Member States need a better understanding of which measures can be used for adaptation purposes. **We recommend that an ENRD Thematic Group and an EIP-Agri Focus Group for climate adaptation is established.** Among other issues, this should investigate the best measures and tools that can deliver environmental and production adaptation needs in synergy and ways of deploying individual measures for adaptation purposes in different circumstances.

Better dissemination of knowledge and improved advice to farmers about the techniques and practices which can improve climate performance (both mitigation and adaptation) is needed. **We recommend that consideration is given to requiring Member States to ensure that farmers taking part in the proposed new eco scheme or receiving RDP funding for land management practices have access to suitable advisory services. This would include a maximum number of farmers to be addressed by an individual advisor to ensure timely and frequent engagement. Training for advisors on climate action should be required, including continual professional development in this area to remain current on new approaches and techniques.**

Adaptation can require changes to entire farming systems, possibly including managed abandonment and/or relocation. **Member States need to be able to fund changes to whole farming systems and to fund the management of land which is being or has been abandoned if necessary. The design of the 'intervention types' available to Member States in the proposed new delivery mechanism needs to allow for this.**

Efficiency of public spending can be difficult to achieve when mainly private interests are at stake, as is often the case with adaptation. **Member States should be required, as part of their CAP plan, to explain how they intend to use non-grant mechanisms such as loans to maximise value for money.**

19.2.2 DATA RECOMMENDATIONS

Data is not currently available to enable a reliable quantitative estimate of the extent to which permanent grassland has been ploughed in the recent past. LPIS does not distinguish permanent grassland which has been ploughed and reseeded from that which has remained unploughed. Since this distinction is fundamental to assessing the CAP's protection of soil carbon **we recommend that Member States are required to record in LPIS when and to what extent ploughing of land which remains permanent grassland occurs.** Provided that wider issues with accessibility to LPIS data are resolved, this will enable a better assessment of the effectiveness of permanent grassland protection to be made.

More generally, **we recommend that an urgent review is undertaken of the data needed by Member States to understand, manage and evaluate the contribution of agriculture and forestry to climate action, particularly mitigation. The review should cover the availability, granularity (scale), consistency and timeliness of data for at least the following: soil maps covering carbon content and erosion risk; landscape features that can be considered as carbon stocks; fertiliser use and application methods at holding level; tillage practices adopted at holding level; manure management arrangements at holding level; whether livestock housing is cooled or heated. For abatement and adaptation actions data on their cost should be collected.**

On climate spending the ESI-Fund tracking methodology is not a sufficiently precise tool for tracking expenditure on climate action. **We recommend that it is modified to track both mitigation and adaptation spending as separate (overlapping) totals when this is possible, and to remove the scope for subjective allocations to focus areas to affect the result.** The ring-fenced 30% expenditure required for certain measures beneficial for climate and the environment makes it difficult to see and programme the contribution of CAP support to climate action. **We recommend that the ANC payment (M13) is not included within the 30% ring-fence, as it does not address climate (or environment) sufficiently directly. Furthermore, having a defined minimum spend on climate and a separately defined minimum spend on environment needs and objectives would improve the relevance of CAP expenditure towards these objectives.**

20 REFERENCE LIST

ACARE (2015) Revolutionary solutions for local food systems, in *Social Innovation for Agriculture of the Future*.

Agrosynergie EEIG (2013) *Evaluation of the structural effects of Direct Support*. Agrosynergie EEIG, Brussels.

Agrosynergie EEIG (2015) *Evaluation of Article 68 measures*. Report for European Commission, Brussels.

Agrosynergy (2018) *Impact of the CAP on viable food production*.

Aleksandrowicz, L, Green, R, Joy, E J, Smith, P and Haines, A (2016) The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: a systematic review. *PLoS ONE* No 11 (11).

Allen, B, Kretschmer, B, Baldock, D, Menadue, H, Nanni, S and Tucker, G M (2014) *Space for energy crops - assessing the potential contribution to Europe's energy future*. Report produced for BirdLife Europe, European Environmental Bureau and Transport & Environment, Institute for European Environmental Policy, London.

Allen, B, Nanni, S, Schweitzer, J-P, Baldock, D, Watkins, E, Withana, S and Bowyer, C (2015) *International review of Bio-economy Strategies with a focus on waste resources*. Institute for European Environmental Policy, Brussels.

Alliance Environnement and EFI (2017) *Evaluation study of the forestry measures under Rural Development*. Alliance Environnement and European Forest Institute, Brussels.

Alliance Environnement and Thünen-Institut (2017) *Evaluation study of the payment for agricultural practices beneficial for the climate and the environment*. Alliance Environnement, Brussels.

Altieri, M, Nicholls, C, Henao, A and Lana, M (2015a) Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development* No 35 (3), 869-890.

Altieri, M A, Nicholls, C I, Alejandro, H and Lana, M A (2015b) Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development* No 35 (3), 869–890.

Animal Task Force (2017) *A strategic research and innovation agenda for a sustainable livestock sector in Europe. Suggested priorities for research for Horizon2020 2018-2020 Work Programme to enhance innovation and sustainability in the livestock production sector of Europe's food supply chains*. Second White Paper of the Animal Task Force, Brussels.

Arrouays, D and et al. (2002) *Contribution à la lutte contre l'effet de serre. Stocker du carbone dans les sols agricoles de France?* INRA, Paris.

