Kuikman, Peter and Vullings, Wies and Pescadinha, BC and Timmerman, Jos and Dwyer, Janet C andPowell, John R (2014). *Study on the analysis of climate hotspots in Member States as regards rural development (EAFRD).* Project Report. European Commission.

Study on the analysis of climate hotspots in Member States as regards rural development (EAFRD)

071303/CLIMA/ETU/2013/661577/A2

Administrative summary

Service Contract number 40701.2009.001-2009.354

This service contract (CC Hotspots & RD) is based on a response by Alterra, Wageningen UR (NL) with CCRI at the University of Gloucestershire (UK) to DG CLIMA's call for tender for the contract 'STUDY on the analysis of climate hotspots in Member States as regards rural development (EAFRD)' with reference CLIMA.A.2/ETU/2013/0027rl submitted on Aug 19, 2013.

The duration of the contract was 5 months, from October 30, 2013 to March 30th, 2014.

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A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://ec.europa.eu).
Luxembourg: Office for Official Publications of the European Communities, 2014

ISBN 978-92-79-38414-1
DOI: 10.2834/81004
No of catalogue: ML-02-14-635-EN-N

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Summary

This report on the DG CLIMA service contract "STUDY on the analysis of climate hotspots in Member States as regards rural development (EAFRD)" as agreed at the kick off meeting in Brussels on November 26, 2013. The general objective of this service contract is provide for a "proper analysis of the climate hotspots in each Member State in order to support an increased level of ambition with regards to climate action in rural areas via the priorities as set out in the Partnership Agreements, as well as in concrete measures in the rural development programmes, and taking into account Member State specific knowledge on the main causes of greenhouse gas emissions in the rural areas as well as ecologic, economic and social risks of the expected degree of climate change conditions and taking into account the available funding and measures under the EAFRD".

The output of the project is this report and 28 briefing documents, one for each current Member State, describing the main climate hotspots in the Member States, and detailing recommendations and exemplary measures to address these climate hotspots from the possibilities offered by the new EU rural development policy.

Here we report on the results of tasks 1 (and 2) and 3 of this Service Contract:

- Task 1: Develop an operational concept of "climate hotpots in Member States related to the EU's rural development policies" and a common methodology on how to identify such climate hotspots in rural areas of each Member State (this report).

- Task 2: Assess and synthesize main climate mitigation and adaptation hotspots (see Annex I of this report).

- Task 3: Recommend combinations of "measures" under various "focus areas" under the draft of the European Agricultural Fund for Rural Development (EAFRD) for which an example for Malta has been provided in line with the Kick off meeting and outlined in the Inception Report; this is based on an analysis of relevant measures.

In task 4 we have created 28 briefing documents, one for each Member States on the outline and information on adaptation and mitigation hotspots, on the causal relation with climate change, on the Rural Development Programme (RDP) actions that can be funded and the favoured delivery strategy and purpose for each of the 28 Member States.

Introduction

Introduction to the project

DG CLIMA is looking for ways to integrate or mainstream climate actions within existing funds like European Agricultural Fund for Rural Development (EAFRD). They have produced a fact Sheet that outlines proposals for how climate action could be mainstreamed into the Member States' rural development programmes supported through European Agricultural Fund for Rural Development (EAFRD). It offers an overview of the potential for climate mainstreaming in the EARFD and examples of mitigation and adaptation (http://ec.europa.eu/clima/publications/docs/06-climate_mainstreaming_fact_sheet-eafrd_en.pdf)

However it is difficult for DG CLIMA to assess whether all region-specific climate issues/hotspots, which are in the scope of the available RDP measures, have been addressed by Member States. This study should be able to help pinpointing the "regional essentials". This is done by providing briefing documents per member state consisting of two parts:
Part one outlines climate hotspots EU and given MS's are faced with (task 1) and part two establishes which Rural Development Programme (RDP) actions and measures would be most fitting to address the climate hotspots in the MS's (task 3) in a set of 28 briefing documents targeting individual Member States (task 4).

This document describes the methodology used to produce the 28 briefing documents.

Concept of a climate hotspot

In the field of e.g. geology, a hotspot is a place or location in the crust that overlies a warm area and thus physically a hot (in terms of temperature) spot. In biological terms it may be a concentration of genetic diversity e.g. old forest or wetland; and, in economic terms it may be thought of as a concentration of productive capacity and activity. In many other fields the term hotspot is used with a specific interpretation or conceptualisation linked to time, location or activity or a combination of the three and specific for those fields.

Recently, Piontek et al. (2013) have introduced and discussed the concept of "climate change impact hotspots in a warming world" in PNAS. Piontek and co-workers focus on the impact of climate change and how to efficiently and effectively respond with adaptation. They link regional exposure to climate change with projected impact of climate change in areas such as water, agriculture, ecosystems and malaria. A hotspots in their framework has been defined as a region of geographical place where climate change has an ensemble of multi-sectoral climate change impact. The results of the study are at global scale yet the concept is interesting for this study.

The approach taken in this study to identify a hotspot starts from the viewpoint of i) climate vulnerability of a sector or activities and subsequent need and options to adapt (adaptation hotspot) or ii) a contribution of a sector or activity to cause climate change as result of emissions of greenhouse gases from specific activities or in a sector and/or location or from an (agricultural or natural) ecosystem.

We have identified where in Europe this relation with climate change is particularly manifest and more so compared to elsewhere on the basis of a literature review (Annex I).

We can define two 'types' of climate 'hotspot' for the purposes of this study:

- Hotspot for **climate adaptation**: Physical region or sectors (economic, social, ecologic) that have a high vulnerability to climate change, either because projected climate impacts are high and the adaptation capacity is low, or to reduce or prevent the impact of climate change via specific measures.
- Hotspot for **climate mitigation**: location or sector where certain specific activities contribute towards high emission of GHG, or action would be required to prevent high emissions of GHG from occurring in the future.

Hotspot for climate adaptation

For adaptation- according to ESPON (2011), the exposure to climate together with the physical, environmental, social, cultural and economic sensitivity of a region, determine the possible impact that climatic change may have on a region. A region might be able to adapt in the future. This high or low adaptive capacity enhances or counteracts the climate change impacts and eventually leads to a region's overall vulnerability to climate change (ESPON, 2011).

To give an example, the impact of high precipitation is more flooding in low countries such as The Netherlands. If the Netherlands has adapted to this change and reduced the potential impact via e.g. a national action plan and creating floodplains, building higher dykes , then the actual vulnerability of this region is or will be low irrespective of climate change.

If there is no or low adaptive capacity in reducing the risk in flooding then this region remains highly vulnerable to climate change and flooding.

The ESPON study (ESPON, 2011) also shows the differences between the European regions (see Maps 1 and 2) in terms of potential vulnerability and response capacity and identifies and provides maps on physical, environmental, social, cultural and economic sensitivity. However, these maps include indicators (15 total) that are not all relevant for this study on climate change and rural development and cannot be separated into relevant and less relevant indicators.

Each region or sector (economic, ecologic, social) have their own exposure to climate change (high temperature, high precipitation, etc.) that could lead to a potentially negative impact. The actual vulnerability of a region or sector, and there with the impact, depends on a combination of the intensity of climate change, the sensitivity of the region or sector determined by its environmental, social, economic and cultural characteristics, and the adaptive capacity. A region or sector might be able to adjust to the impact in the future through adaptation, making the region or sector less vulnerable to climate change. This adaptive capacity could enhance or counteract the climate change impacts.

For this project climate adaptation hotspots will occur where specific region or sectors have a high climate impact, a high sensitivity and low adaptive capacity. For this project, climate adaptation hotspots occur when climate change has an impact on the physical, environmental, social, cultural and economic sensitivity of a region. If the adaptive capacity of a region is considered low, then this would imply a region with a high vulnerability to climate change.

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Adaptive capacity (in relation to climate change impacts) The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is 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.

Source: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds), 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Hotspot for climate mitigation

For mitigation – a hotspot may occur where emissions from an activity are high; this could be expressed per unit of area (this study) or relative to best practice. In relation to causal concentrations of activity, the interest is in mitigating or reducing emissions of GHGs. GHG emissions may be concentrated geographically, or dispersed across a wide area, yet the focus on mitigation will require targeting activities and actors. For the purposes of this study the activities of interest relate particularly to livestock management.
Livestock emit methane from food digestion, and in addition nitrous oxides and ammonia are emitted from livestock wastes.

The manner in which livestock are fed and housed, the level of grazing, the type of feed, and organic waste management all influence emissions of greenhouse gases.

The other major source of GHGs in a rural economy is from consumption of fossil fuels. Fuel consumption occurs directly through heating (e.g. crop drying, transport), and indirectly through application of artificial fertilisers and pesticides.

Hotspots in rural development terms can thus occur where there are concentrations of livestock, and where intensive arable farming occurs.

Another alternative and potentially (more) effective way of thinking about mitigation hotspots is in relation to the product cycle, identifying where in a particular product related and production cycle emissions of GHGs are optimised. For this to be feasible one would need to set benchmarks or norms that would specify and identify efficient production and separate this from inefficient or less/least efficient production processes. Mitigation actions would be most effective where they successfully target and change the emissions intensity (and efficiency) of production processes. For this project this approach is deemed too complex, but it could be considered for further future research. In addition there is limited data to enable best practice measures to be derived for different agricultural practices that would enable a comparison across different regions or member states. This the approach taken is to identify areas of intensive arable or intensive livestock activity.

Methodology on how to identify climate hotspots.

It is one thing to define a hotspot, it is another to put that definition into practice and to use it to identify areas where either emissions or vulnerability to climate change constitute 'hotspots' for prioritising action. Climate change hotspots across Europe in this study are based on an assessment of climate change on i) vulnerability and impact and on ii) emissions calculations for agriculture and (agricultural/forest) land use, or potential to contribute to GHG reductions, across Europe using a range of secondary sources of data. We refer to these as "adaptation" and "mitigation" hotspots, respectively. For both types of hotspots a physical location is the starting point and we take NUTS_2 as level of resolution, reporting at MS level. This section discusses how it is possible to refine the identification of hotspots using various data sources and methodological approaches. In order to arrive at these conclusions, a prior review of relevant studies and scientific literature was undertaken (see p.9). We draw from the findings of that review, in discussing how we have addressed each type of hotspot.

Adaptation hotspot

For the hotspot identification for climate adaptation we started with a cross section of the main climate change drivers (change in precipitation, change in susceptibility to drought and change in temperature) and the four sectors identified in the IPCC technical report on Climate Change and Water e.g. water resources, agriculture and ecosystems, health and industry and society. This resulted in a matrix with a number of impacts. From this list the impacts that are related to the domain of rural development are selected on basis of the list of themes that was specified in the inception report and the issues named in the factsheet of DG CLIMA (http://ec.europa.eu/clima/publications/docs/06-climate_mainstreaming_fact_sheet-eafrd_en.pdf). In table 1 the impacts that are covered in this report are indicated.

Mitigation hotspot

For the hotspots for climate mitigation we focus on NUTS_2 regions across EU27 and identify those NUTS_2 regions that together make up 80% of all EU27 total emissions from land use and agricultural activities (follow 80 – 20 rules and more likely 1/3 – 2/3 rules with 1/3 area with 2/3 of all emissions.

For the hotspots for mitigation related to GHG emissions from agriculture and land use, we have used data on CH_4 and N_2O at NUTS_2 region level across EU 27 (Lesschen et al., 2012) to identify relevant agricultural activities (e.g. type and number of animals, manure, fertilization). These emissions include the top 5 sources for GHG emissions from agriculture and land use e.g. N_2O from fertilizer and from manure application, CH_4 from ruminant digestion and manure storage and CO_2 from cultivation and drainage of organic soils (and CO_2 from cultivation of mineral soils and land use change).

This quantification of the mitigation hotspots is fairly straightforward, as the raw data on sources and emissions that can be utilized to produce maps at NUTS-2 level are all available from Lesschen et al (2009). For soil-C stocks and emissions we have data on organic soils (indicating the potential source and valuable stock to protect). Unfortunately, we cannot not take a similar approach for CO_2 emissions from mineral soils as comprehensive data on actual losses of carbon from mineral soils for Europe are not available. The JRC has a recent soils map with a single observation on soil carbon.

For the mitigation hotspots, we recalculated some measures using the raw data from Lesschen et al, to identify hotspots (such as for Emission density which required a calculation of emissions per ha). We used 'quartile' analyses (examining how data is distributed between different quartiles of the full range of variation) to identify where the majority (75%) of all emissions occur on least (25%) of the land in the member state, to indicate the location or region in a particular member state that qualifies as a hotspot. Naturally, all emissions potentially can be mitigated, yet this identification of concentrated emissions of greenhouse gases most likely addresses the highest concentration of activities and could thereby lead to the most cost effective mitigation of greenhouse gases.

For hotspots for climate mitigation the potential for reducing emissions in any particular sector or location would ideally be taken into account (i.e. checking how far emissions are already reduced to their efficient minimum). However, data on this notion of potential are scarce and potential indicators of potential do not cover all the sectors, farming systems and activities required. So, we are instead making the simplifying assumption that it is feasible to mitigate all human-induced (and reported) emissions.

Assessment of the most relevant literature

For these impacts a broad literature review was carried out to find relevant scientifically published geographical data upon which the hotspots identification could be based. The sources are listed in Annex I to this report.

From this review, we have identified 6 distinct 'generic' types of hotspot (table 2), some of which are then further divided into sub-categories depending upon specific influencing factors. Below we describe and detail these hotspots and summarize the studies and data which we have used for analysis of their occurrence and significance across the EU (see annex I for a description of the key sources).

The hotspots are all based on scientific robust and complete datasets that can be visualised on maps. In some cases a strong relationship between an impact and climate is suspected, but if it is not scientifically proven and shown on a map, it is not possible to take these impacts into account as a hotspot.

Furthermore not all the climate studies that focussed one or more of the impacts were useful for this study, because they for example delivered methodological tools that could be used to make new indicators but that was beyond the scope of this project. In Annex I Part A, we have described per study the usefulness for this project and if we have used the results in developing the hotspots.

In table 1 the impacts that are covered within this report are highlighted (table modified and on the basis of the IPCC technical report on Climate Change and Water).

Table 1: Risks sectors through climate change. IPCC technical report on Climate Change and Water identified 4 sectors e.g. water resources, agriculture and ecosystems, health and industry and society. We have identified and highlighted in yellow those impacts that we could cover in this report on RD and Climate Change

	Water resources	**Agriculture and ecosystems**	**Health**	**Industry and society**
Heavy precipitation events and other extreme events (storm, wind, hail)	Flooding Adverse effects on quality of surface and groundwater due to sewer overflows Contamination of water supply Water scarcity may be relieved	Damage to crops Soil erosion Inability to cultivate land due to waterlogging of soils	Increased risk of deaths, physical injuries and infectious, respiratory and skin diseases Risk of psychological disorder	Disruption of settlements, commerce, transport and societies due to flooding, migration Pressures on urban and rural infrastructures Loss of property
Higher variability of precipitation, including increased droughts	Changes in run-off More widespread water stress Increased water pollution due to lower dissolution of sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution Salinization of coastal aquifers	Land degradation Lower yields/crop damage and failure Increased livestock deaths Increased risk of wildfire	Increased risk of food and water shortage; Increased risk of malnutrition; Increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies Reduced hydropower generation potentials Potential for population migration
Increased temperatures	Increased water temperatures Increase in evaporation Earlier snow melting Permafrost melting Prolonged lake stratification with decreases in surface layer nutrient concentration and prolonged depletion of oxygen in deeper layers Increased algae growth reducing dissolved oxygen levels in the water body which may lead to eutrophication and loss of fish Changes in mixing patterns and self purification capacity	Less water available for agriculture, more irrigation needed Changes in crop Productivity Changes in growing season Changes in species composition, organism abundance, productivity and phenological shifts, for example earlier fish migration	Changes in vector-borne diseases Increase of fatalities due to heat waves, and decreased personal productivity Increased risk of respiratory and skin diseases due to oone and pollen	Risk for infrastructure fixed in permafrost Degradation of freshwater quality

Source: This table shows the risks for water and other sectors through climate change. It is modified and based on the IPCC technical report on Climate Change and Water (Bates *et al.*, 2008).

