

METHODOLOGIES FOR CLIMATE PROOFING
INVESTMENTS AND MEASURES UNDER COHESION
AND REGIONAL POLICY AND THE COMMON
AGRICULTURAL POLICY

Identifying the climate risks related to rural areas and
adaptation options

April 2013

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1. IDENTIFYING THE CLIMATE RISKS RELATED TO RURAL AREAS

This section provides a very brief summary of predicted climate change impacts relating to agriculture, forestry and biodiversity across the EU. It also provides an indication of the relative severity of threats for each EU climate region. This is provided simply as an indication of the type of evidence that will need to be collated and interrogated at a much greater level of detail to inform decisions about the prioritization of actions within RDPs.

The information provided is derived from the project Methodologies for climate proofing investments and measures under Cohesion and Regional policy and the Common Agricultural Policy (CAP) funded by DG Climate action. The Annexes to the main study report provide further details (see add link). This information should be supplemented with data available at the national/regional level in individual Member States.

1.1. Overview

The main climatic drivers are:

- rises in temperatures
- changes in precipitation patterns
- changes in intensity and frequency of weather events (such as extreme precipitation, heat waves, cold spells and storms)
- rises in sea levels
- changes to wind patterns

1.2. Agriculture

The impacts of climate change on the agricultural sector are extremely varied between and within regions. Most of the evidence relates to the effects of climate change on agricultural production, particularly crop production (yields and location), with little literature available that examining the impacts on livestock. The impacts are necessarily generalised and mask high-impact disturbances that may occur within regions. It is important to note that there are considerable uncertainties inherent in the longer terms projections in terms of the likely scale and timescale of the predicted impacts. In addition, although many of the effects of climate change involve constraints that need to be overcome, the impacts on production can be both negative and positive. For example, yield improvements for some crops have been predicted in Northern Europe as a result of increase CO₂ levels in the atmosphere, although other factors such as predicted increases in water scarcity, increased soil erosion and storm events are likely to constrain such increases in reality.

Water scarcity is already being experienced in some areas of Europe and longer and more frequent droughts are anticipated in large parts of Southern Central and Eastern Europe, as well as parts of Northern Europe, with significant risks to crop yields. More arid conditions are likely to exacerbate soil degradation as a result of wind erosion and will also cause heat stress for livestock. There is less clarity about the likely changes in precipitation that might be experienced. An increase in magnitude and frequency of high precipitation events is likely in many parts of Northern, Central and Southern Europe which could damage crops and lead to waterlogging and exacerbate soil erosion where bare soil exists. The higher incidence of these types of extreme weather events (droughts, storms) are likely to severely disrupt crop production and increase the unpredictability and variability of crop yields. These

higher temperatures and increased rainfall are also likely to lead to a noticeable increase in the incidence of disease, pests and pathogens, including the spread of invasive alien species.

The table below provides an overall assessment of the risks to the agricultural sector from different impacts of climate change. However, this should be treated with care. It is extremely difficult to provide this kind of assessment for the agricultural sector for three reasons. Firstly, climate change impacts on the agriculture sector can be positive as well as negative (for example in relation to the CO₂ concentrations in the atmosphere and the impacts this may have on yields). Secondly, this sort of regional assessment masks predicted local high-impact disturbances, although these should be taken into account in adaptation strategies. Thirdly, for some threats, for example flooding or storm and pest outbreaks, it is not ‘scale’ that matters, but the frequency, unpredictability and severity of their occurrence.

AGRICULTURE	Flooding – Coastal and River ²	Water scarcity -continuous/drought ²	Air quality	Disease/pest outbreak ²	Soil erosion	Storms ²	extremes inc fires and changes over time ²	Precipitation ²
Overall EU Assessment	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
North	Medium	Low-Medium	Low	Medium	Medium	Medium	Low	Medium
North-West	Medium	Low-Medium	Low	Medium	Medium	Medium	Low	Medium
Southern	Medium	High	Low	Medium	High	High	High	Medium
Central & Eastern	Medium	Medium	Low	Medium	Medium	High	Medium	Medium

1.3. Forestry

Effects of climate change include increased risk of biotic (pests and diseases) and abiotic (droughts, storms and fires) disturbances to forest health. However, the exact effects of climate change on forests are complex and not yet well understood. The impacts of climate change will vary throughout the different geographic regions of Europe, with forest fires likely to dominate in southern Europe and the limited diversity of tree species in boreal forests enhancing the risk of significant pest and disease impacts. Next to negative climate change impacts, especially in the long term, opportunities arise as well in the forestry sector. Evidence to date suggests that productivity in northern and central Europe has increased and is likely to continue to increase. Further, northward expansion of potential distribution of some tree species is expected and potentially more favourable conditions for summer recreation in mountainous regions will exist (Lindner et al. 2010). However, with more drastic changes in climate towards the end of the 21st century, severe and wide ranging negative climate change impacts have to be expected in most European regions (Lindner et al. 2008), with the Mediterranean region as the most vulnerable to climate change based on potential impact assessment and adaptive capacity (Lindner et al. 2010).