Baldock, D and Mottershead, D (2017) *Towards an integrated approach to livestock farming, sustainable diets and the environment: challenges for the Common Agricultural Policy and the UK*. Institute for European Environmental Policy, London / Brussels.

Banuri, T, Barker, T, Bashmakov, I, Blok, K, Christensen, J, Davidson, O, Grubb, M, Halsnæs, K, Jepma, C, Jochem, E, Kauppi, P, Krankina, O, Krupnick, A, Kuijpers, L, Kverndokk, S, Markandya, A, Metz, B, Moomaw, W R, Moreira, J R, Morita, T, Jiahua, P, Price, L, Richels, R, Robinson, J, Sathaye, J, Swart, R, Tanaka, K, Taniguchi, T, Toth, F, Taylor, T and Weyant, J (2001) Technical summary, in Pachauri, R (ed), *Climate change 2001: Mitigation. A Report of Working Group III of the Intergovernmental Panel on Climate Change*.

Barbier, E (2011) The policy challenges for green economy and sustainable economic development. *Natural resources Forum* No 35 (3), 233-245.

Bardají, I, Garrido, A, Blanco, I, Felis, A, Sumpsi, J M, Garcíá-Azcárate, T, Enjoiras, G and Capitanio, F (2016) *Research for AGRI Committee - State of play of risk management tools implemented by Member States during the period 2014-2020: national and European frameworks*. European Parliament, Brussels.

Barnett, J and O'Neill, S (2010) Maladaptation. *Global Environmental Change* No 20 (2), 211-213.

Bartsch, D, Hans-Jörg, B, Engel, K-H, Ewen, C, Flachowsky, G, Gathmann, A, Heinze, P, Koziolek, C, Leggewie, G, Meisner, A, Neemann, G, Rees, U, Scheepers, A, Schmidt, S, Schulte, E, Sinemus, K and Vaasen, A (2009) *BEETLE-Report: Long-term effects of GM plants on health and the environment (including biodiversity): prioritisation of potential risks and delimitation of uncertainties*.

Battini, F, Agostini, A, Boulamanti, A K, Giuntoli, J and Amaducci, S (2014) Mitigating the environmental impacts of milk production via anaerobic digestion of manure: Case study of a dairy farm in the Po Valley. *Science of the Total Environment* No 481, 196-208.

Bellarby, J, Tirado, R, Leip, A, Weiss, F, Lesschen, J P and Smith, P (2013) Livestock greenhouse gas emissions and mitigation potential in Europe. *Global Change Biology* No 19 (1), 3-18.

Bernués, A, Ruiz, R, Olaizola, A, Villalbe, D and Casasus, I (2011) Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. *Livestock Science* No 139 (1-2), 44-57.

Bock, B B (2012) Social innovation and sustainability; how to disentangle the buzzword and its application in the field of agriculture and rural development. *Studies in agricultural economics (Budapest)* No 114, (2) pp57-63. Budapest.

Bohmanova, J (2006) Studies on genetics of heat stress in US holsteins, University of Georgia.

Boulamanti, A K, Donida Maglio, S, Giuntoli, J and Agostini, A (2013) Influence of different practices on biogas sustainability. *Biomass and Bioenergy* No 53, 149-161.

Brady, M, Hristov, J, Hojgard, S, Jansson, T, Johansson, H, Larsson, C, Nordin, I and Rabinowicz, E (2017) *Impacts of Direct Payments: lessons for CAP post-2020 from a quantitative analysis*. AgriFood Economics Centre, Lund, Sweden.

Bryngelsson, D, Wirsenius, S, Hedenus, F and Sonesson, U (2016) How can the EU climate targets be met? A combined analysis of technological and demand-side changes in food and agriculture. *Food Policy* No 59, 152-164.

Bues, A, Preissel, S, Reckling, M, Zander, P, Kuhlman, T, Topp, K, Watson, C, Lindström, K, Stoddard, F L and Murphy-Bokern, D (2013) *The environmental role of protein crops in the new Common Agricultural Policy*. IP/B/AGRI/IC/2012-067, European Parliament DG for internal policies, Brussels.

Burgos, S, Embertson, N, Zhao, Y, Mitloehner, F, DePeters, E and Fadel, J (2010) Prediction of ammonia emission from dairy cattle manure based on milk urea nitrogen: Relation of milk urea nitrogen to ammonia emissions. *Journal of Dairy Science* No 93 (6), 2377-2386.

BusinessGreen (2017) *Tackling livestock emissions: the innovative, necessary and rapidly expanding new market: Insight report*. Incisive Media, London.

Cameron, D R, Marvin, D C, Remucal, J M and Passero, M C (2017) Ecosystem management and land conservation can substantially contribute to California's climate mitigation goals. *Proceedings of the National Academy of Sciences of the United States of America* No 114 (48), 12833-12838.

Castañeda-Vera, A (2017) Evaluation of risk management tools for stabilising farm income under CAP 2014-2020. *Economía Agraria y Recursos Naturales* No 17 (1).

Castaneda-Vera, A and Garrido, A (2017) Evaluation of risk management tools for stabilising farm income under CAP 2014-2020. *Agricultural and Resource Economics* No 17 (1), 3-23.

Charatsari, C, Folinas, D and Lioutas, E (2010) *Using gap analysis to measure the quality of agricultural education programs / Ανάλυση χασμάτων μεταξύ προσδοκώμενης και αντιλαμβανόμενης ποιότητας υπηρεσιών γεωργικής εκπαίδευσης*. pp.