Definition of climate hotspots

We have developed and defined a total of 6 generic hotspots (listed in table 2 below, first column). Of these, 3 are adaptation hotspots and 3 are mitigation hotspots. Several of these generic hotspots have been further broken down into a total of 12 detailed hotspots (table 2 below, second column).

The adaptation hotspots include:

1. Water-limited crop yield (direct impacts)
2. Other (non water-) limited crop yield and production changes with indirect impacts on a set of detailed hotspots: Soil erosion and impact of extreme weather (2a), Inland and coastal Flood Risks (2b) and Forest Fire Danger (2c)
3. Rural economic resilience focussing on tourism and attractiveness of regions to tourists

The mitigation hotspots include:

4. Land use and land use change and forestry and deforestation with organic and peat soils and losses of carbon (4a), topsoil carbon losses from mineral soils via land use and soil management (4b) and land use change and forestry (4c)
5. Agricultural greenhouse gas emissions with animal production systems and CH_4 emissions (5a), Agricultural (arable and grassland systems) N_2O emissions (5b) and agricultural fossil fuel use and CO_2 emissions (5c)
6. Renewable energy with share of renewables in the total energy use.

The description and sources used to identify the hotspots have been outlined in the section below and maps and data are detailed in Annex I. An overview of the hotspots per Member State is provided in table 3 and this will be used to identify hotspots for the briefing documents per Member State. An overview of the variations in total number of hotspots at NUTS2 level is presented in figure 4.

Table 2: Description of the hotspot with its causal relation with climate change and possible adaptation or mitigation options.

Generic Hotspot	Detailed hotspot	Description and explanation on hotspots
ADAPTATION		**Description of the hotspot, causal relation with climate change and possible adaptation or mitigation options.**
Water-limited crop yield and (forestry) production (1)		The effect of climate change on the impact of water limitation on crop yield varies across Europe. This can either lead to a positive and a negative effect on yield. The climate crop model which is used for analyses of the environmental variables (temperature, precipitation and atmospheric CO_2 concentration) and management variables (planting date, nitrogen and fertilizer and irrigation applications (Iglesias, 2011) does predict that yield production will change and decrease strongest along the Mediterranean region. The hotspots identified by Iglesias (2011) are not crop specific and the study shows an overall picture where the yield production are most vulnerable to climate change. In this study we define a “crop yield hotspot” as a region where climate change has a negative impact (reduce yield) of -25 to -5% on the projected crop yield in 2080 compared to crop yield of today (based on EEA, 2012).

Generic Hotspot	**Detailed hotspot**	**Description and explanation on hotspots**
		In irrigated agricultural production, higher demand for irrigation water need to be matched by availability of water to other sectors than agriculture alone. On this issues, no comprehensive studies and data are available to identify specific regions at risk.
Other (non water-limited) crop yield and production changes (2a-2c)		
2a	Soil erosion due to water and wind, extreme weather events e.g. (hail) storms, late frost, early flowering	Due to little reliable quantitative projections, a map of the current situation on soil erosion by water has been used to estimate which regions are more likely to be vulnerable in the future. In the absence of adaptation measures soil will become more vulnerable for erosion especially when there is increased variations in rainfall pattern and intensity. These (extreme) events will make soils more susceptible to water erosion, including the off-site effects of soil erosion increasing. Variations in rainfall patterns and intensity, and in storm frequency and intensity may affect erosion risk either directly, through the physical displacement of soil particles, or indirectly, through removing protective plant cover. A second threat is erosion through wind from enhanced and more frequent extreme weather events; wind and storm - often coinciding with more intense precipitation – and will enhance losses of top soil via erosion (to be completed for wind if data are available). Damage may also be caused by weather events such as hail storms during the growing season, windfall in crops from storms during the growing season and impacts from frost during or after flowering in crops or from wet conditions preventing harvests in autumn or from so called phonological shifts. Further impact may result from (limited) harvestability of crops due to adverse weather conditions during harvest periods e.g. high rainfall and resulting wet soils that prevent (heavy) machinery to be used for harvest or reduce the quality of the crop. For the potential impacts here, no comprehensive and conclusive data are available to identify and assign specific risks to regions across Europe. For coastal erosion see below. Further impact may result from changes in patterns and intensity of occurrence of pests and diseases affecting crop establishment or yield. For the potential impacts here, no comprehensive and conclusive data are available to identify and assign specific risks to regions across Europe.
2b	Flood Risks (inland and coastal flooding)	Global warming is projected to intensify the hydrological cycle and increase the occurrence and frequency of **inland flood events** in large parts of Europe. However, estimates of changes in flood frequency and magnitude remain highly uncertain. In regions with reduced in snow accumulation during winter, the risk of early spring flooding would decrease. **Coastal flooding** is due to expected sea level rise in combination with low lying land mostly in delta areas across Europe and in combination with poor infrastructures to protect land from flooding at high water and sea level rise. Physical damage to land and infrastructures may be expected in addition to impact on agricultural (and other) land through saline intrusion and salinization of land used for agricultural production. No specific data are available to identify areas at risk under this threat. Hotspots are related to any delta associated with the major river systems area across Europe.

Generic Hotspot	Detailed hotspot	Description and explanation on hotspots
2c	Forest Fire Danger	The increase numbers of droughts, heat waves and dry spells due to climate change, will affect across most of the Mediterranean area and more generally in southern Europe. These projected changes would increase the length and severity of the fire season, the area at risk and the probability of large fires.
Rural economic resilience (3)	Tourism	Tourism is in many areas a major economic activity in addition to agriculture and forestry. For identifying the projections tourism we identify winter and summer tourism; two sources and maps were used for projection of changes due to higher temperatures in the summer-period (2021-2050) and for projection of changes due to changes in snowfall days in winter for winter tourism (2041-2070). The temperature in the summer period will likely increase most in the Mediterranean area; likely more and extended periods of droughts may occur in summer periods. The combination is expected to render the Mediterranean area as less favourable for tourism in summer. The adaptation option here is to shift the tourism seasonality and focus on season with more attractive climates. If not, tourism will decline. Projections in reduced number of snow cover days in winter periods in northern (and central) Europe are up to 40–70 days in 2071–2100 compared to the baseline period 1961–1990. The study used a RCM driven by an ensemble of 7 GCMS for 4 SRES emission scenarios. There will also be reductions in snow mass in Europe. This will likely to occur in Switzerland, the alpine range of Italy, the Pyrenees, and Balkan mountains. These changes will make tourism in winter vulnerable as activities will strongly depend on snow covers. These changes in snow cover can further have dramatic effect on melting water volume and intensity as it contributes up to 60–70 % of annual river flows and will impact flooding risks in river systems across Europe (and is not qualified specifically). An effective response for the sector tourism would be to consider diversification of activities to attract tourism in other – more attractive – seasons in response to climate change and to maintain attractiveness of a region.
MITIGATION	**Detailed hotspot**	**Description of the hotspot, causal relation with climate change and possible adaptation or mitigation options.**
Land use and land use change and forestry and deforestation (4)		
4a	Organic and peat soils	Organic soils and peat soils characterized by high top soil organic carbon content or 'deep soil' peat lands are identified as hotspots and identified with the darkest colours. The topsoil organic carbon hotspots were identified by a map with data of European Soil Database 2003 provided by Joint Research Centre (JRC) (EEA, 2012). Changes in the short term and losses of organic matter and CO_2 emissions will most likely be driven by land management practices e.g. (continued land use or additional land use change with) drainage and cultivation; The extend of this additional land use change and cultivation of organic and peat soils has not been documented but is highly relevant for future emissions of CO_2. These human activities may mask the impact and evidence of direct climate change impact on soil carbon stocks. There are expectations that climate change (warmer and drier) will impact soil carbon in the long term and enhance loss of peat and organic matter and lead to emissions of CO_2 as

Generic Hotspot	Detailed hotspot	Description and explanation on hotspots
		conditions for oxidation improve and areas with permanent frost may change to more variable temperature conditions in soil and may become attractive for changing land use to (drained and cultivated) agricultural land. However, these effects of climate change via higher temperatures on high carbon and organic soils soil are complex and lack rigorous supporting datasets and are not considered here.
4b	Topsoil organic carbon	Mineral soils with high soil organic carbon contents can be identified as potential hotspots. Specific farm and soil management may result in losses of soil organic carbon and CO_c emissions. There is no information on identification of the scale or location of such land and soil management across Europa and associated CO_2 emissions. JRC has recently updated topsoil information for 0-20 cm from its LUCAS study and this study does provide only one measurement in time (Tóth *et al.*, 2013).
4c	Land use and land use change	Land use change will impact carbon stocks in soils and carbon stocks in vegetation and loss of permanent vegetation does result in CO_2 emissions. Any deforestation is likely to contribute to CO_2 emission from organic carbon losses from soils as well as from loss of carbon stocks in biomass (wood). Land use change in agriculture e.g. converting pastures and permanent grassland to arable land (with more or less intensive soil management and tillage operations) will result in losses of soil organic carbon and CO_2 emissions. The reverse, changing land use from cropland to pasture and grassland will store more carbon as organic matter in soils and remove CO_2 from the atmosphere as will afforestation or reforestation do. EEA (2013) estimate that the so-called 'carbon sink' activities (such as when carbon is absorbed by forest growth with any net benefit then being accounted for) are expected to contribute towards an (additional) emission reduction of 1.5 % of the EU-15 (!) base-year emissions towards 2020 and based on data for the period 2008–2011.
Agriculture and greenhouse gas emissions (5)		
5a	Animal production systems with CH_4 emissions	The sources and activities for emissions of methane are linked to livestock production in mostly ruminants (milk and beef production in cows, sheep and goats) and storage of any animal wastes and manures. The highest emissions are from enteric fermentation. Relative emissions of methane are related to feed quality, feed quantity and whether or not animals are grazing or kept and fed inside. Relative emissions of methane do vary with set-up and quality of manure storage systems. The CH_4 emissions from EU agriculture are approximately 60% of the total agriculture related emissions of non – CO_2 greenhouse gases methane plus nitrous oxide.
5b	Agricultural (arable and grassland systems) N_2O emissions	The sources for emissions of nitrous oxide are linked to animal production and specifically the storage and application of animal manures. The emissions from application of manure and urine and droppings during grazing are highest and depend on the N contents of urine and manure. Further emissions of N_2O are related to synthetic fertilizer applications and application of animal manures. These emissions may vary and higher of lower emissions depend on fertilizer type and quality and amount and timing of fertilizer and manure application. The N_2O emissions from EU agriculture are approximately 40%

Generic Hotspot	Detailed hotspot	Description and explanation on hotspots
		of the total agriculture related emissions of non – CO_2 greenhouse gases methane plus nitrous oxide.
5c	CO_2 emission from fossil fuel use in agriculture	Agricultural activities require use of energy for cooling and heating, land use and transport. The energy use in agriculture and related emissions are not identified and reported separately from energy use in other sectors and generally are much lower than the emission of non – CO_2 greenhouse gases methane and nitrous oxide. Contribution via production of renewable energy from biomass and other sources are discussed below in hotspot 6 Renewable energy potential.
6 Renewable Energy potential		The contribution to production of renewable energy is from land and biomass (biodiesel and bio-ethanol, incineration, anaerobic digestion or gasification) and from other sources e.g. animal waste en manures (anaerobic digestion). Further contributions are expected from setting up installations in rural areas for generating wind and photo voltaic solar energy. This hotspot is defined such as it indicates the abstract potential for setting up RE and to how much it still could be activated in order to achieve the national targets. MS report to EU on renewable energy in a National Renewable Energy Action Plan (NREAP). ECN (2011) has summarized projections for shares of Renewable Energy in the total energy use per MS. We have used the analysis by EEA (EEA, 2013) (see http://www.eea.europa.eu/publications/trends-and-projections-2013) to identify progress towards 2020 climate and energy targets for the different MS in EU.

Hotspots and their causal relationship with climate change

For each of 6 categories of generic hotspots (see table 2), here we further detailed the causal relation with climate change on both the receiving side (vulnerability leading to need for adaptation) and the causal side of climate change (emissions of greenhouse gases leading to and a request for mitigation actions). Annex I part A, has the full detail on the literature review and the overview of data sources and maps that have been used to identify and draw hotspots on the map of Europe. In several cases data were available from studies to identify and locate a hotspot yet in other cases only maps for Europe with impacts were available. Either of the sources was used to locate hotspots on maps of Europe for each hotspot (Annex I, part B).

From this set of maps, hotspots per Member State have been identified and are presented in table 3. These hotspots have been mapped for EU28 at NUTS2 level by overlay of the hotspots maps with circles on an EU28 map NUTS2 map (Figure 4). This map shows for each NUTS2 region how many hotspots have been identified for a specific region. This map has been used to produce a series of regional maps for each member state where the hotspots are located and identified via circles drawn on the basis of expert knowledge and these have been used in the briefing documents (Figure 3 in briefing documents).

Adaptation Hotspots

1. Crop yield, water limitation and changes (Figure 1 and 2 in Annex I)

Climate change affects the impact of crop yields due to water limitation across Europe. This can lead to both a positive and a negative effect on crop yield and production across Europe depending on the type of crop and regional differences in climate (change) and soil (Supit et al, 2012). Each region has a different exposure to climate change as each region has its own characteristics in physical, environmental, social, cultural and economic sensitivities (Greiving, 2013).

A “crop yield hotspot” here means that climate change has a negative impact (reduce yield) of -25 to -5% on the projected crop yield in 2080 compared to crop yield of today (EEA, 2012). The water limited crop yield hotspots identified here are not crop specific and show the overall picture of where the yield production is considered most vulnerable to climate change. According to EEA (2012), the mean projected changes show a pattern of decreases in yields along the Mediterranean and large increases in Scandinavia. However, throughout large parts of western and central Europe mean changes in crop yields are likely to be small”.

The results from ClimWatAdapt (Flörke, *et al.*, 2009) indicate that there are regional differences, where in general drought induced problems will occur throughout large areas in the EU with the exception of Northern Europe, Poland and the Baltic States, whereas Ireland, the UK, Belgium and The Netherlands are most vulnerable for floods.

More recent, the AVEMAC project (http://mars.jrc.ec.europa.eu/mars/Projects/AVEMAC, Donatelli et al., 2013)) assessed the potential vulnerability of European agriculture to changing climatic conditions towards 2030 and identified impact of climate change in 3 major crops across Europe (maize, wheat, rape seed) on yields. AVEMAC has used 2 scenario’s on climate change e.g. the warmest and coldest realizations of the A1B scenario over Europe.

The study results in significant variations in the yield predictions across regions and for different 2 different predictions of climate change.