It is worth noting that there is lack of data, especially harmonised data sets at an EU level to document these effects. Although there have been some attempts to address this, gaps in the evidence base remain. One project that aims to improve knowledge base is the EU funded BioSoil project which demonstrated how harmonised soil and biodiversity data can

contribute to developing forest monitoring (of soils, carbon sequestration, climate change effects and biodiversity).

FORESTRY	Flooding - Coastal ²	Flooding - River ²	Water scarcity-continuous/drought ²	Air quality	Disease/ Pest ²	Soil erosion	Storms ²	Ice/Snow (Winter extremes) ²	Temperature extremes inc fires ²	Temperature change over time
Overall EU Assessment	Medium	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
North	Medium	Medium	Low	Low	High	Low	High	High	Medium	Low
North-West	High	High	Low	Low	High	Low	High	Low	Low	Low
Southern	Medium	Low	High	Low	High	Medium-High	Medium	Low	High	Medium
Central & Eastern	Medium	High	Medium/High ³	Low	High	Low	High	Medium	Medium	Low

Source: Own assessment. Note the regional assessment reflects the general regional assessment of threats from climate change

Notes:

1. 'Scale' is understood in terms of frequency, severity or extension, as appropriate.
2. Unpredictability of these threats may further aggravate high and medium impacts for these threats.
3. 'High' impacts are likely in certain regions of South-Eastern new MS (Romania, Bulgaria) and regions in Central Europe with semi-arid conditions, eg in Hungary.

1.4. Biodiversity

Studies largely show that habitat destruction and degradation is currently the greatest threat to biodiversity; although climate change is likely to become an additional profound and possibly greater threat. There is now a considerable body of evidence that climate change is already having measurable biological and ecological effects on biodiversity (ie ecosystems, species and the genetic diversity of species) in Europe and globally.

Species respond individualistically to climate change, with direct impacts including changes in phenology, species abundance and distribution, community composition and ecosystem processes. Climate change will also lead to indirect impacts on biodiversity through changes in the use of land and other resources. These may be more damaging than direct impacts due to their scale, scope and speed. There is abundant evidence that species are responding to these climate effects to some extent by changing their behaviour (eg breeding earlier), their physiology (eg through natural selection of the best adapted genotypes) and by moving to more suitable locations (eg to higher latitudes, higher altitudes on land and to deeper waters in the oceans)(Huntley, 2007). These responses may enable species to adapt and maintain their populations, albeit in different locations. However, adaptation is constrained for many species because they have:

- Small and fragmented populations or ranges;
- Populations with high rates of mortality or low breeding productivity due to other pressures and therefore do not produce enough offspring to maintain populations levels without immigrants from other populations (ie they are sink populations) and may therefore already be threatened;
- Biological constraints on dispersal and colonisation;

- Bounded distributions (eg because they occur on isolated islands or mountains or at very high latitudes);
- Blocked dispersal routes (eg by sea, topography, otherwise inhospitable habitats); or
- High dependence on other specific habitats and species that are impacted by climate change.

It is particularly important to note that many, if not all species are likely to be affected to some degree by the indirect impacts of climate change. This is because most will depend on another species (eg for food) or be affected by another species (eg as a predator, competitor or parasite) that will be affected by climate change. The net results will be that communities of species, and their food-webs and predators etc that make up ecosystems will be increasingly disrupted.

Three strategic actions needed for biodiversity adaptation are:

- Assess the vulnerability of species, habitats, and ecosystems to climate change;
- Develop strategies and practical measures that increase the resilience of ecosystems, habitats and their associated species populations to climate change, thereby improving their adaptive capacity;
- Develop strategies and practical measures that accommodate changes by facilitating the movement of species (and habitats) to new areas with suitable climatic conditions.

It is apparent that many of the measures that will help to increase the resilience of existing populations will also facilitate the movement of species. This is because, for example, measures that increase habitat quality are likely to increase breeding productivity and therefore the recruitment of emigrants and their individual condition. Increasing emigration rates and the survival rates of emigrants will increase the probability of successful dispersal and colonisation. Similarly, actions that increase connectivity by reducing habitat fragmentation may help to increase the resilience of existing populations, e.g. by establishing larger and more robust meta-populations. Therefore, many practical measures for biodiversity adaptation will provide multiple resilience and functional connectivity benefits.