Chenu, C, Klumpp, K, Bispo, A, Angers, D, Colnenne, C and Metay, A (2014) Stocker du carbone dans les sols agricoles: évaluation de leviers d'action pour la France. *Innovations Agronomiques* No 37, 23-37.

Coffey, AND, SQW, Edater and SPEED (2016) *Evaluation study of the implementation of the European Innovation Partnership for Agricultural Productivity and Sustainability*. Report prepared for the European Commission.

Collier, R J, Dahl, G E and VanBaale, M J (2006) Major Advances Associated with Environmental Effects on Dairy Cattle. *Journal of Dairy Science* No 89 (4), 1244-1253.

Conant, R, Easter, M, Paustian, K, Swan, A and Williams, S (2007) Impacts of periodic tillage on soil C stocks: A synthesis. *Soil & Tillage Research* No 95 (2007) 1–10.

Cortignani, R and Dono, G (2018) *Agricultural policy and climate change: An integrated assessment of the impacts on an agricultural area of Southern Italy*. 26-35 pp.

COWI (2017) *Mainstreaming of adaptation into the ESIF 2014-2020*. Report for European Commission DG CLIMA, COWI, Denmark.

Croezen, H, Kampman, B and Schepers, B (2008) *Review of the Indirect Effects of Biofuels*.

CRPA, TI and IFCN (2014) *Assessing farmers' cost of compliance with EU legislation in the fields of environment, animal welfare and food safety*. Study commissioned by the European Commission

Directorate-General for Agriculture and Rural Development (AGRI-2011-EVAL-08), Centro Ricerche Produzioni Animali, Thünen Institute of Farm Economics and International Farm Comparison Network on Dairy, Brussels.

Dasselaar, A v (2012) *Qualitative overview of mitigation and adaptation options and their possible synergies & trade-offs, AnimalChange project - Deliverable 8.1, Grant agreement number: FP7-266018*. DLO, Wageningen.

De Visser, C L M, Schreuder, R and Stoddard, F (2014) The EU's dependency on soya bean import for the animal feed industry and potential for EU produced alternatives. *OCL* No 21(4) D407.

DG Agriculture (2017) *Report on the distribution of direct payments to agricultural producers (financial year 2016)*. European Commission, DG Agriculture, Brussels.

DG for Research and Innovation (2017) *New Techniques in Agricultural Biotechnology*. European Commission, Brussels.

DGAgri (2017) *Direct payments*.

Dolfing, A G (2017) Scenarios for reducing the greenhouse gas emissions of the Dutch dairy sector, Copernicus Institute for Sustainable Development, Utrecht University.

Dominguez, P and Fellman, T (2015) The needs for comprehensive climate change mitigation policies in European Agriculture. *EuroChoices* No 14, 11-16.

Dubbeling, M (2012) *Report on the (most relevant) potential impacts of Urban and Peri-urban Agriculture and Forestry (UPA/F) on climate change adaptation, mitigation and other co-developmental benefits. Project IFQ1-1036: Monitoring impacts of urban and peri-urban agriculture and forestry on climate change*. RUAF Foundation, The Netherlands.

Dwyer, J, Kubinakova, K, Lewis, N, Powell, J, Vigani, M, Fährmann, B, Gocht, A, Grajewski, R, Sauras, M C, Cachinero, P N, Mantino, F, Berriet-Solliec, M and Pham, H-v (2016) *Research for AGRI Committee - Programmes implementing the 2015-2020 Rural Development Policy*. European Parliament, Brussels.

EC (2013) *Principles and recommendations for integrating climate change adaptation considerations under the 2014-2020 rural development programmes*, *Commission Staff Working Document*. European Commission, Brussels.

EC and EEA (2017) *European Climate Adaptation Platform*. http://climate-adapt.eea.europa.eu Accessed

Ecorys (2017) *Modernising and simplifying the Common Agricultural Policy: Summary of the results of the Public Consultation*. Brussels.

Ecorys, IEEP and Wageningen University & Research (2016) *Mapping and analysis of the implementation of the CAP*. Final Report to the Directorate-General for Agriculture and Rural Development, Brussels.

EEA (2015a) *National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism*. Accessed

EEA (2015b) *Overview of climate change adaptation platforms in Europe*. 5/2015, EEA, Copenhagen.

EEA (2017a) *Climate change, impacts and vulnerability in Europe 2016*. European Environment Agency, Luxembourg.

EEA (2017b) *Climate change, impacts and vulnerability in Europe 2016: An indicator-based report*. EEA Report No 1/2017, European Environment Agency, Copenhagen.

EEA (2017c) *COACCH: The economic cost of climate change in Europe*. European Environment Agency.

EEA (2017d) *Food consumption — animal based protein: Indicator SCP 020*. https://www.eea.europa.eu/data-and-maps/indicators/13.2-development-in-consumption-of-2 Accessed

EEA (2017e) *Soil organic carbon*. https://www.eea.europa.eu/data-and-maps/indicators/soil-organic-carbon-1/assessment#tab-related-briefings Accessed

EEB (2017) *The Future of the CAP: An urgent need for a truly sustainable agriculture, land and food policy*. European Environmental Bureau, Brussels.

EIB (2015) *EIB Climate Strategy: mobilising finance for the transition to a low carbon and climate-resilient economy*. European Investment Bank.