According to the AVEMAC study (Donatelli et al., 2013) the following is likely to happen:

- Higher water precipitation and changes in extreme events, including more and more intense floods and droughts, are projected to affect the water quality and intensify many forms of water and also cause thermal pollution, with possible damage to ecosystems.
- Extreme events such as droughts could have an immense impact on water availability for agriculture which could lead to more need for land degradation, damage and failure in yields and crop. On the other hand it could also lead to increased livestock deaths and higher risk of wildfire. Increasing temperatures could have an impact on several types of ecosystems and regions, e.g. the composition of forests is expected to change which may increase the risk of erosion and landslides in mountainous areas, but also have other effects on the water cycle in the plains, e.g. through reduced water retention in the soil. Higher temperature could also change the species composition, abundance, or productivity and phenological shifts, for example earlier fish migration. Higher temperature could lead to less water availability for agriculture, with a result of more need for irrigation. There could also be an effect on the growing season for certain types of crops and its productivity.

2. Other (*non water-limited*) crop yield and production changes (2a-2c)

In this hotspot we consider loss of fertile soils via soil erosion due to water and wind (2.1) and or inland flooding and coastal flooding (2.2), Forest Fires (2.3). Our literature review show no comprehensive and conclusive data available to assess the risk on enhanced or new development of pests and diseases nor on losses of crop yield via damage to or loss of crops as a result of extreme weather events e.g. (hail) storms, late frost, early flowering as well as frequency and occurrence of conditions that prevent harvesting a crop These issues as part of the potential hotspot will not be further detailed in this report

2.1. Soil Erosion and damage to or loss of crop yield or crops (on erosion see Figure 3 and 4 in Annex I)

Increased precipitation (rain, sleet and snow) intensity and variability will increase the risks of flooding and drought. This likely to increase soil erosion but also in damaging crops and the inability to cultivate land due to waterlogging of soils or to harvest crops due to water logging of soils and inability to use (heavy) machinery.
According to EEA on climate change, impacts and vulnerability in Europe (EEA, 2012), "soil erosion rates and extent are expected to reflect changing patterns of land-use and climate change. Variations in rainfall patterns and intensity and in storm frequency and intensity may affect erosion risk either directly, through the physical displacement of soil particles, or indirectly, through removing protective plant cover".
However, reliable quantitative projections are currently not available. Soil erosion hotspots are identified when the location is most likely to be vulnerable for soil erosion and when there is an increased variation in rainfall pattern and intensity. This will make soils more susceptible to water erosion, including the off-site effects of soil erosion increasing (EEA, 2012).
The map of soil erosion by water was calculated by the Revised Universal Soil Loss Equation (RUSLE). The data presented were validated through comparisons with national datasets and expert judgement. The model did consider localised intense precipitation (EEA, 2012).

2.2. Inland and coastal flood Risk (Figure 5 and 6 in Annex I)

Global warming and changes in rainfall patterns and intensity are projected to identify increases the occurrence and frequency of flood events in large parts of Europe. These projections remain highly uncertain.
The river flooding risk that has been identified across EU may not necessarily match all recent flooding events. In regions with reduced in snow accumulation during winter, the risk of early spring flooding would decrease. Flood risk hotspots are identified through comparison of areas where floods occurred in the period 1998–2009 with projections of flood occurrence.

Coastal zone flooding and erosion is due to expected sea level rise in combination with low lying land mostly in delta areas across Europe and in combination with poor infrastructures to protect land from flooding at high water and sea level rise. Physical damage to land and infrastructures may be expected in addition to impact on agricultural (and other) land through saline intrusion and salinization of land used for agricultural production. No specific data are available to identify areas at risk and hotspots under this threat.

2.3. Forest Fire Danger (Figure 7 and 8 in Annex I)

Climate change projections suggest substantial warming and increases in the number of droughts, heat waves and dry spells across most of the Mediterranean area and more generally in southern Europe. These projected climate changes would increase the length and severity of the fire season, the area at risk and the probability of large fires, and possibly enhance desertification.
Forest fire hotspots are identified on the basis of two maps with projections on vulnerability for forest fires in 2070-2100, expressed as the Seasonal Severity Rating (SSR).

3. Rural economic resilience (3) with focus on tourism (Figure 9, 10 and 11 in Annex I)

Projections suggest that the attractiveness of the Mediterranean for tourism will decline during the summer months, although this may increase in spring and autumn. “Climate change could benefit the Mediterranean tourist industry if it evens out demand, reducing the summer peak while increasing occupancy in the spring and autumn” (SOER-Environmental Outlook 2010). Nevertheless without such tourism shifts, the Mediterranean tourist industry could be vulnerable of climate change as for many Mediterranean regions the tourism is a very important for their economy (SOER-Environmental Outlook 2010).

It is projected that the snow‐ cover in much of Europe will be reduced over the 21st century. This will affect the winter sports industry across Europe. “Responses are already in place, including artificial snow-making, and this has increased in recent years. However, adaptation options pose sustainability and environmental issues such as water use by snow‐ machines negatively affects current water resources, energy use and associated GHG emissions, all of which need to be assessed” (COER-Environmental Outlook 2010).

For identifying the tourism hotspots, two maps with projections on effects on summer and winter tourism respectively were used; Projected changes in summer tourism (2071-2100) and projected changes in snowfall days (2041-2070).

Mitigation hotspots

4. Land use and land use change and forestry and deforestation.

There are expectations that climate change has an impact on soil carbon in the long term. Changes on soil carbon in the short term will most likely be driven by land management practices and land-use change. These rapid changes can mask the evidence of direct climate change impact on soil carbon stocks. The effects of climate change on soil are complex and generally lack rigorous supporting datasets.

4.1. Organic and peat soil (Figures 18 and 19 in Annex I)

The "organic soil and peat soil" hotspots were identified by a map with data of European Soil Database 2003 provided by Joint Research Centre (JRC) (EEA, 2012). Changes in the short term and losses of organic matter and CO_2 emissions are caused by cultivation and drainage of these soils and will most likely be driven by land management practices e.g. (continued land use or additional land use change with new) drainage and cultivation of peat soils and soils with high organic matter contents. CO_2 emissions from peat soils and liming are high for regions in northern Europe with peat soils and a region in Hungary.

4.2. Topsoil organic carbon

Mineral topsoils with high soil organic carbon contents are potential hotspots. Specific farm and intensive soil management with tillage or harvesting of tuber and root crops will result in losses of carbon and CO_2 emissions. The topsoil organic carbon hotspots were identified by a map with a data source of European Soil Database 2003 provided by Joint Research Centre (JRC) (EEA, 2012). The CO_2 emission from SOC stock changes is highly diverse. In specific areas stocks remain equal or slightly increase due to implementation of specific mitigation measures on soil management and agricultural land abandonment over the period 2000-2010. In other regions carbon is lost from the soil due to land conversion for agricultural expansion or converting permanent systems to cropping areas or (continued) intensive soil management in specific cropping systems. There is no information on identification of the scale or location of such land use (change) and management across Europa. JRC has recently updated soils information from its LUCAS study and this study does provide only one measurement in time.

4.3. Land use and land use change and deforestation

Land use change will impact carbon stocks in soils and carbon stocks in vegetation. The loss of permanent vegetation and conversion to cropland does result in CO_2 emissions.

Deforestation is likely to contribute to CO_2 emission from organic carbon losses from soils as well as from loss of carbon stocks in biomass (wood). Nabuurs et al. (2013) have analysed the European Forest area dynamics and conclude that the growth in European Forest area is declining over the last two decades from net expansion of 400kHa to 300 kHa. They note that the gross expansion of Forest is partly countered by gross deforestation yet this remains unnoticed in statistics. Deforestation in Europe is characterized by small and scattered events according to Nabuurs et al. (2013). Variations across Member States in Europe is significant and specific data on land use are available from a database Corinne Land Cover 1990-2006 Changes for Europe (EEA, 2012). Every hectare of deforestation means an immediate and significant loss of carbon that can only be compensated for by reforestation and long time periods as re-growth is generally slow. Nabuurs et al. (2013) outline a diverse set of actions and measures to combat losses of carbon from deforestation and forest management to conserve carbon stocks and prevent losses from disturbances.

Land use change in agriculture e.g. converting pastures and permanent grassland to arable land (with more or less intensive soil management and tillage operations) will result in losses of soil organic carbon and CO_2 emissions. The reverse, changing land use from cropland to pasture and grassland will store more carbon as organic matter in soils and remove CO_2 from the atmosphere as will afforestation or reforestation do.

5. Agriculture and greenhouse gas emissions

The combination of agricultural activities results in emissions of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). For CH_4 and N_2O the pattern is more or less similar, with high emissions in the livestock intensive regions and related to feed conversion via enteric fermentation of specific species of animals e.g. ruminants (dairy and beef cows, goats and sheep) and in the those sectors where synthetic fertilizers and manure are applied in the field or urine and manure is produced while grazing.

5.1. Animal production systems with CH4 emissions (Figure 12, 13, 16 and 17 in Annex I)

The maps on CH_4 emissions show the spatial distribution of the GHG emissions from the different sources and activities These are linked to livestock production in mostly ruminants (milk and beef production in cows, sheep and goats) and storage of any animal wastes and manures. The highest emissions are from enteric fermentation. Relative emissions of methane are related to feed quality, feed quantity and whether or not animals are grazing or kept and fed inside. Relative emissions of methane do vary with set-up and quality of manure storage systems. This variation in sources across regions in Europe is not reflected in most emission calculations at Member States level.

The CH4 emissions from EU agriculture are approximately 60% of the total agriculture related emissions of non – CO2 greenhouse gases methane plus nitrous oxide.

5.2. N_2O Emissions from agriculture (Figure 14, 15, 16 and 17 in Annex I)

The maps show the spatial distribution of the GHG emissions from the different sources and activities. For N_2O the pattern shows high emissions in the intensive cropping regions where synthetic fertilizers are applied and in those (intensive) livestock areas where manure and fertilizers are applied to land or intensive grazing with urine and manure in pastures is practiced or where manure is stored in manure storage facilities before applying it in the field or elsewhere.

5.3. CO_2 emission from fossil fuel use in agriculture

Agricultural activities require use of energy for cooling and heating, land use and transport. The energy use in agriculture and related emissions are not identified and reported separately from energy use in other sectors and generally are much lower than the emission of non – CO2 greenhouse gases methane and nitrous oxide. Contribution via production of renewable energy from biomass and other sources are discussed below.

6. Renewable Energy to substitute fossil fuels

The contribution to reduction of CO2 emissions from the use of fossil fuel is via substitution by renewable energy. The production of renewable energy is based on land use and biomass production and processing (biodiesel and bio-ethanol, incineration, anaerobic digestion or gasification) and from other sources e.g. animal waste en manures (anaerobic digestion). Land based emissions of CO2 and N2O for the range of biofuels and bio-energy from specific sources is not available at the level of detail required for this study.

Further contributions are expected from setting up installations in rural areas for generating wind and photo voltaic solar energy.

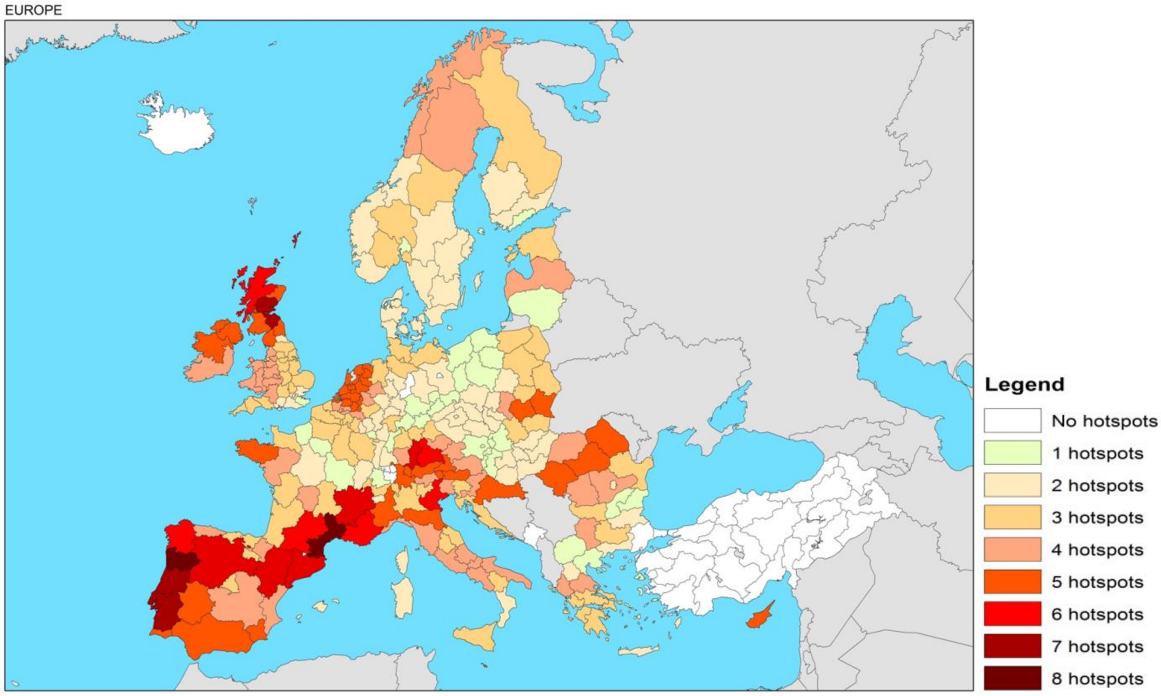

Figure 4: Regional distribution of a total of 6 generic hotspots with a total of 9 detailed hotspots accounted for as outlined in table 3 for 28 EU Member States at NUTS2 level.

Table 3. Hotspots identified in Europe for 28 MSs individually. The Hotspots have been defined in table 2 of this report and the background information is listed and referenced in Annex I; this Annex I also identified how the expert based hotspot identification has been completed and what sources have been used in doing so n.a. is No Data available; the cell colour red refers to more severe impact than impact in orange cells.

	Adaptation						**Mitigation**				
	Water limited crop yield and forestry production	Non – water limited crop yield and forestry				Rural Economic Resilience	Land use and Land Use Change and deforestation.	Agricultural GHG emissions			
Countries	**Crop yield-water limitation**	**Soil erosion**	**Flood risks**	**Pests and Crop Diseases**	**Forest Fire**	**Tourism**	**Topsoil organic**	**CH4 Emissions agriculture**	**N2O Emissions agriculture**	**Renewable Energy**	**Total Hotspots**
Austria				n.a.		yes	yes	yes	yes	yes	5
Belgium			yes	n.a.				yes	yes	yes	4
Bulgaria	yes		yes	n.a.		yes					3
Croatia	yes	yes	yes	n.a.		yes		yes			5
Cyprus	yes			n.a.	yes	yes		yes		yes	5
Czech Republic			yes	n.a.						yes	2
Denmark				n.a.				yes		yes	2
Estonia				n.a.	yes	yes	yes				3
Finland			yes	n.a.		yes	yes				3
France	yes	yes	yes	n.a.	yes	yes	yes	yes	yes	yes	9
Germany			yes	n.a.	yes		yes	yes	yes		5
Greece	yes			n.a.	yes	yes		yes	yes		5
Hungary			yes	n.a.		yes					2
Ireland				n.a.			yes	yes	yes	yes	4
Italy	yes	yes	yes	n.a.	yes	yes		yes	yes		7
Latvia				n.a.	yes	yes	yes			yes	4
Lithuanian				n.a.		yes					1
Luxembourg				n.a.				yes	yes		2
Malta	yes			n.a.		yes		yes	yes	yes	5
Netherlands			yes	n.a.			yes	yes	yes	yes	5
Poland		yes	yes	n.a.	yes	yes	yes		yes	yes	7
Portugal	yes	yes		n.a.	yes	yes		yes	yes	yes	8
Romania		yes	yes	n.a.	yes	yes	yes				5
Slovakia		yes	yes	n.a.		yes					3
Slovenia	yes	yes		n.a.		yes		yes			4
Spain	yes	yes	yes	n.a.	yes	yes	yes	yes	yes		8
Sweden		Yes		n.a.		yes	yes				3
UK		Yes	yes	n.a.		yes	yes	yes	yes	yes	7

RDP Measures

This part (task 3) establishes which RDP measures under various focus areas in the draft European Agricultural Fund for Rural Development (EAFRD) would be most fitting to address the climate hotspots in the Member States. This then will and has been be used in the production of a set of 28 briefing documents targeting individual Member States (in task 4). One briefing document is included and provides an example for the outline and structure of these documents (and a set of 5 briefing documents has so far been made available to DG CLIMA).

Outline of the briefing documents

- Executive summary
  1. Background
     - Climate data
     - Agriculture
     - Environment
  2. Climate Hotspots
     - Description
       - Climate mitigation hotspots in relationship to agriculture and rural areas
       - Climate adaptation hotspots in relationship to agriculture and rural areas
  3. Rural development programme potential
  4. Expected impacts and implications for expenditure
     - RDP 2007-13
     - Potential implications for RDP funding 2014-20

For each Member State, an analysis is made of the relevant measures under various focus areas for each of the 6 climate hotspot identified to complete sections 3 and 4 of the briefing documents. Sources that are consulted include: CAP health check factsheets, RDP statistics produced by Eurostat for the Commission, including spending by MS, local MS information drawn from scientific studies, mid-term evaluations of 2007-13 RDPs, the RuDI framework study, OSCAR project data, information from the Climate-adapt pages of the EEA, and locally-relevant RD indicator sources and contextual information.

The project has identified hotspots at the national MS level in task 1 and 2. This has been done at NUTS_2 level for emissions and mitigation and at national level (or at Federal states levels where averaging across regions will be used), resulting in one briefing document per MS (task 4). The activities that are carried out included: i) selection of potential measures, ii) search for measures that are currently carried out in RDPs and iii) description of potential and current measures, defining the shortfall that the new programmes should seek to address.

Results

We present for each of 6 generic hotspots and 12 specific hotspots a list of RDP actions that can be funded and a list of relevant measures and their intended purpose in relation to their causal relations with climate change. The formal references to the Measures' Article Numbers under the EAFRD regulation are provided as well. Table 4 summarises at a generic level, the interaction between proposed RDP measures and climate change issues and within each briefing document, the most appropriate delivery strategies are also discussed in more detail. Attention is paid to coordination with other funds.

Furthermore, expected impacts and implications for expenditure are discussed by considering the performance of RDPs 2007-2013, assessing its potential implications for RDP funding 2014-2020 in each of the briefing documents.

The following section gives a step-by-step guide to the role of the briefing documents and how they can best be used to assess the adequacy of future RDPs in respect of climate change actions. We recommend that anyone using the briefing documents should read this guidance first.

Briefing documents: their purpose, structure and interpretation

The briefing documents are designed to enable the reader to gain a swift understanding of some of the key context, challenges and opportunities to address climate adaptation and mitigation, through Rural Development programming. Context information helps to explain why certain conditions exist in the territory, and these will affect the relative applicability and efficacy of different RDP measures and delivery approaches. Details of the key climate adaptation and mitigation hotspots for the Member State highlight the specific challenges that RDP measures and actions can seek to address and some opportunities that they can seek to capture through funding. Finally, a consideration of RDP experience to date, in respect of tackling climate change goals, can provide valuable information about the lessons learned, achievements made and/or gaps identified, in that process; thereby suggesting appropriate next steps for the new RDP.

The structure of the documents thus follows this logic.

An ***executive summary*** condenses the most critical background information on the context for RDP action; lists the main hotspots identified for mitigation and adaptation and summarises the types of RDP action and measure that are therefore suggested for the new RDP.

The ***background*** section gives key data and helpful web-links and references to enable assessment of:

- Member State emissions of GHG; targets for the Effort-sharing agreement concerning emissions reduction at the EU level to meet its 2020 target; and national-level targets for GHG reductions and renewable energy generation;
- key characteristics of the agricultural and forestry sectors and the rural areas in the Member State which influence RDP measures' applicability and relative efficacy – such as farm structures, the extent and quality of human capital, efficiency and outputs, environmental quality, and the dependence of the rural economy upon certain sectors, which will affect its resilience.

In using the background section, the agricultural information gives an idea of key structural features that will affect the relative attraction of different RDP measures, in this country. For example:

- for larger farms, agri-environment payments can be an attractive option for introducing management to assist with adaptation or mitigation actions, whereas for very small farms the transaction costs of negotiating such payments may outweigh their financial benefits;
- although investment aids to private beneficiaries can in theory prove attractive to both small and large farms, very small farms may have difficulty preparing business plans and/or attracting match-funding, which may imply either a need for financial engineering or funding for advisory services to help overcome these issues;

- collective or public sector investment funding for infrastructure may be particularly appropriate where farm structures are small and farmers lack high levels of education or training; and/or support for co-operation may help to make climate action more strategic and more feasible for large numbers of small holdings;
- training is likely to be most valuable in situations where farmers do not already have high levels of education, but the delivery method will need careful design to ensure that it is attractive and accessible to targeted beneficiaries.

The hotspots section presents the selected hotspots relevant to that Member State, from among a longer, generic list of hotspot types drawn up as appropriate for all EU-28. These are divided into hotspots for adaptation, and hotspots for mitigation actions. These hotspots identify which Climate issues are most important for this Member State to seek to address, particularly thinking about the potential sphere of influence of RDP actions and measures and bearing in mind the relative importance of that Member State's own climate targets and their agreed contribution to meeting EU targets.

The ***Rural Development Program Potential*** section contains three main elements:

- A short section reviews what the state of play is, in respect of using RDP funding to address climate actions to date;
- A second substantive section links the hotspot types to a generic selection of appropriate potential RDP actions and measures (see table 4). For each hotspot type, the most appropriate actions that can be supported using RDP funding are identified and listed, and then the relevant RDP measures and their purpose are matched to these actions. These details are extracted from the generic table as appropriate to each MS, noting the regional differences that also apply in the case of specific hotspot types, and this information is used to compile the tables 3.1 and 3.2 in the briefing document. In this process, key background and context information may also be used to tailor some of this information to the particular situation of each Member State;
- A final section notes key points concerning what would appear to be optimal delivery strategies for achieving climate action within the RDP, again bearing in mind the contextual information from the background section, as well as the lessons from the RDP state of play.

The first of these elements is important for several reasons. Knowing the relative scale of RDP funding in previous programme periods, compared to CAP pillar 1 funding, gives an idea of the likely perceived importance of RDP as an aid to achieving climate action, as opposed to other options such as the greening and cross-compliance options within Pillar 1; and/or the use of ERDF and ESF funding. Then, to assess the scope for action under the new RDP 2015-2020; it is relevant to know what was done for climate in the 2007-2013 period, considering both the planned scale and scope of action, and the available evidence on actual achievement in this respect. It is quite likely that for some Member States, a strong climate action plan for the 2007-2013 period may well not have been achieved in practice, due to external circumstances such as the impact of the global recession, and/or problems with absorption of funding due to complex delivery approaches and high transaction costs for beneficiaries.

The tables 3.1 and 3.2 are designed to summarize the key ingredients that officers should be looking to identify within draft RDPs, including which measures and which kinds of action appear most appropriate for addressing climate hotspots – the priority climate issues for that Member State (MS). The supporting notes on delivery suggest where there are specific design features for RDP funding that might help to ensure effective roll-out of these measures and actions, across the territory of the MS.

The tables 3.1 and 3.2 have considered all the main measures in the EAFRD which could be useful for climate actions. In addition, Member States should be aware of the potential to use LEADER funding to support small-scale developments similar to those that are already indicated for investment, basic services and co-operation funding, as well as training and advice. Furthermore, in all actions where some capacity for experimentation and learning with farmers and rural communities could be beneficial (e.g. in improving resource efficiency, soil management or new types of rural renewable energy provision), Member States should consider these as potential topics for the new EIP - European Innovation Partnership; and facilitate the building of appropriate connections between local areas and stakeholders and research organisations, to establish these.

Table 4 List of (6) Generic Hotspots and (12) specific hotspots with descriptions on the causal relationship with climate change, the RDP action that can be funded and a list of relevant measures and their intended purpose with the reference Measures Article Numbers under RDP.

Hotspot ADAPATION	Description of the hotspot, causal relation with climate change	RDP – actions that can be funded	Relevant measures and their purpose	Measures: Article numbers
1 Water-limited crop yield and (forestry) production	The effect of climate change on the impact of water limitation on crop yield varies across Europe. This can either lead to a positive or a negative effect. Yield production will decrease most in the Mediterranean region: a negative impact of -25 to -5%. The hotspots are not crop specific and show an overall picture where the yield production is most vulnerable to climate change.	• Action to increase the efficiency of water use in agriculture; and • action to increase the capture of rainwater, to reduce reliance on groundwater aquifers. • Action to switch cropping towards varieties and crops or stock with drought tolerance or no/low requirement for additional water supply; • action to reduce water use in livestock systems • Action to recover water from farm holdings by capture, storage, cleaning and recycling.	Investment in water-saving equipment; Training in state of the art technologies and practices; Advice on reduce and make more efficient on-farm water use; Investment in more efficient water infrastructure (reservoirs, pipes) Investment in breeding/testing novel crops and stock, research and demonstration Investment in water capture and recycling systems on farms Support for co-operation in new collective institutions for enhanced water planning and management	14 15 17 types a, b and c 35
2 Crop yield limited by other factors (diseases, storms)	Yield losses may be caused by weather events such as hail storms during the growing season, windfall in crops from storms and impacts from frost during or after flowering in crops or wet conditions preventing harvest in autumn or so called phenological shifts. Impact may result from changes in patterns and intensity of occurrence of pests and diseases affecting crop establishment or yield and harvestability of crops. No comprehensive EU level datasets are usable for this hotspot type, but it can be tracked to some extent using hotspot data for storms (see below)	• Action to reduce incidence of anticipated losses due to disease epidemics • Action to improve biosecurity measures • Action to reduce damage to crops and livestock from extreme weather events e.g. heat stress, heavy rains/storms; or to help farmers to cope with the aftermath	Training and advice on disease control strategies Early warning systems for diseases and extreme weather events Training and advice on practices to minimise damage from unexpected events Farm, forestry investment to enable adoption of improved resilience business technologies Funding to cope with impacts of unexpected events Crop and animal insurance or other risk management instruments Support for co-operation to establish new partnerships to improve resilience planning and monitoring	14, 15 15, 17 type c 19 14, 15 17 type a, d 24 36-39 35

2a Soil erosion Due to water, wind, extreme weather events	A map of current soil erosion by water was used to estimate which regions are more likely to be vulnerable in future. Climate change will trigger increased variation in rainfall pattern and intensity, making soils more susceptible to water erosion. Variations in storm frequency and intensity may affect erosion risk directly, through the displacement of soil particles, or indirectly, removing protective plant cover. A second threat is erosion through wind; and storms - often coinciding with more intense precipitation – leading to increase in losses of soil via erosion. Cultivated slopes and mountainous terrain will face enhanced risk.	• Action to reduce soil erosion by adopting conservation focused crop production techniques – minimum-till, cover crops, undersowing, rotation to decrease bare soil, etc. • Action to restore or create landscape features which prevent erosion – walls, terraces, hedgerows, buffer strips alongside watercourses, in-field grass strips, woodland areas or shelterbelts, silt capture structures, rainwater channelling away from crop fields • Action to reduce erosion from compaction/poaching on grazed land: sub-soiling, reduced stocking densities, improved stock management to reduce concentrated overgrazing/poaching • Action to reduce erosion from recreational use of land – spreading visitors more thinly, restoring paths • Action to build up soils: composting, organic matter addition, other novel techniques	AEM-climate actions to practice more soil-conserving techniques of in-field management, including organic farming Non-productive investment in landscape features Investment in agricultural infrastructure to manage or reduce soil sediment transfer Afforestation of private or public land in suitable locations, and sensitive forest management Renewable energy cropping with short-rotation species that will stop soil sediment reaching water courses Training, information and advice on crop management for soil conservation Training, information and advice on stock management for soil conservation AEM Payments to reduce stocking levels on sensitive sites and/or to use more labour to manage grazing Investment aid for pathway restoration and repair, signage and creation of alternative routes across land Investment aids for composting facilities, safe FYM handling and re-use, Investment in soil conserving equipment (e.g. subsoiler, soil injection equipment, min-till equipment) Support for co-operation to establish groups of farmers to organise and carry out investment programmes in areas defined as 'at risk'	28 29 17 types c, d 22 25 19 14 15 28 20 17 type a or b 35
2b Flood Risks	Global warming is projected to intensify the hydrological cycle and increase the occurrence and frequency of flood events in large parts of Europe. However, estimates of changes in flood frequency and magnitude remain highly uncertain. In regions with reduced snow accumulation during winter, the risk of early spring flooding would decrease.	Actions to manage floodwater flows: sacrificial areas, channels, subterranean storage Actions to reduce incidence of flooding by upstream land management: - Conservation practices for grazing livestock - Tree planting - River restoration works - Re-creation of wetlands - Changes to field drain systems - Construction of dykes etc. - Continuous crop cover, - restrictions on cultivation of steep slopes	AEM to support sacrificial area creation AEM to support wetland management Investment aid to create channels and other infrastructure (public or private) AEM for enhanced grazing livestock management to reduce soil compaction and erosion Non-productive capital investment for tree planting or buffers Afforestation aids and aids for sensitive management Co-operation to enable groups of farmers to take collective, planned actions in sensitive areas Training, information and advice to support implementation works	28,25 30 17 type c, a 28 17 type d 22, 25 37 14, 15