EIP-Agri Focus Group (2017) *Reducing emissions from cattle farming - final report*. EIP-Agri Focus Group.

ENRD (2013a) *Dairy farm with biogas production unit in Romania - EAFRD-funded project*. https://enrd.ec.europa.eu/sites/enrd/files/gp_ro_dairy_farm_renewables_web.pdf Accessed

ENRD (2013b) *Projects & Practice database*. https://enrd.ec.europa.eu/projects-practice_en Accessed

(2013) *An EU Strategy on Adaptation to Climate Change.* Communication from the Commission to the European Parliament and the Council, COM(2013) 216, 2013, Brussels.

European Commission (2017) *Risk management schemes in EU agriculture: Dealing with risk and volatility*. EU Agricultural Markets Briefs No 12 September 2017, European Commission Agriculture and Rural Development, Brussels.

European Commission (2018) *Commission Staff Working Document (2018) 301: Impact Assessment*, Brussels.

European Court of Auditors (2016) *Making cross-compliance more effective and achieving simplification remains challenging*. Brussels.

European Court of Auditors (2017) *Special report 21/2017: Greening: a more complex income support scheme, not yet environmentally effective*. ECA.

FAO (2002) *La séquestration du carbone dans le sol pour une meilleure gestion des terres*. FAO, Rome.

FAO (2013) *Mitigation of Greenhouse Gas Emissions in Livestock Production: A Review of Technical Options for non-CO2 Emissions*. Food and Agriculture Organization of the United Nations, Rome.

FAO (2016) *FAOSTAT Statistical Databases*. http://faostat3.fao.org/home/index.html Accessed

Fellmann, T (2012) The assessment of climate change-related vulnerability in the agricultural sector: reviewing conceptual frameworks, in *FAO/OECD Workshop Building Resilience for Adaptation to Climate Change in the Agriculture sector*. FAO, Rome, 23-24 April 2012.

Forster, D, Menadue, H, Tweed, J, Nesbit, M, Illes, A, Williams, R, Van der Laan, J and Eichler, L (2017) *Climate mainstreaming in the EU budget: preparing for the next MFF*.

Frelih-Larsen, A, Bowyer, C, Albrecht, S, Keenleyside, C, Kemper, M, Nanni, S, Naumann, S, Mottershead, D, Landgrebe, R, Andersen, E, Banfi, P, Bell, S, Brémere, I, Cools, J, Herbert, S, Iles, A, Kampa, E, Kettunen, M, Lukacova, Z, Moreira, G, Kiresiewa, Z, Rouillard, J, Okx, J, Pantzar, M, Paquel, K, Pederson, R, Peepson, A, Pelsy, F, Petrovic, D, Psaila, E, Šarapatka, B, Sobocka, J, Stan, A-C, Tarpey, J and Vidaurre, R (2016) *Updated inventory and assessment of soil protection policy instruments in EU Member States*. Final Report to DG Environment, Ecologic Institute, Berlin.

Frelih-Larsen, A, MacLeod, M, Osterburg, B, Eory, A V, Dooley, E, Kätsch, S, Naumann, S, Rees, B, Tarsitano, D, Topp, K, Wolff, A, Metayer, N, Molnár, A, Povellato, A, Bochu, J L, Lasorella, M V and Longhitano, D (2014) *Mainstreaming climate change into rural development policy post 2013*. Final report for DG CLIMA, Ecologic Institute, Berlin.

Garnett, T, Godde, C, Muller, A, Röös, E, Smith, P, De Boer, I J M, zu Ermgassen, E, Herrero, M, Van Middelaar, C E, Schader, C and van Zanten, H (2017) *Grazed and confused? Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question – and what it all means for greenhouse gas emissions*. Food Climate Research Network (FCRN), Oxford, UK.

Garrido, P, Elbakidze, M, Angelstam, P, Plieninger, T, Pulido, F and Moreno, G (2017) Stakeholder perspectives of wood-pasture ecosystem services: A case study from Iberian dehesas. *Land Use Policy* No 60, 324-333.

Gerber, P J, Steinfeld, H, Henderson, B, Mottet, A, Opio, C, Dijkman, J, Falcucci, A and Tempio, G (2013) *Tackling climate change through livestock - A global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations (FAO), Rome.

Gocht, A, Ciaian, P, Bielza, M, Terres, J-M, Röder, N, Himics, M and Salputra, G (2017) EU-wide economics and environmental impacts of CAP greening with high spatial and farm-type detail. *Journal of Agricultural Economics* No 68 (3), 651-681.

Gocht, A, Ciaian, P, Diaz-Caneja, M B, Terres, J, Roder, N, Himics, M and Salputra, G (2016) *Economic and environmental impacts of CAP greening: CAPRI simulation results*. EUR 28037 EN, Joint Research Centre, Publications Office of the European Union.

Groeneveld, A, Peerlings, J, Bakker, M and Heijman, W (2016) The effect of milk quota abolishment on farm intensity: Shifts and stability. *NJAS - Wageningen Journal of Life Sciences* No 77, 25-37.

Hart, K (2015) *Green direct payments: implementation choices of nine Member States and their environmental implications*. Institute for European Environmental Policy, London.

Hart, K, Allen, B, Keenleyside, C, Nanni, S, Maréchal, A, Paquel, K, Nesbit, M and Ziemann, J (2017) *Research for AGRI Committee - The consequences of climate change for EU agriculture. Follow-up to the COP21 - UN Paris Climate Change Conference*. European Parliament: Agriculture and Rural Development, Brussels.