2c Forest Fire Danger	The projected increased number of droughts, heat waves and dry spells due to climate change, will affect most of the Mediterranean area and more generally across southern Europe. These projected changes would increase the length and severity of the fire season, the area at risk and the probability of large fires	Actions to conserve water/moisture in soils and vegetation, creation of reservoirs Education for visitors to drought-prone areas concerning fire risks and how to avoid them Wardening – early warning systems - to reduce risk of fires spreading Creating fire-breaks in vulnerable vegetation types Fire fighting equipment installed as required Managed burning to reduce severity of uncontrolled fires	AEM for water-conserving actions on farmland and semi-natural vegetation AE-forest payments for water-conserving actions in woods, or for restoring forests damaged by fire Investment aid for reservoirs Project funding for notices, guides, training and advice on how to minimise fires; controlled burning Funding for co-operation to plan and manage fire avoidance, among groups of landholders Funding for wardens Investment aid for infrastructure (fire-breaks) Investment aid for fire-fighting equipment installed on farm or forest land	28, 30 34, 24 17 type a,c 19, 20 37 15 17 type a,c 17 type a, 25
3 Rural economic resilience – noting especially tourism	The temperature in the summer period will likely increase most in the Mediterranean area; meaning more and extended periods of drought in Summer. This is expected to render the Mediterranean area less favourable for tourism in summer, but may extend the tourism period into spring and autumn. Projections of reduced snow cover days in winter periods in northern (and central) Europe are up to 40–70 days in 2071–2100 compared to the baseline period 1961–1990. There will also be reductions in snow mass in Europe. This will be likely in Switzerland, the alpine range of Italy, the Pyrenees, and Balkan mountains. These changes will make winter tourism vulnerable as activities strongly depend on snow cover.	Action to discourage new tourism or other rural business investment in areas where hotspots suggest that the opportunities for this type of growth will be significantly limited in future. Action to promote venues for tourists outside the main summer or winter seasons Water-conserving actions for rural tourism operators and SMEs in heat-stressed locations. Action for new rural businesses designed to change the tourism or rural business offer to make it more climate-friendly (seasonal shift, modal shifts, different market niches) Actions to help summer or winter tourism businesses to research and develop alternative offers/outputs for new markets and clients Support for alternative rural businesses for areas where current tourism will decline due to lack of snow cover or too much heat. Help to diversify and add value to farm and forestry products, as an alternative income source for former part-time farmers whose other income was from tourism, in these areas. Actions to expand the (sustainable) leisure sector for local residents, where viable, as an alternative to tourism	Aid for rural business start ups Aid for business marketing and development Aid for tourism business training, advice Aid for environmental audits of rural businesses to reduce water use Investment in promotional campaigns and consumer education and awareness-raising Aids for processing and marketing of farm products Co-operation aids to help farmers and tourist sector actors to work together to plan and develop a new tourism offer which is more in line with climate capabilities Investment aids for water-conserving landscaping on and around tourist facilities	19 17 type b 14, 15 15 17, 20 17 type b 37 20

MITIGA-TION	Description of the hotspot, causal relation with climate change	RDP – actions that can be funded	Relevant measures and their purpose	
4a Agriculture and forestry land use and land-use change: Topsoils with high organic carbon	Areas and soils with high top soil organic carbon contents are identified as hotspots. There are expectations that climate change (warmer and drier) will impact soil carbon in the long term and enhance loss of peat and organic matter and lead to emissions of CO_2. Mitigation can be effected by land management practices to conserve and build organic matter e.g. re-wetting, ceasing cultivation, adding carbon/OM .	Actions to protect existing large areas of high-carbon soils (peat) Action to revert arable land to permanent cover, to protect soil carbon Action to create or restore wetlands to protect carbon-rich soils	AEM/water framework/Natura2000 payments to restore and protect wetlands for conserving carbon-rich soils Reduced stocking and more careful management of livestock to reduce erosion threats on high OM soils (reducing poaching) Training and advice in techniques to reduce erosion by livestock or cropping practices AEM payments to adopt cropping practices to reduce erosion of high OM soils eg continuous cover, winter green manures AEM payments or investment buy-outs to cease cropping the most valuable OM/Carbon-rich soils	28,29,30, 28 or 29 14, 15 28 28, 30, 17 type c
4b Agriculture and forestry land use and land-use change: mineral topsoils	Mitigation can be effected by land management practices to improve soil structure and health, building organic matter e.g. ceasing cultivation, reducing compaction, adding carbon/OM	Actions to build soil carbon, through modified farming practices or conversion to organic farming Equipment to enable injection of soils with carbon-rich substances (biochar), and other experimental techniques with similar aims	Training in techniques to increase soil carbon Advice on management practices to conserve or build soil carbon AEM-climate payments to adopt novel carbon-building/conserving management techniques in farming Organic farming payments Forest AEM to adopt carbon-building management in woodlands Investment in equipment to enable soil carbon charging with biochar and similar EIP groups to experiment with novel approaches to soil carbon building/restoration	14 15 28 29 34 17 type a, c, d EIP
4c Agriculture and forestry land use change: changes in permanent land cover including forests	Loss of permanent vegetation results in CO_2 emissions. Deforestation will contribute to CO_2 emission from soils as well as from loss of carbon stocks in biomass (wood). Farm land use change e.g. converting pastures and permanent grassland to arable land (with more or less intensive soil management) results in losses of soil organic carbon and CO_2	Pay farmers to take land out of cultivation and put either under trees, or into permanent vegetation cover types. Loss of permanent pasture and forest is generally regulated now or covered by CAP pillar 1 cross-compliance conditions, so it is not generally appropriate to use RDP resources to finance actions to prevent ploughing of pastures or clearing of forest.	Agri-environment-climate measures to create permanent vegetation on former cropped land. Afforestation aids to take land out of farming and plant with/create new areas of forest Agri-environment-climate measures to adopt new farming systems which replace annual crops with permanent vegetation types (e.g. agro-forestry, orchards with permanent grass underneath), possibly farm and business development aid to enable these changes Non-productive investment to take land out of annual cropping and create ponds or other non-productive features	28 22 28 23 25 19 17 type d

	emissions. Changing land use from cropland to pasture and grassland will store more carbon as organic matter in soils and remove CO_2 from the atmosphere as will afforestation or reforestation.			
5a CH_4 Emissions agriculture[1]	Emissions of methane are linked to animal production and animal wastes and manures. Highest emissions are from enteric fermentation related to feed quality, quantity and whether or not animals are grazed.	Actions to promote more efficient feeding, to reduce methane losses per animal Action to store and use methane from farm animal wastes and manures in renewable energy production, Action to reduce the number of stock kept on farms, either by increasing efficiency of marketable output per animal and/or simply reducing production as part of a strategy for greater sustainability, along with diversification/adding value.	Investments in new equipment for analysing and adjusting feed components, among livestock producers Training and advice on improved nutrition for reduced methane production Investment in better storage and handling facilities for manures, to reduce, capture and re-use methane emissions (e.g. in power) AEM to reduce stocking on certain kinds of farm Investments to improve efficiency in livestock production Organic farming (will reduce stocking rates) Support for cooperation to form groups to tackle this issue	17 type a, c 14, 15 17 type a,c 28 17 type a 29 37
5b N_2O Emissions agriculture	Sources for emissions of nitrous oxide are linked to specifically the storage and application of animal manures. Emissions from manure and urine during grazing are highest and depend on N content. Further emissions of N_2O are related to synthetic fertilizer application and depend on fertilizer type and amount.	Same as for methane emissions from agriculture, PLUS Actions to reduce over-use of chemical fertilisers on crops, increase use of organic wastes, adopting more rational / integrated crop management techniques	As above cell, plus Training and advice in rational input use on cropped land and soils testing and management Soil testing equipment Equipment to enable tailoring of input use more precisely to soil conditions and crop requirements (e.g. fertigation, early warning systems for trace elements) Support for cooperation to enable groups of farmers to experiment and learn together, how to reduce unnecessary use of chemical inputs in crop farming	14, 15 19, 17 type a or c 37
5c (Heavy) use of fossil fuels in agriculture	Agriculture can require use of energy for cooling and heating, land use and transport. Energy use in agriculture and related emissions are not identified and reported separately from energy use in other sectors and generally are much lower than the emission of non–CO2green-house gases, but intensive horticulture and indoor livestock may imply hotspots.	Fuel efficiency actions among farming and forestry businesses Fuel efficiency actions among rural community facilities and other rural businesses Insulation and heat recovery/exchange systems to reduce fuel use for these functions Adoption of renewable energy generation (see next hotspot)	Training and advice in how to reduce energy use Agricultural investment in energy-saving equipment: insulation, heat exchange systems Non-agricultural investment in energy-saving equipment and systems Infrastructure to help link rural energy users to local renewable sources Support for co-operation to establish groups to plan and implement these changes	14,15 17 type a 19 17 type c 36

6. High potential and low current generation of renewable energy in rural areas	Where Member States have a relatively higher dependence than others upon oil, gas or coal for current energy needs and have yet to make a serious investment in renewable energy generation; there may be scope for rural development to make a significant contribution to climate mitigation action via encouraging rural businesses to help contribute to the growth in renewable energy generation.	Scope to encourage significant increase of renewable energy generation in connection with farming and forestry businesses – either from solar, wind, AD plants or micro-hydro generation, or those few sustainable/efficient biofuels options Scope to encourage more energy self-sufficiency among relatively isolated rural communities, via generation using renewables and funding for rural community heating and CHP systems and their infrastructure	Training and advice for farmers and foresters in options for renewable energy generation Investment aids for private development of renewable energy generation on farms or woodland sites Investment in public or community-owned renewable energy generation facilities Investment in energy distribution infrastructure to enable small-scale renewable generators to have access either to a national grid, or to local users (e.g. rural community heating or CHP schemes) Investment for rural community facilities to install renewable energy heating/power systems Advice and training for non-farming/forestry rural businesses to help them to assess and adopt renewable energy heating or CHP options.	15 14 17 type a 19 20 17 type c 25, 26 20 14, 15

[1] A reconsideration of the sustainability of intensive livestock systems may be warranted in those regions where intensive indoor cattle and dairy production could be limited by summer drought and/or increased spring flooding in their fodder production areas. Greater efficiency in GHG emissions can be achieved by improved nutritional and waste management but there may also be circumstances where innovative and more extensive approaches bring life cycle benefits for climate mitigation. Further research and development in this area, notably in combining EAFRD with Horizon2020 funding, would seem worthwhile.

Conclusions and reflections

In this section we conclude and reflect on a series of issues which appeared so far during the execution of this study:

- we have identified via expert knowledge a series of hotspots for climate change at Member State and NUTS2 level and this analysis shows substantial variation in the number of hotspots per across regions and Member States in Europe
- we have had difficulties of sourcing good data as many studies don't make their underlying datasets available or datasets cannot be assessed in the scientific literature
- we have identified several studies and tools that would allow stakeholders and member states to perform their own assessment of vulnerabilities to climate change; from these studies (e.g. Oscar) no integrated assessment of such EU wide vulnerability is available that could form the basis for our identification and analysis of climate hotspots
- as a result, the analysis on hotspots for issues that arise from impact from climate change or from emissions and removals of greenhouse gases with impact on climate change has therefore been qualitative in most cases and completed by expert judgment on the basis and linked to referenced studies
- the challenge of assessing progress to date with RDPs when climate change is insufficiently covered in the available evaluations
- the obvious risk of over-simplification when documents have to cover a whole member state's territory in only 10-15 pages
- resources to the study were too limited to make a thorough analysis of the experience of climate actions within existing RDPs nor of the significance to rural areas of climate actions taking place in other sectors beyond agriculture and forestry (e.g. wider investment in renewables from biomass and in particular other sources of renewable energy).

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ANNEX I Assessment of literature

This Annex I does list the results from the literature review of most relevant sources (part A on literature review) and identifies the data and maps on hotspots that have been used in this study (part B).

Part A Results from our literature review on relevant studies for identification of climate hotspots

Literature Review Matrix	Conclusion on the study	Purpose of study	Definition on hotspots & vulnerability	Perspective of the study	Data
ESPON Greiving, S., M. Fleischhauer, C. Lindner, J. Lückenkötter, L. Peltonen, S. Juhola, P. Niemi, J. Vehmas, S. Davoudi, and E. Achino. 2013. ESPON CLIMATE-Climate Change and Territorial Effects on Regions and Local Economies. The ESPON.	Not specifically on rural development but there are maps or graphs that can be used for rural development.	Most of the existing vulnerability studies have a clear sectorial focus, addressing very specific potential impacts of climate change on single elements of a particular sector. The existing studies have so far not employed such a comprehensive methodological approach. Therefore, the ESPON Climate project developed a new comprehensive vulnerability assessment methodology and applied it to all regions across Europe in order to create the evidence base needed for a climate change responsive European territorial development policy	There is no definition on hotspot. Vulnerability to Climate: The exposure to climate together with physical, environmental, social, cultural and economic sensitivity of a region, determine the possible impact that climatic change may have on a region. A region might be able to adjust in the future. This adaptive capacity enhances or counteracts the climate change impacts and thus leads to a region's overall vulnerability to climate change.	The definition is based on vulnerability framework of Fussel and Klein, 2006 The paper explains climate change vulnerability based on IPCC and show the related key concepts through a diagram. The paper focuses on the evolution of climate change vulnerability assessments, in particular as reviewed by the Intergovernmental Panel on Climate Change (IPCC).	In the report there are many maps and graphs related to climate impacts and vulnerability in Europe, MS and region, baseline and for the future. Not specifically on rural development but there are maps or graphs that can be used for rural development. The website has a map finder-menu. The maps showed in the report, have baseline and future scenarios.

OSCAR Optimal design of climate change policies through the EU's rural development policy 071201/2011/609681/SER/CLIMA.A.2	A tool for Member States to identify hotspots and to support the development of RDP measures that optimally address climate change objectives post-2013.	The aim of the project was to develop guidance for Member States to support the development of RDP measures that optimally address climate change objectives post-2013. (Guidelines OSCAR) According to PowerPoint presentation for EC: The principal aim of the project is to produce a manual and checklist on "optimal design of climate change policies within Rural Development Policy" for Member States.	Hotspots: Spatial areas and/or processes within rural enterprises, in which there is significant scope for GHG mitigation and/or significant issues with respect to adapting to projected climate change.	the conceptual framework to assess the climate change impacts of rural development measures and operations. This included a Life Cycle Assessment (LCA) based approach to assessing greenhouse gas (GHG) emissions and carbon sequestration, the development of a completely new technique to assess the impacts on the adaptive capacity of ecosystem services, known as an Adaptive Capacity Impact Assessment (ACIA), and a Production Impact Assessment (PIA) to account for impacts on land use enterprises. Use almost the same vulnerability framework as ESPON. Framework made by Fussel and Klein, 2006. But OSCAR use different definitions.	Developed a tool for the MS to: •Identify of hotspots within a region with respect to GHG emissions and adaptation. •Calculate and assess impacts on Mitigation, Adaptation and Productivity by RDP operations within specific regions. •Compare selected RDP measures and operations with respect to mitigation, adaptation and production performance within a specified region. •Assess the cost-benefit of RDP measures and operations, including the production of Marginal Abatement Cost (MAC) curves for mitigation and marginal adaptation costs curves for adaptation.
CLIMSAVE http://www.climsave.eu/climsave/ index.html	A Tool for stakeholders to identify hotspots and understand future impacts of climate change and the related vulnerability of human and environmental systems.	CLIMSAVE project wants to facilitating policy-makers and other stakeholders who want to understand the future impacts of climate change and the related vulnerability of human and environ-mental systems.	The CLIMSAVE vulnerability hotspot approach aims to assess spatially the impacts of future scenarios on human well-being and environmental systems.	The perspective is based on vulnerability framework of Füssel and Klein, 2006.	The tool has several models for stakeholders identify hotspots and understand future impacts of climate change and the related vulnerability of human and environmental systems.

		According to CLIMSAVE, the current adaptation policy and practice is often myopic, and focused on improving the ability to cope with current climate variability and on 'climate proofing' against short-term changes in climate risks. There is a need for longer term vision. CLIMSAVE integrated assessment models combined with future scenario analysis.			There are no studies with result based on CLIMSAVE.s
EEA-report: Climate Change impact and vulnerability in Europe EEA 2012. Climate change, impacts and vulnerability in Europe 2012 Copenhagen, Denmark.	Many maps can be used for rural development: Forest fire, temperature, soil, crop yield precipitation. Many maps differ in the time horizon, economic scenarios. And not all maps are future projections. The report and on the EEA website shows a set of climate vulnerability maps which can be related to rural development.	The EEA report presents an indicator-based assessment of past and projected climate changes, their observed and projected impacts, and the associated vulnerability of and risks to society, human health and ecosystems in Europe.	EEA does not have a main definition on hotspots nor synonyms more an explanation of the interpretation.	The terms vulnerability and risk are often used to describe the potential (adverse) effects of climate change on ecosystems, infrastructure, economic sectors, social groups, communities and regions." No core definition but explains the possible different interpretations. The EEA accepts the existence of various definitions and interpretations of vulnerability and risks in climate change science and policy.	In the report there are many maps and graphs related to climate impacts and vulnerability in Europe, MS and region, baseline and for the future. Not specifically but there are maps or graphs that can be used for rural development. Website: There is a map finder-menu. Haven't explore/analysed the website for the possibilities. The maps showed in the report, have baseline and future scenarios

				The approach in this report was therefore not to choose one specific definition of vulnerability and risk over others but to provide further clarification where needed. Hence, the use of these terms in this report always follows the underlying literature, and further explanation is provided where needed.	
AVEMAC Project Donatelli, M., G. Duveiller, D. Fumagalli, A. Srivastava, A. Zucchini, V. Angileri, D. Fasbender, P. Loudjani, S. Kay, V. Juskevicius, T. Toth, P. Haastrup, R. M'barek, M. Espinosa, P. Ciaian, S. Niemeyer (2013) Assessing agriculture vulnerabilities for the design of effective measures for adaptation to climate change (AVEMAC project). Publications Office of the European Union, Luxembourg. Pp. 176 pp. (doi: 10.2788/16181).	Although the project has weather maps and detailed maps on specific crop yield, there are clear. Baseline is 2020 or 2030.	The motivation of this study has been the lack of information on vulnerabilities, risks, and needs for the adaptation of European agriculture under a changing climate in the next decades. DG AGRI asked the scientific support of the JRC to conduct this study in order to present the existing knowledge through mapping and characterizing the vulnerabilities of EU agricultural systems to climate change, to come up with a methodological framework and to propose follow-up actions.	The word vulnerability is used to identify the negative responds on climate change for the agriculture. There is no explicit explanation on the perception of vulnerability.		Maps on weather variables for Horzon 2020 and 2030 . Using climate model HadCM3 and ECHAM5. Scenarios A1b. Crop yield simulation for several types of crops with HadCM3 and ECHAM5. Agriculture: crop yield maps

		Eventually the results of this study shall help the formulation of appropriate policy options and the development of adequate policy instruments to support the adaptation to climate change of the EU agricultural sector.			
PESETA-project Ciscar, J. C., Iglesias, A., Feyen, L., Goodess, C.M., Szabó, L., Christensen, O.B., Nicholls, R., Amelung, B., Watkiss, P., Bosello, F., Dankers, R., Garrote, L., Hunt, A., Horrocks, L., Moneo, M., Moreno, A., Pye, S., Quiroga, S., van Regemorter, D., Richards, J., Roson, R., Soria, A. 2009. Climate change impacts in Europe. Final report of the PESETA research project.	For the climate scenarios of the study, two time frames have been considered: the 2020s and the 2080s. There are more maps for the 2080s. The maps don't have a high resolution.		No definition explained: no hotspot nor vulnerability.		
Adaptation to Climate Change in the Agricultural Sector - AGRI-2006-G4-05 Ana Iglesias, Ana, Keesje Avis, Magnus Benzie, Paul Fisher, Mike Harley, Nikki Hodgson, Lisa Horrocks, Marta Moneo, Jim Webb (2007) Adaptation to Climate Change in the Agricultural Sector AGRI-2006-G4-05. AEA report.		This study aims to provide the EC with an understanding of the potential implications of climate change and adaptation options for European agriculture, covering the EU 27. It also aims to assist policy makers as they take up the adaptation challenge and develop measures to reduce the vulnerability of the sector to climate change.	Explains that the concepts of impacts, vulnerability, risk and adaptation are not defined in the UNFCCC nor in the Kyoto Protocol; the terms are used loosely by many scientific and policy communities and have a meaning in common usage. Explains how the study define Impacts, Risk Opportunity and Adaptation.		The full report provides comprehensive technical analyses, together with background information and details of the methodology, literature sources and stakeholder interactions used in the study.

Climate Adapt http://climate-adapt.eea.europa.eu	The European Climate Adaptation Platform (Climate-ADAPT) aims to support Europe in adapting to climate change. It is an initiative of the European Commission and helps users to access and share information based on a wide range of research and knowledge projects on climate change adaptation on European, transnational and national level.	Information on: ◦ Expected climate change in Europe ◦ Current and future vulnerability of regions and sectors ◦ National and transnational adaptation strategies ◦ Adaptation case studies and potential adaptation options ◦ Tools that support adaptation planning			The CLIMATE-ADAPT database has information on adaptation research-projects from EU framework programmes, EU transnational cooperation programmes and other international programmes. Highlighted projects in CLIMATE-ADAPT include: • ClimateCost • CLIMSAVE • MEDIATION • ECONADAPT
European Rural Development Network http://enrd.ec.europa.eu/en/home-page_en.cfm	The ENRD serves as a platform for the sharing of ideas and experience on how rural development policies are working in practice and how they can be improved. Provides information on Rural development issues for each member states.	The European Network for Rural Development (ENRD) is connects rural development stakeholders throughout the European Union (EU). Its mission is to contribute to the efficient implementation of the rural development policy.			
Climate Change Vulnerability Assessments: An Evaluation of Conceptual Thinking. Füssel, H., and Klein, R. 2006. Climate change vulnerability assessments: an evolution of conceptual thinking. Climatic Change 75 (3):301-329.	Defining and understanding climate hotspots & vulnerability	Reviews the develop-ment of the conceptual ideas underpinning assessments of vulnerability to climate change. a conceptual framework that defines key concepts of the vulnerability asses-sment and their	Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.	Assessments of the vulnerability to climate change are aimed at informing the development of policies that reduce the risks associated with climate change.	

		analytical relationships. The purpose of this conceptual framework is two-fold: first, to present a consistent visual glossary of the main concepts underlying the IPCC approach to vulnerability and its assessment; second, to show the evolution of vulnerability assessments	Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.		
Climate change hotspots mapping: what have we learned? Sherbinin, A. 2013. Climate change hotspots mapping: what have we learned? Climatic Change:1-15.	Defining and understanding climate hotspots & vulnerability	This paper offers a timely assessment of the strengths and weaknesses of current hotspots mapping approaches with the goal of improving future efforts. It also highlights regions that are anticipated, based on combinations of high exposure, high sensitivity and low adaptive capacity, to suffer significant impacts from climate change.	Hotspots maps can help to communicate issues in a manner that may be easier to interpret than text. Hotspots maps are developed with a number of goals in mind. Academic researchers are generally seeking to vet data and methodologies, applied researchers may be interested in guiding institutional strategies. NGOs are often communicating climate impacts via hotspots map. hotspots maps are often explicitly developed to help aid organizations in priority setting and strategic planning with regards to climate adaptation projects.	This paper reviews a number of global and regional hotspots mapping efforts, assessing data and methods, the hotspots identified, and their efficacy as tools for risk communication and decision making. Efforts to date can largely be characterized as supply-driven academic exercises rather than responding to demands from the policy community. Yet in a world where human security is potentially imperilled by temperature increases of >4 °C, and where “loss and damage” has become part of the UNFCCC on Climate Change lexicon, demand for hotspots maps will	

				likely increase as decision makers seek to identify where impacts will be greatest and what adaptation measures, if any, are possible.	
Consequences of climate change for European agricultural productivity, land use and policy Olesen, J. E., and M. Bindi. 2002. Consequences of climate change for European agricultural productivity, land use and policy. European journal of agronomy 16 (4):239-262.	It gives a scope on how climate change affect agriculture in a European perspective in terms of the effect on European agricultural productivity, land use and policy	The aim of this paper is to review the current knowledge on the impact of climate change on agriculture in Europe and in the context EU agricultural policy. It discusses the possible effects of climate change on European agricultural policy as well as the interaction between agriculture and other important sectors of European society.	There is no definition on hotspots. The article does explains how climate change could effect a certain European area, and what the impact could be in agriculture.	-	
Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems Lindner, M., M. Maroschek, S. Netherer, A. Kremer, A. Barbati, J. Garcia-Gonzalo, R. Seidl, S. Delzon, P. Corona, and M. Kolström. 2010. Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. Forest Ecology and Management 259 (4):698-709.	It gives a scope on observed and projected impacts of climate change on forests in Europe divided in different climate regions in Europe. .	This study compiles and summarizes the existing knowledge about observed and projected impacts of climate change on forests in Europe. As forests have to adapt on the changes in mean climate variables and also to increased variability with risk of extreme weather events. Sensitivity, potential impacts, adaptive capacity, and vulnerability to climate change are reviewed for European forests.	Vulnerability can be defined as the degree to which a system is susceptible to be affected by adverse effects of climate change. The vulnerability of a given system is a function of the climate variation to which this system is exposed (exposure), its sensitivity (together resulting in impacts on goods and services), and its adaptive capacity.		The research is based on a study commissioned by the European Directorate General for Agriculture and Rural Development ‵‵Impacts of Climate Change on European Forests and Options for Adaptation′′

Projected changes in mineral soil carbon of European croplands and grasslands, 1990–2080. Smith, J., P. Smith, M. Wattenbach, S. Zaehle, R. Hiederer, R. J. Jones, L. Montanarella, M. D. Rounsevell, I. Reginster, and F. Ewert. 2005. Projected changes in mineral soil carbon of European croplands and grasslands, 1990–2080. Global Change Biology 11 (12):2141-2152.	Shows	A pan-European assessment of future changes in cropland and grassland soil organic carbon (SOC) stocks to date, using a dedicated process-based SOC model and state-of-the-art databases of soil, climate change, land-use change and technology change.	-	This paper shows results of a model on the effect of climate change on soil carbon of European croplands and grasslands, 1990–2080	Based on the project ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling
Trajectories of land use change in Europe: a model-based exploration of rural futures Verburg, P. H., D. B. van Berkel, A. M. van Doorn, M. van Eupen, and H. A. van den Heiligenberg. 2010. Trajectories of land use change in Europe: a model-based exploration of rural futures. Landscape ecology 25 (2):217-232.		This paper provides a typology of land use change in Europe at a high spatial resolution based on a series of different scenarios of land use change for the period 2000–2030. A series of simulation models ranging from the global to the landscape level are used to translate scenario conditions in terms of demographic, economic and policy change into changes in European land use pattern.	-	The objective of this paper is to provide a typology of land use change in Europe at a high spatial resolution based on a series of different scenarios of land use change for the period 2000–2030. The results are combined with common typologies of landscape and rurality in order to identify regions with similar conditions and land use dynamics.	RUFUS FP7 project
Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation Berry, P., M. Rounsevell, P. Harrison, and E. Audsley. 2006. Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation. Environmental Science & Policy 9 (2):189-204.		In this paper those issues relevant to climate change impacts on agriculture and species are discussed. Outputs from models are used to assess the vulnerability of farmers and species to climate and socio-economic change by estimating	Discuss the concept of vulnerability from the point of views of organisations (UNEP, IPCC) and from other authors.	The results showed that the vulnerability of both farmers and species is dependent on the scenario under consideration. In agriculture, it is the socio-economic scenarios that particularly lead to different patterns of intensification,	

		their sensitivity and capacity to adapt to external factors as a means of identifying what causes the differences in their vulnerability.		extensification and abandonment. For species, vulnerability is more related to the climate change scenarios.	
Assessing climate change effects on European crop yields using the Crop Growth Monitoring System and a weather generator I. Supit, I., C. Van Diepen, A. De Wit, J. Wolf, P. Kabat, B. Baruth, and F. Ludwig. 2012. Assessing climate change effects on European crop yields using the crop growth monitoring system and a weather generator. Agricultural and Forest Meteorology 164:96-111.					Climate change impacts on potential and rainfed crop yields on the European continent were studied using output of three General Circulation Models and the Crop Growth Monitoring System in combination with a weather generator. IPSL-CM4 MICRO3.2 ECHAM5/MPI-OM

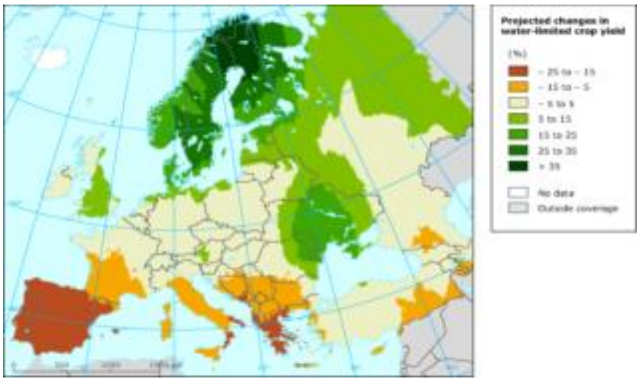
Part B Identification of hotspots for this study

Adaptation Hotspots

Loss of water limited crop yields

Climate change is influencing the European agricultural production as the temperature will further increase. This has an impact on the crop production across Europe (Supit, et al. 2011). However, the effect on the impact of water limitation on crop yield across Europe varies strongly. This combination of changes in temperature and water limitation can either lead to a positive and a negative effect on crop production depending on the type of yield and regional differences in climate (change) and soil (Bindi and Olesen, 2011).

Figure 1 Projected changes in water-limited crop yield

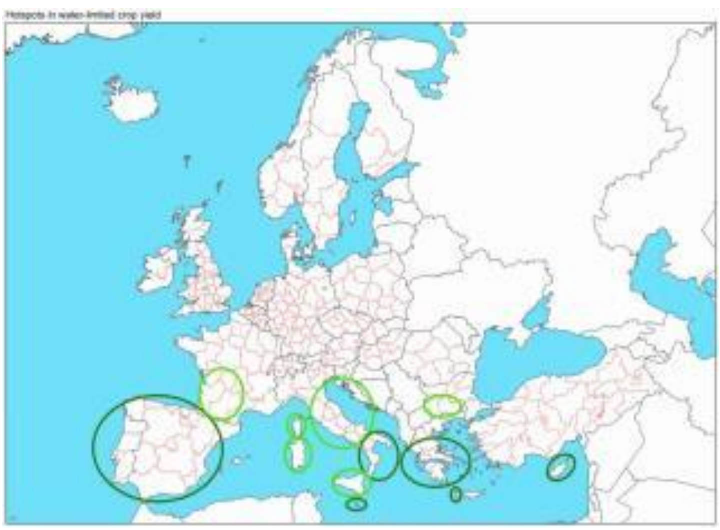


Source: EEA (2012) Climate change, impacts and vulnerability in Europe 2012. EEA Report No 12/2012, Copenhagen
Data Source: Looking into the future of agriculture in a changing climate provided by Universidad Politecnica de Madrid. Iglesias, Ana, Quiroga, Sonia and Diz, Agustin, 2011, 'Looking into the future of agriculture in a changing climate', European Review of Agricultural Economics, 38(3), pp.427 –447.