Havlík, P, Valin, H, Herrero, M, Obersteiner, M, Schmid, E, Rufino, M C, Mosnier, A, Thornton, P K, Böttcher, H, Conant, R, Frank, S, Fritz, S, Fuss, S, Kraxner, F and Notenbaert, A (2014) Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences of the USA* No 111 (10), 3709-3714.

Hegarty, R, Goopy, J, M Herd, R and McCorkell, B (2007) Cattle selected for lower residual feed intake have reduced daily methane production. *Journal of Animal Science* No 85 (6), 1479-1486.

Hennessy, T (2014) *CAP 2014-2020 Tools to Enhance Family Farming: Opportunities and Limits*. European Parliament, Directorate-General for Internal Policies, Policy Department B: Structural and Cohesion Policies, Brussels.

Henseler, M and Dechow, R (2014) Simulation of regional nitrous oxide emissions from German agricultural mineral soils: A linkage between an agro-economic model and an empirical emission model. *Agricultural Systems* No 124 (Supplement C), 70-82.

Herrero, M, Thronton, P K, Notenbaert, A M, Wood, S, Msangri, S, Freeman, H A, Bossio, D, Dixon, J, Peters, M, van der Steeg, J, Lynan, J, Parthasarathy Roa, P, Macmillan, S, Gerard, B, McDermott, J., Seré, C and Rosegrant, M (2010) Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science* No 327 (822).

Hoben, J P, Gehl, R J, Millar, N, Grace, P R and Robertson, G P (2011) Nonlinear nitrous oxide (N2O) response to nitrogen fertilizer in on-farm corn crops of the US Midwest. *Global Change Biology* No 17 (2), 1140-1152.

Höglund Isaksson, L, Winiwarter, W, Purohit, P and Gomez-Sanabria, A (2016) *Non-CO2 greenhouse gas emissions in the EU-28 from 2005 to 2050: GAINS model methodology*. IIASA, Laxenburg, Austria.

Hristov, A N, Oh, J, Lee, C, Meinen, R, Montes, F, Ott, T, Firkins, J, Rotz, A, Dell, C, Adesogan, A, Yang, W, Tricarico, J, Kebreab, E, Waghorn, G, Dijkstra, J and Oosting, S (2013) *Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO2 emissions*. FAO, Rome, Italy.

Hubert, A (2010) *Empowering people, driving change. Social innovation in the European Union*. Bureau of European Policy Advisors (BEPA).

Huyghe, C, de Vliegher, A, Gils, v and Peeters, A (2014) *Grasslands and herbivore production in Europe and effects of common policies*. Versailles.

Huygue, C, Vlieger, A D, Gills, B V and Peeters, A (2014) *Grassland and herbivore production in Europe and effects of common policies*. pp.

Hyland, J J, Jones, D L, Parkhill, K A, Barnes, A and Williams, A (2015) *Farmers' perceptions of climate change: identifying types*.

Ignaciuk, A (2015) *Adapting agriculture to climate change: a role for public policies*. OECD Food Agriculture and Fisheries Papers No. 85, OECD, Paris.

Ignaciuk, A and Boonstra, C (2017) *Synergies and trade-offs between agricultural productivity and climate change mitigation and adaptation: Netherlands case study*. Broschure, OECD, Paris.

Ignaciuk, A, Coger, T and Dameron, V (2017) *Synergies et arbitrages entre productivité agricole et adaptation au changement climatique et atténuation : étude de cas sur la France*. OECD, Paris.

European Commission (2/13/2012) *Innovating for Sustainable Growth: A Bioeconomy for Europe.* Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2012) 60 final, 2/13/2012, European Commission, Brussels.

INRA (2014) *ANIMALCHANGE Final Report Summary*.

IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken,P.R. Mastrandrea, and L.L. White (eds.)]. No, 190.

Jansson, T, Nordin, I, Wilhelmson, F, Manevska-Tasevska, G, Weiss, F and Witzke, P (2018) *Coupled agricultural subsidies in the EU undermine climate efforts*. AgriFood Economics Centre.

Keenleyside, C, Radley, G, Tucker, G M, Underwood, E, Hart, K, Allen, B and Menadue, H (2014) *Results-based payments for biodiversity guidance handbook: Designing and implementing results-based agri-environment schemes 2014-2020*. Prepared for the European Commission, DG Environment, Contract No ENV.B.2/ETU/2013/0046, Institute for European Environmental Policy, London.

Kemény, G, Varga, T, Fogarasi, J and Tóth, K (2012) *The development of Hungarian agricultural insurance system*. Research Institute of Agricultural Economics (AKI), Budapest.

Kirchner, M, Schönhart, M and Schmid, E (2016) *Spatial impacts of the CAP post-2013 and climate change scenarios on agricultural intensification and environment in Austria*. 35-56 pp.

Kneafsey, M, Venn, L, Schmutz, U, Balázs, B, Trenchard, L, Eyden-Wood, T, Bos, E, Sutton, G and Blackett, M (2013) *Short food supply chains and local food systems in the EU. A state of play of their socio-economic characteristics*. JRC Scientific and Policy Reports, EUR 25911 EN, Publications Office of the European Union, Luxembourg.