For identification of hotspots we have used the map published by EEA on Climate change, impacts and vulnerability in Europe (EEA, 2012). This map shows a projection of changes in the water limited crop yield and has been developed by a ClimateCrop model (Iglesias, 2011). According to this map, the projected changes of yield production will "decreases along the Mediterranean and large increases in Scandinavia. However, throughout large parts of western and central Europe mean changes in crop yields are likely to be small" (EEA, 2012). The ClimateCrop model used analysis to environmental variables (temperature, precipitation and CO2 levels) and management variables (planting date, nitrogen and irrigation applications; 3,600 simulations per site) (Iglesias, 2011).

For this project we have identified a hotspot as a region when the yield production will decrease with a negative impact of -25 to -5% (EEA). The hotspots identified used here are not crop specific and shows an overall picture where the yield production are most vulnerable to climate change. We have not specified the information to different crops as the actual crops cultivated will vary. For specific crops the results may vary with crop responses to climate variables (e.g. C3 versus C4 crops). We consider to include a summary of Supit *et al.* (2012) on the crops considered in the analysis.

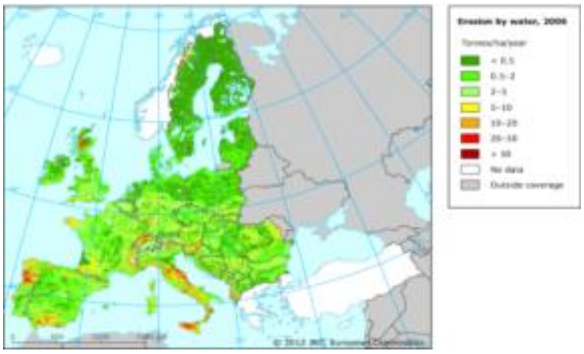
Figure 2 Hotspots in water-limited crop yield



Soil erosion by water

As climate is changing and rainfall patterns, rainfall seasonality and/or rainfall intensity, this will have impact soil erosion by water. If there are changes in erosion patterns and volume then there changes in agriculture productivity and in water quality will be expected (Lee, 1999). "An expected increase in rainfall, caused by stronger gradients of temperature and pressure and more atmospheric moisture, may result in a larger frequency of high intensity precipitation events, causing increased soil erosion" (Bindi and Olesen, 2011).

Figure 3 Erosion by water 2006



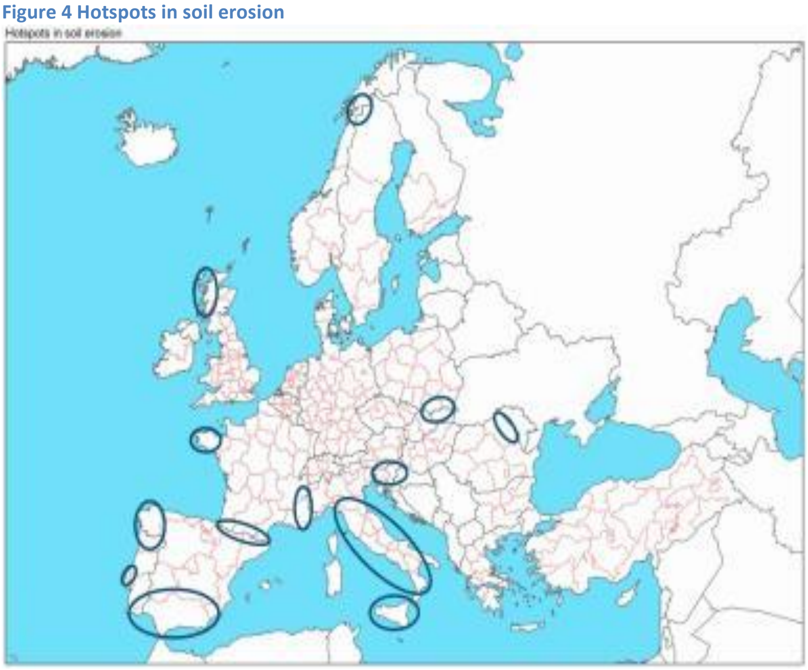
Source: EEA (2012) Climate change, impacts and vulnerability in Europe 2012. EEA Report No 12/2012, CopenhagenData source: The State of Soil in Europe provided by Joint Research Centre (JRC). E-OBS provided by ENSEMBLE FP6 project. Corine Land Cover 2006 seamless vector data provided by European Environment Agency (EEA). Modelling Soil Erosion at European Scale. Towards Harmonization and Reproducibility provided by Joint Research Centre (JRC).

The map we used to identify hotspots for soil erosion by water was calculated by the Revised Universal Soil Loss Equation (RUSLE). The data presented were validated through comparisons with national datasets and expert judgement. The model did not consider localised intense precipitation (EEA, 2012). However, reliable quantitative projections are currently not available. For this reason we used this map (figure 4) to identify hotspots for soil erosion by water of the year 2006.

A hotspot has been identified when a region is most likely to be vulnerable for soil erosion at a high rate of loss of topsoils of 10-30 tonnes/ha year indicated as a dark red and orange area. In these regions, there is increased variations in rainfall pattern and rainfall intensity.

This will make soils more susceptible to water erosion, including the off-site effects of soil erosion increasing. (EEA, 2012)

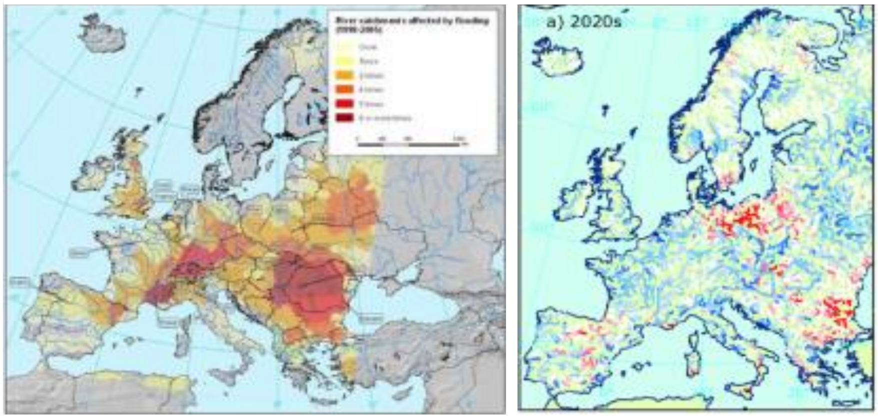
Figure 4 Hotspots in soil erosion



Flooding from high water; will need to check if and how much is vulnerability of land and agricultural production is included here.

Global warming and changes in rainfall patterns and intensity is projected to increase the occurrence and frequency of flood events in large parts of Europe. Nevertheless, projections in changes in flood frequency and the impact remain highly uncertain. Current river flooding risk across EU is not matching all recent events and may not be recognized by MSs. However, studies have been made in identifying the trends in flood increasing in regional and national level (reference to be included: EEA based on Global Active Archive of Large Flood Events, Dartmouth Flood Observatory; check for UK study on risks).

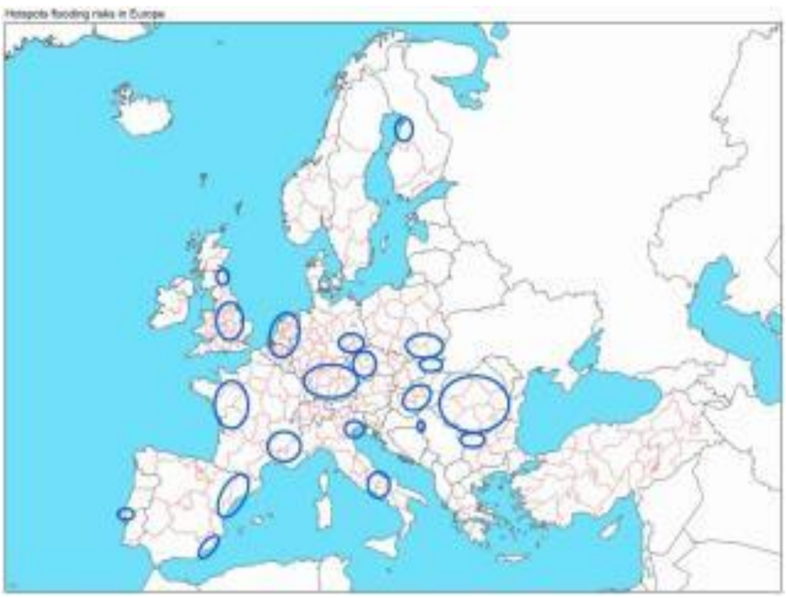
Figure 5 Recurrence of flood events in Europe and Expected impact of climate change on future flood 2070-2100



Source: EEA based on Global Active Archive of Large Flood Events, Dartmouth Flood Observatory and Euro-Mediterranean Centre on Climate Change (CMMC)

Figure 7 shows on the left hand the occurrence of flood events in Europe from 1998–2009. This picture is incomplete because events with small spatial extent and/or impact are not included. Over the last decade large areas have been affected by flooding. The influence of anthropogenic climate change remains inconclusive. The map on the right shows an evaluation of possible future flood damage due to climate change with no adaptation or disaster risk reduction measures. Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis (PESETA) study indicate that flood damage is projected to rise across much of Western and Central Europe while decreases in flood damage are consistently projected for the North‑ eastern Europe.
For identifying the hotspots on flooding the two maps of current and future situations.

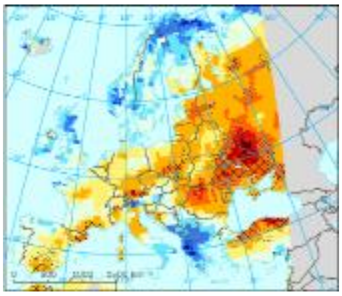
Figure 6 Hotspots flooding risks in Europe

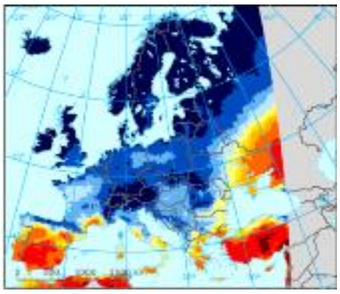


Forest and nature fire

Fire risk depends on a combination of factors such as weather, vegetation, topography, forest management practices and socio-economic context. In recent years, the fire events were mostly caused by extreme weather conditions. Although wild fires are also started and caused by human activity or action, the weather conditions play an prominent role in the level of fire risk. Therefore a changing climate is expected to have a potentially strong impact on forest fire in Europe (EEA, 2012).

Figure 7: Projected risk on forest fire





Source : EEA (2012) Climate change, impacts and vulnerability in Europe 2012. EEA Report No 12/2012, Copenhagen.

For identifying fire risk across Europe, we used two maps with the projections of forest fires in the year 2070-2100. These maps show the Seasonal Severity Rating (SSR) by JRC. The map on the left shows the trend of forest fire danger in SSR % per year. As the map on the right, indicates projected annual average SSR in 2071–2100 .

Both maps show the projected risk of fire danger, however the maps shows significant differences as well. The map on the right show an increase risk in fire danger in the Iberian Peninsula, whereas the map on the left shows for the same region an increasing of only -0.5 to 0.5 % per year. The opposite is true for a high risk in the Northern part of Europe such as, south of Germany, Estonia and Lithuania whereas the map on the right indicates no risk in these areas.

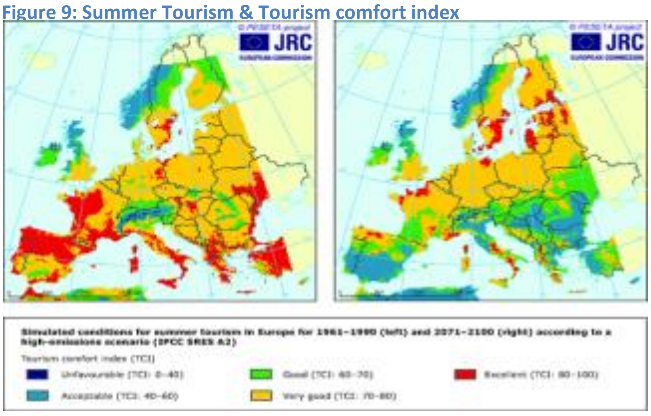
Several studies (Lindner et al. 2010) climate change projections suggest substantial warming and increases in the number of droughts, heat waves and dry spells across most of the Mediterranean area and more generally i southern Europe. These projected climate changes would increase the risk of forest fire.
For risk of forest fire we identified hotspots a combinantion of these two maps with a high SSR. The results of combining the two maps is shown in figure 8. Here the climate impact for risk of fire is likely to accure in the south Europe. Nevertheless, climate change will impact the central east part of Europe, such as south of Germany and Poland and in the Baltic states as Estonia and Lituanhia.

Figure 8 Hotspots forest and nature fire risks in Europe.

Climate change and tourism

For identifying the projections on winter and summer tourism, two maps were used map: Projected changes in summer tourism (2071-2100). As for the winter tourism we used the map for projected changes in snowfall days (2041-2070).

Figure 9: Summer Tourism & Tourism comfort index



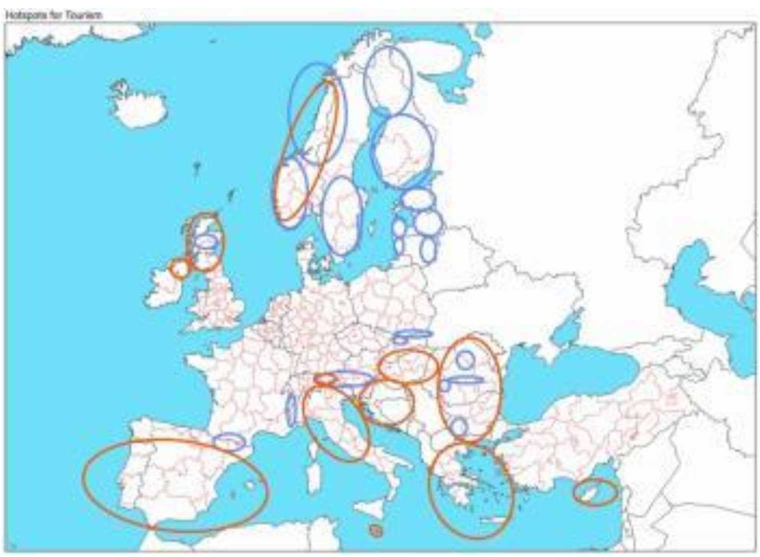
Projections suggest that the attractiveness of the Mediterranean for tourism will decline during the summer months. Although this may increase in the spring and autumn. "Climate change could benefit the Mediterranean tourist industry if it evens out demand, reducing the summer peak while increasing occupancy in the spring and autumn" (SOER-Environmental Outlook 2010, EEA, 2010). Nevertheless without such tourism shifts, the Mediterranean tourist industry could be vulnerable of climate change as for many Mediterranean regions the tourism is a very important for their economy. (SOER-Environmental Outlook 2010, EEA, 2010).

Figure 10: Projected changes in snowfall days 2041-2071

There will be a decrease in number of days with snow fall exceeding 1 cm across Europe. The number of days with snow fall more than 10 cm increases in large parts of northern Europe however in most other regions this number decrease. The map also show projections in reductions in snow fall and snow cover in Switzerland, the alpine range of Italy, the Pyrenees, and Balkan mountains . This could have an effect in melt water and river flows

There is, however, considerable uncertainty in these projections due to large differences between the upper and lower limits of the model projections. Because snow cover is sensitive to snowfall as well as temperature, increased snowfall will not necessarily translate into more snow on the ground. A study has projected a reduced number of snow cover days in northern Europe of up to 40–70 days in 2071–2100 compared to the baseline period 1961–1990" (EEA, 2012).

Figure 11: Hotspot for Tourism

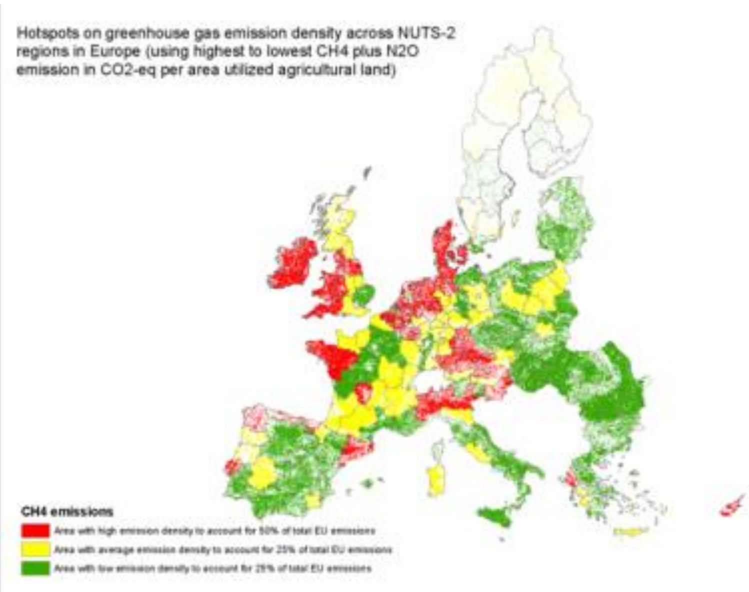


Mitigation hotspots

CH4 Emission from agriculture from ruminants and (fermentation of feed and grazing) and manure storage

The sources for emissions of methane are linked to animal production and animal wastes and manures. The highest emissions are from enteric fermentation and related to feed quality, feed quantity and whether or not animals are grazing.

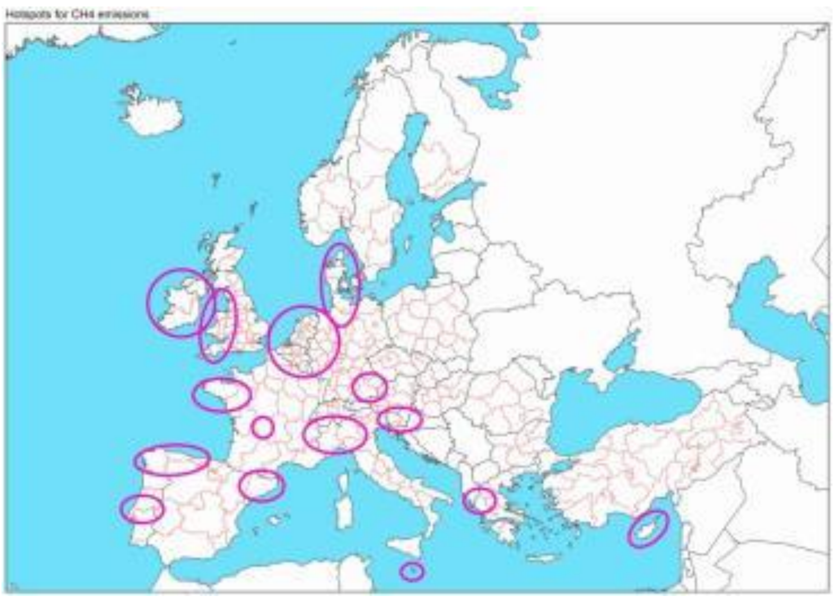
Figure 12: CH4 emissions across Europe



Source: Lesschen J.P., B. Eickhout, W. Rienks, A.G. Prins & I. Staritsky (2009) Greenhouse gas emissions for the EU in four future scenarios. WAB report 500102 026, PBL Environment Assessment Agency, Bilthoven, Netherlands. Pp. 322

The maps show the spatial distribution of the GHG emissions from the different sources: For CH_4 and N_2O the pattern is more or less similar, with high emissions in the livestock intensive regions. CO_2 emissions from peat soils and liming are high for regions in northern Europe with peat soils and a region in Hungary. The CO_2 emission from SOC stock changes is more diverse. In most areas stocks remain equal or slightly increase due to implementation of the mitigation measures and agricultural land abandonment over the period 2000-2010. Some regions carbon is lost from the soil due to land conversion for agricultural expansion.

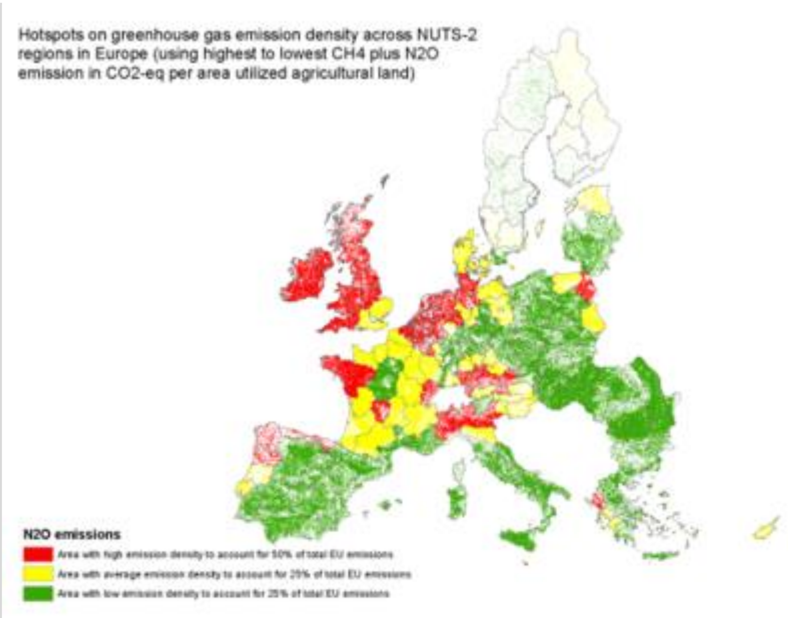
Figure 13: Hotspots for CH4 emissions



N_2O emission from agriculture (application of synthetic mineral fertilizers and animal manure storage and application

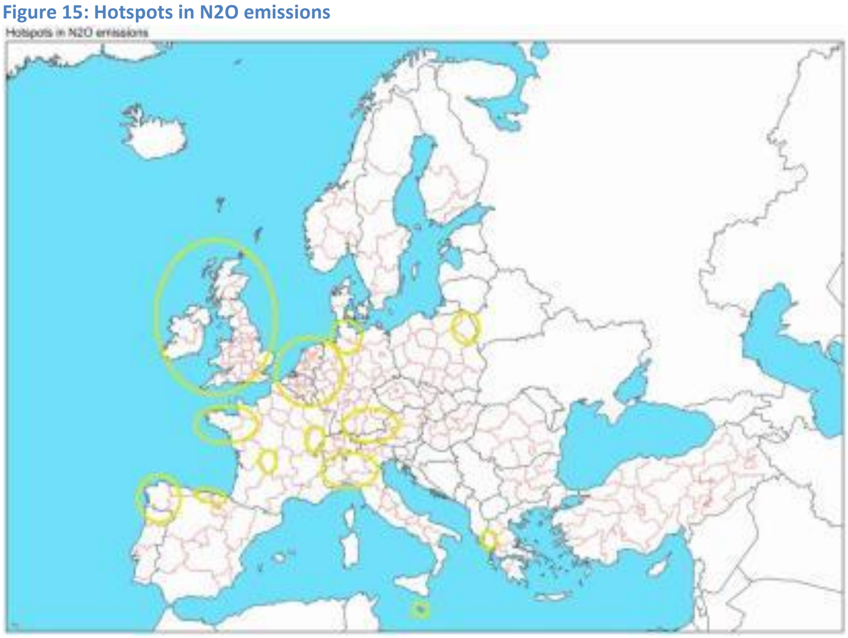
The sources for emissions of nitrous oxide are linked to animal production and specifically the storage and application of animal manures. The emissions from application of manure and urine and droppings during grazing our highest and depend on the N contents of urine and manure. Further emissions of N_2O are related to synthetic fertilizer applications and depend on fertilizer type and amount.

Figure 14: N2O emissions density across Europe



The maps show the spatial distribution of the GHG emissions from the different sources: For CH_4 and N_2O the pattern is more or less similar, with high emissions in the livestock intensive regions.

Figure 15: Hotspots in N2O emissions



CH_4 and N_2O emissions across Europe

The sources for emissions of methane are linked to animal production and animal wastes and manures. The highest emissions are from enteric fermentation and related to feed quality, feed quantity and whether or not animals are grazing. The sources for emissions of nitrous oxide are linked to animal production and specifically the storage and application of animal manures. The emissions from application of manure and urine and droppings during grazing our highest and depend on the N contents of urine and manure. Further emissions of N_2O are related to synthetic fertilizer applications and depend on fertilizer type and amount.

Figure 16: Greenhouse gas emissions density across regions in Europe

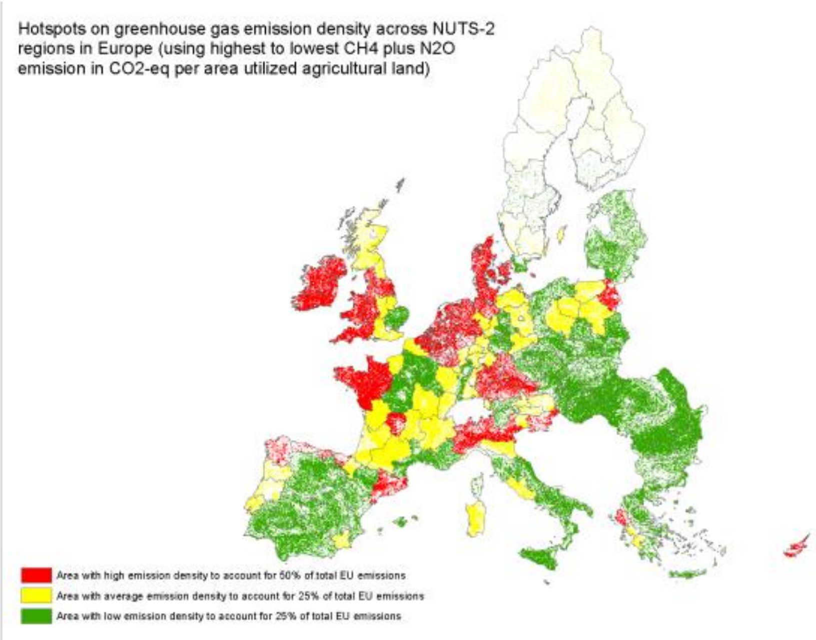
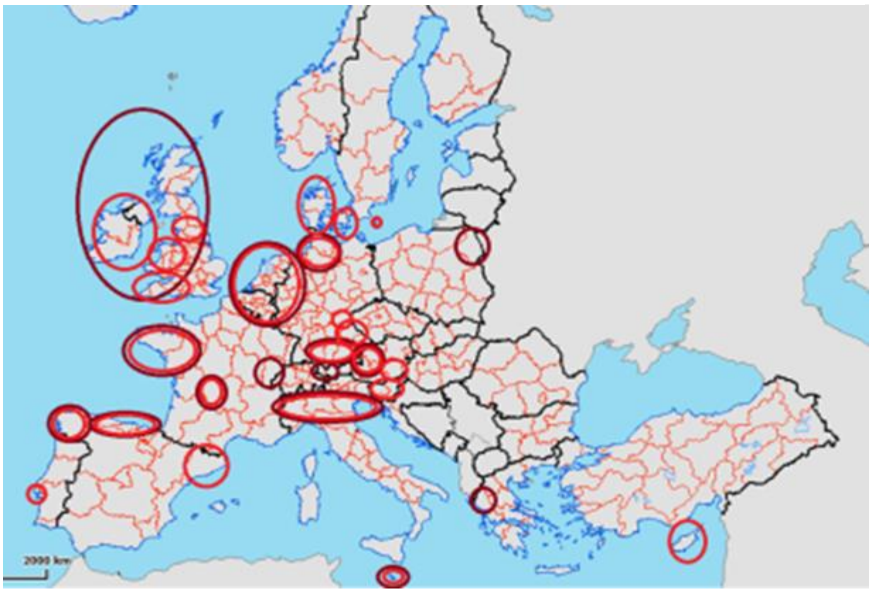


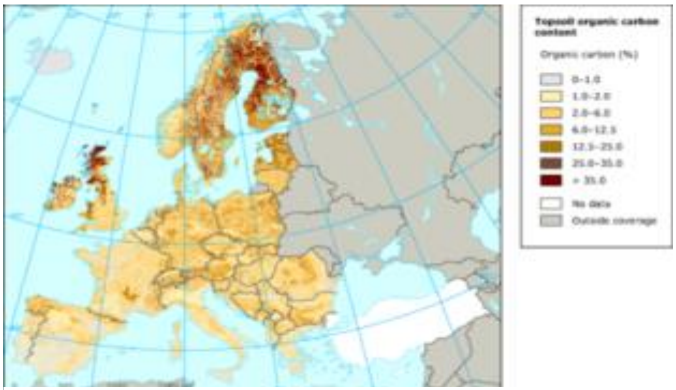
Figure 17: Hotspots of the total greenhouse gas emissions CH4 & N2O



Loss of organic matter through cultivation and drainage of organic soils (peat and other high organic matter soils)

Soil organic plays a key role in building and sustaining soil fertility, affecting physical, chemical and biological soil properties. (Bindi and Olesen, 2011) Increased temperature will have an effect on the turnover rate of the soil organic 'material'. Depending on actual conditions and location, cultivation and drainage of peat and other high organic carbon soils will lead to enhanced CO_2 emissions; this probably will be most pronounced from peat soils and also affect the use of these soils for agricultural purposes" (Bindi and Olesen, 2011). There are expectations that climate change have an impact on soil carbon in the long term, changes in the short term will more likely be driven by land management practices and land-use change, which can mask the climate change impact on (loss of) carbon stocks in high carbon and peat soils due to enhanced decomposition and oxidation processes (Bindi and Olesen, 2011).

Figure 18: Topsoil organic carbon



Source: EEA (2012) Climate change, impacts and vulnerability in Europe 2012. EEA Report No 12/2012, Copenhagen
Data Source: European Soil Database 2003 provided by Joint Research Centre (JRC) Corine Land Cover 2006 raster data provided by European Environment Agency (EEA)

The topsoil organic carbon hotspots were identified by a map with a data source of European Soil Database 2003 provided by Joint Research Centre (JRC) (EEA, 2012). The map shows the percentage of organic carbon content in the surface horizon of soils in Europe. Based on this map we identified the hotspots identified as darkest colours and these regions correspond to soils with high contents of organic carbon. In these regions both areas not cultivated or drained have low losses as opposed to those areas that are cultivated and drained. CO_2 emissions from peat soils and liming are high for regions in northern Europe with peat soils and a region in Spain.

The CO_2 emission from SOC stock changes in mineral soils (as opposed to peat soils) is more diverse. In most areas stocks remain equal or slightly increase due to implementation of the mitigation measures and agricultural land abandonment over the period 2000-2010. In some regions carbon is lost from the soil due to land conversion for agricultural expansion and or intensive soil management. No sufficient data to identify hotspots across EU are at hand.

Figure 19 Hotspots in topsoil organic carbon content across Europe