Knickel, K, Brunori, G, Rand, S and Proost, M D C (2009) *Towards a Better Conceptual Framework for Innovation Processes in Agriculture and Rural Development: From Linear Models to Systemic Approaches*. pp.

Knierim, A and Prager, K (2015) *Agricultural Knowledge and Information Systems in Europe: Weak or strong, fragmented or integrated?* PROAKIS.

Krauss, M, Ruser, R, Müller, T, Hansen, S, Mäder, P and Gattinger, A (2017) Impact of reduced tillage on greenhouse gas emissions and soil carbon stocks in an organic grass-clover ley- winter wheat cropping sequence. No 239, 324-333.

Labarthe, P and Laurent, C (2009) *Transformation of agricultural extension services in the EU : Towards a lack of adequate knowledge for small-scale farms*. pp.

Lal, R (2009) Sequestering atmospheric carbon dioxide. No 28 (3), 90-96.

Lanier, J E, Jordan, D, Barnes, J S, Matthews, J, Grabow, G L, Griffin, W J, Bailey, J E, Johnson, P D, Spears, J F and Wells, R (2004) Disease Management in Overhead Sprinkler and Subsurface Drip Irrigation Systems for Peanut. *Agronomy Journal* No 96 (4).

Laurent, C and Labarthe, P (2006) Agricultural extension and market regulation: learning form a comparison of six EU countries. *Journal of Agricultural Education and Extension* No 12 (1), 5-16.

Lemus, R and Lal, R (2005) Bioenergy crops and carbon sequestration. *Critical Reviews in Plant Sciences* No 24, 1-21.

Long, T B, Blok, V and Coninx, I (2016) Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production* No 112, 9-21.

Lóránt, A, Allen, B, Aubert, P-M, Hoffmann, A and Kinniburgh, F (2017) *Achieving net-zero emissions in the agriculture sector: Synthesis of climate-related drivers of change in the agriculture sector - Background paper to the first meeting of the EU Stakeholder platform.*

Louhichi, K, Ciaian, P, Espinosa, M, Perni, A and Gomez y Paloma, S (2017) Economic impacts of CAP greening: an application of an EU-wide individual farm model for CAP analysis (IFM-CAP), in *European Review of Agricultural Economics*. International Association of Agricultural Economists, 2015 Conference, August 9-14, 2015, Milan, Italy.

M'barek, R, Barreiro-Hurle, J, Boulanger, P, Caivano, A, Ciaian, P, Dudu, H, Espinosa, M, Fellmann, T, Ferrari, E, Gomez y Paloma, S, Gorrin Gonzalez, C, Himics, M, Louhichi, K, Perni, A, Philippidis, G, Salputra, G, Witzke, P and Genovese, G (2017) *Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020*. Publications Office of the European Union, Luxembourg.

Magrini, M-B, Anton, M, Cholez, C, Corre-Hellou, G, Duc, G, Jeuffroy, M-H, Meynard, J-M, Pelzer, E, Voisin, A-S and Walrand, S (2016) Why are grain-legumes rarely present in cropping systems despite their environmental and nutritional benefits? Analyzing lock-in in the French agrifood system. *Ecological Economics* No 126, 152-162.

MAPAMA (2015-2020) *Asignación de derechos de pago básico*. Nota técnica, 2, MAPAMA, Spain.

Marelli, L, Padella, M, Edwards, R, Moro, A, Kousoulidou, M, Giuntoli, J, Baxter, D, Vorkapic, V, Agostini, A, O'Connell, A, Lonza, L and Garcia-Lledo, L (2015) *The impact of biofuels on transport and the environment, and their connection with agricultural development in Europe*. Study for the European Parliament IP/B/TRAN/IC/2012_117, Joint Research Center, Institute for Energy and Transport, Sustainable Transport Unit, Brussels.

Martineau, H, Wiltshire, J, Webb, J, Hart, K, Keenleyside, C, Baldock, D, Bell, H and Watterson, J (2016) *Effective performance of tools for climate action policy - meta-review of Common Agricultural Policy (CAP) mainstreaming*. Report for European Commission DG CLIMATE ACTION under specific contract number 340202/2014/688088/SER/CLIMA.A.2 implementing Framework Contract CLIMA.A.4/FRA/2011/0027, Ricardo-AEA & IEEP, Didcot, UK.

Matthews, A (2016) *Is agriculture off the hook in the EU's 2030 climate policy?* Blog article. http://capreform.eu/is-agriculture-off-the-hook-in-the-eus-2030-climate-policy/ Accessed 14.11.2016

Matthews, A, Mahé, L-P, Bureau, J-C, Dax, T and Copus, A (2016) *Research for AGRI Committee – CAP reform post-2020 - Challenges in agriculture*. European Parliament DG for internal policies.

Matthews, A, Salvati, L and Scoppola, M (2017) *Trade Impacts of Agricultural Support in the EU*. International Agricultural Trade Research Consortium.

Matthews, R, Hogan, G and Mackie, E (2018) *Carbon impacts of biomass consumed in the EU: Supplementary analysis and interpretation for the European Climate Foundation*. Project report for ECF.

Mendelsohn, R (2012) The economics of adaptation to climate change in developing countries. *Climate Change Economics* No 3 (2).

Meynard, J-M, Jeuffroy, M-H, Le Bail, M, Lefèvre, A, Magrini, M-B and Michon, C (2017) Designing coupled innovations for the sustainability transition of agrifood systems. *Agricultural Systems* No 157, 330-339.

Millar, N, Robertson, G P, Grace, P R, Gehl, R J and Hoben, J P (2010) Nitrogen fertilizer management for nitrous oxide (N2O) mitigation in intensive corn (Maize) production: an emissions reduction protocol for US Midwest agriculture. *Mitigation and Adaptation Strategies for Global Change* No 15 (2), 185-204.

Miyake, S, Renouf, M, Peterson, A, McAlpine, C and Smith, C (2012) Land-use and environmental pressures resulting from current and future bioenergy crop expansion: A review. *Journal of Rural Studies* No 28 (4), 650-658.

Mollier, P (2016) *Freins à la captation du carbone par les sols : urgence de l'initiative 4 pour mille*. Accessed

Moreno, G and Pulido, F (2008) The Functioning, Management and Persistence of Dehesas, in Rigueiro-Rodríguez, A, McAdam, J, Mosquera-Losada, M R (eds), *Agroforestry in Europe: Current Status and Future Prospects*, pp127-160. Springer Netherlands

Mottet, A, Gerber, P, Weiss, F, Eory, V, Witzke, P, Huck, I, Carmona, G, Kuikman, P, Silvestri, S and Havlik, P (2015) *Report on the quantitative analysis of policy issues, including methodology and results*.

MULE (2016) *Bericht zur Lage der Landwirtschaft des Landes Sachsen-Anhalt*. Magdeburg.

Nkrumah, J D, Li, C, Basarab, J B, Guercio, S, Meng, Y, Murdoch, B, Hansen, C and Moore, S S (2004) Association of a single nucleotide polymorphism in the bovine leptin gene with feed intake, feed efficiency, growth, feeding behaviour, carcass quality and body composition. *Canadian Journal of Animal Science* No 84 (2), 211-219.

Norman, H D, Hutchison, J L and Miller, R H (2010) Use of sexed semen and its effect on conception rate, calf sex, dystocia, and stillbirth of Holsteins in the United States. *Journal of Dairy Science* No 93 (8), 3880-3890.

Nunes, A, Figueiredo, A and Almeida, A (2012) *The effects of farmland abandonment and plant succession on soil properties and erosion processes: a study case in centre of Portugal*. Centro de estudos de Geographia.

OECD (2017) *Evaluation of the EU Common Agricultural Policy (CAP) 2014-20*.

OECD (2018) *Meat consumption (indicator)*. https://data.oecd.org/agroutput/meat-consumption.htm Accessed 15 June 2018

Oenema, O, Velthof, G L, Klimont, Z and Winiwarter, W (2012) *Emissions from agriculture and their control potentials*.

Olesen, J E and Bindi, M (2002) Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy* No 16 (4), 239-262.

Olesen, J E, Trnka, M, Kersebaum, K C, Skjelvag, A O, Seguin, B, Peltonen-Sainio, P, Rossi, F, Kozyra, J and Micale, F (2011) Impacts and adaptation of European crop production systems to climate change. *European Journal of Agronomy* No 34 (2), 96-112.

Oréade-Brèche (2017) *Etat des lieux de la mobilisation des Programmes de Développement Rural Régionaux en faveur de la politique agro-écologique*. Ministère de l'agriculture et de l'alimentation.

Pérez Domínguez, I, Fellmann, T, Weiss, F, Witzke, P, Barreiro-Hurlé, J, Himics, M, Jansson, T, Salputra, G and Leip, A (2016) *An economic assessment of GHG mitigation policy options for EU agriculture (EcAMPA 2)*. JRC Science for Policy Report, EUR 27973 EN, Publications Office of the European Union, Luxembourg.

Perry, C and Karajeh, F (2017) *Does improved irrigation technology save water? A review of the evidence*. FAO, Cairo.

Price, J P N, Balshaw, H and Chambers, B J (2014) *Managing grasslands to mitigate flooding risk*, Aberystwyth, UK.

Ramboll and IVM (2017) *Inventory and analysis of mechanisms to support damage prevention in the EU*. European Commission.

Rees, R M, Bingham, I J, Baddeley, J and Watson, C A (2005) The role of plants and land management in sequestering soil carbon in temperate arable and grassland ecosystems. *Geoderma* No 128 (2005) 130 – 154.

Reeves, J L (2017) Climate change effects on biological control of invasive plants by insects. *CAB Reviews* No 12 (001), 1-8.

Reidsma, P and Ewert, F (2008) Regional farm diversity can reduce vulnerability of food production to climate change. *Ecology and Society* No 13.

Reidsma, P, Ewert, F, Oude Lansink, A and Leemans, R (2009) Vulnerability and adaptation of European farmers: a multi-level analysis of yield and income responses to climate variability. *Regional Environmental Change* No 9 (25), https://doi.org/10.1007/s10113-10008-10059-10113.

Rodrigo-Comino, J, Bogunovic, I, Mohajerani, H, Pereira, Paolo, Sinoga, J and Ries, J (2017) The Impact of Vineyard Abandonment on Soil Properties and Hydrological Processes. *Vadose Zone Journal* No.

Rosenthal, G, Schrautzer, J and Eichberg, C (2012) Low-intensity grazing with domestic herbivores: a tool for maintaining and restoring plant diversity in temperate Europe. *TUEXENIA* No 32 (1), 167-205.

Ruser, R and Schulz, R (2015) The effect of nitrification inhibitors on the nitrous oxide (N2O) release from agricultural soils—a review. *Journal of Plant Nutrition and Soil Science* No 178 (2), 171-188.

Sabaté, X, O'Neill, C, Mitchell, B and Basora, X (2013) *Caring together for nature. Manual on land stewardship as a tool to promote social involvement with the natural environment in Europe.* LandLife documents.

Salmoral, G, Aldaya, M M, Chico, D, Garrido, A and Llamas, M R (2011) The water footprint of olives and olive oil in Spain. *Spanish Journal of Agricultural Research* No 9 (4), 1089-1104.

Sasu-Boakye, Y, Cederberg, C and Wirsenius, S (2014) Localising livestock protein feed production and the impact on land use and greenhouse gas emissions. *Animal* No 8 (8), 1339-1348.

SCAR (2016) *Agricultural Knowledge and Innovation Systems towards the future: A Foresight Paper*. European Commission, DG Research and Innovation, Brussels.

Scherer, L A, Verburg, P H and Schulp, C J E (2017) Opportunities for sustainable intensification in European agriculture. *Global Environmental Change* No 48, 43-55.

Scialabba, N and Müller-Lindenlauf, M (2010) Organic agriculture and climate change. *Renewable Agriculture and Food Systems* No 25 (2), 158-169.

Serra-Wittling, C and Molle, B (2017) *Evaluation des économies d'eau à la parcelle réalisables par la modernisation des systèmes d'irrigation*. IRSTEA.

Smit, B and Skinner, M W (2002) Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change* No 7 (1), 85-114.

Smith, P (2014) Do grasslands act as a perpetual sink for carbon? *Global Change Biology* No 20 (9), 2708-2711.

Smithers, J and Blay-Palmer, A (2001) Technology innovation as a strategy for climate adaptation in agriculture. *Applied Geography* No 21 (2), 175-197.

Soto, I, Sanchez, B, Gomez-Barbero, M, Fellmann, T and Rodriguez-Cerezo, E (2017) *Datasets on technological GHG emissions mitigation options for the agriculture sector*. ISBN 978-92-79-70518-2, Publications Office of the European Union, Luxembourg.

Soussana, J F and Lemaire, G (2013) Coupling carbon and nitrogen cycles for environmentally sustainable intensification of grasslands and crop-livestock systems. *Agriculture, Ecosystems and Environment* No 190, 9-17.

Spielman, D J and Birner, R (2008) *How Innovative Is Your Agriculture? Using Innovation Indicators and Benchmarks to Strengthen National Agricultural Innovation Systems*. Agriculture and rural development discussion paper, World Bank, Washington DC.

Stucker, D and Lopez-Gunn, E (eds) (2015) *Adaptation to Climate Change Through Water Resources Management: Capacity Equity and Sustainability.* Routledge, New York, London.

Valin, H, Peters, D, van den Berg, M, Frank, S, Havlik, P, Forsell, N, Hamelinck, C, Pirker, J, Mosnier, A and Balkovič, J (2015) *The land use change impact of biofuels consumed in the EU: Quantification of area and greenhouse gas impacts*. Ecofys, IIASA, E4tech, Utrecht.

Vernooy, R, Sthapit, B, Otieno, G, Shrestha, P and Gupta, A (2017) The roles of community seed banks in climate change adaption. *Development in Practice* No 27 (3), 316-327.

Verschuuren, J (2017) The impact of soil carbon sequestration on adaptation in Europe's agricultural sector and the potential role of regulatory instruments, in *3rd European Climate Change Adaptation Conference 'Our Climate Ready Future'.* Glasgow.

Weiss, F and Leip, A (2012) Greenhouse gas emissions from the EU livestock sector: a life cycle assessment carried out with the CAPRI model. *Agriculture, Ecosystems & Environment* No 149, 124-134.

Westhoek, H, Lesschen, J P, Rood, T, Wagner, S, De Marco, A, Murphy-Bokern, D, Liep, A, van Grinsven, H, Sutton, M A and Oenema, O (2014) Food choices, health and environment: effects of cutting Europe's meat and dairy intake. *Global Environmental Change* No 26, 196-205.

Williamson, T, Hesseln, H and Johnston, M (2012) Adaptive capacity deficits and adaptive capacity of economic systems in climate change vulnerability assessment. *Forest Policy and Economics* No 15, 160-166.

Wolfert, S, Ge, L, Verdouw, C and Bogaardt, M-J (2017) Big Data in Smart Farming – A review. No 153, 69-80.

World Health Organization (2008) *Reducing your carbon footprint can be good for your health*.

Zarco-Tejada, P J, Hubbard, N and Loudjani, P (2014) *Precision agriculture: an opportunity for EU farmers - potential support with the CAP 2014-2020*. European Parliament, Agriculture and Rural Development, Brussels.

Zeng, S and Gould, B (2016) EU link quota abolition: has the productivity of Irish dairy farms been impacted?, in AAEA (ed) *Agricultural & Applied Economics Association Annual Meeting*. Chicago.

Zinngrebe, Y, Pe'er, G, Schueler, S, Schmitt, J, Schmidt, J and Lakner, S (2017) The EU's ecological focus areas – How experts explain farmers' choices in Germany. *Land Use Policy* No 65, 93-108.

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service: – by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls), – at the following standard number: +32 22999696, or – by email via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

KF-04-18-460-EN-N

doi: 10.2762/54044
ISBN: 978-92-79-85797-3