BIODIVERSITY	Flooding - Coastal	Flooding - River	scarcity-continuous/drought	Air quality	Disease	Soil erosion	Storms	Ice/Snow (Winter extremes)	Temperature extremes inc fires	change over time
Overall EU Assessment	Low/Medium	Low/Medium	Low/Medium	Low	Uncertain	Low	Medium	Low	Medium	Low
North	Medium	Medium	Low	Low	Uncertain	Low	Medium	Medium	Medium	Low
North-West	Medium	Medium	Low	Low	Uncertain	Low	Medium	Low	Low	Low
Southern	Low	Low	Medium	Low	Uncertain	Medium	Low	Low	Medium	Low
Central & Eastern	Low	Low	Low	Low	Uncertain	Low	Medium	Low	Medium	Low

2. LIST OF AGRICULTURE OPTIONS

This section sets out a series of options that could be funded through RDPs, divided into categories: land management, physical infrastructure and advice and training. These options have been identified as actions that are a priority for the forthcoming programming period (2014-2020) on the basis of an assessment that has taken into account the timeframe in which they are needed and their likely effectiveness. This assessment has been carried out at the EU level and this assessment would need to be re-applied at the national/regional level when determining which are a priority in relation to local priorities for climate adaptation.

More details on the options listed and information on cost benefit analyses, where these exist, can be found here [add link to the full study and the options database].

2.1. Land Management

Adaptation Option:	Buffer strips (permanent vegetation)
<i>Buffer strips can include woodland, hedgerows, strips of grassland along water bodies, grass margins, field corners, etc. Vegetated and unfertilized buffer zones act as a shield against overland flow from agricultural fields and reduce run-off from reaching the watercourse, thus decreasing erosion and the movement of pollutants into watercourses.</i>	
Climate threat addressed:	Risk of soil erosion, storms, flooding, flash floods
Urgency:	High urgency for adopting this measure exists because it addresses pressing water protection and biodiversity problems. Moreover, the implementation process requires a long time investment (i.e. the political process needs time to accept the measure, and the implementation itself requires several years to reach full effectiveness). The effect starts when the vegetative zone has been established, including the development of a good root system.
Effectiveness (considering different climate scenarios)	Buffer strips are effective under business-as-usual scenario as they preserve ecosystem services and functioning. Under other scenarios, they address climate change impacts across multiple areas (e.g. soil, biodiversity, water) as well as enhance the adaptability of biodiversity to climate change (via e.g. facilitated migration through connected natural networks). Buffer strips can almost completely offset run-off and erosion in permanent crops and decrease damages caused by flooding events.
Expenditure Category(ies):	RD Regulation Proposal Articles 18, 29, Ecological Focus Areas (Pillar 1)
Cost-Benefit assessment:	Available
Coherence with other policy objectives	The measure supports the implementation of the Water Framework Directive, by contributing to achieving at least good ecological status for all surface water bodies within a defined timetable (European Commission, 2000) as well as the Nitrates Directive and EU Biodiversity Strategy 2020.

Adaptation Option:	Buffer strips (permanent vegetation)
	There is also an obligation in the Pesticides Framework Directive to provide ‘appropriately sized’ buffer zones in which pesticides cannot be used and include these in the National Action Plans by 2012.
Coherence with other adaptation options	The measure shows synergies with options aimed at benefitting biodiversity, as it provides an element in green infrastructure and reduced thermal stress to the aquatic environment. There are also synergies with river restoration measures, as buffer strips by increasing habitat quality in the riparian zone and reducing erosion.

Adaptation Option:	Maintenance of permanent grassland
<i>Species-rich, semi-natural permanent grasslands are accepted as important land use for addressing biodiversity conservation, water regime and climate objectives. Additionally, the conversion of former arable land to grassland can be used at a small field scale to take high risk areas prone to erosion and loss of nutrients/pesticides out of production. As conversion of arable or cropland to grassland is a difficult process, it is crucial to maintain existing permanent grasslands from now and into the long-term.</i>	
Climate threat addressed:	soil erosion, storms, flooding, flash floods
Urgency:	The measure addresses multiple existing environmental problems associated with agriculture and is especially relevant also for mitigation, and should be implemented in the short-term up to 2020.
Effectiveness (considering different climate scenarios)	Permanent grasslands have proven effective in mitigating threats from floods through their high capacity in subsurface storage. Wet grasslands in particular can serve as a buffer zone for agricultural runoff and contribute to reducing erosion. The measure is effective under business-as-usual scenario, and its relevance increases with the severity of climate change impacts.
Expenditure Category(ies):	RD Regulation Proposal Articles 18, 29, 31, Pillar 1 Greening payments
Coherence with other policy objectives	The measure is relevant for the implementation of the Water Framework Directive, the Floods Directive, for biodiversity protection.
Coherence with other adaptation options	Synergies with other adaptation measures such as further conservation areas and habitat restoration, buffer strips, restoration of wetlands and reducing grazing pressure to reduce risk of erosion from flash flooding are possible.

Adaptation Option:	Further conservation areas and habitat restoration
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Adaptation Option:	Further conservation areas and habitat restoration	
<i>Due to different climate change impacts, e.g. increasing temperature, flooding, etc., further conservation areas should be established and habitats should be restored. The focus is on habitats such as wetlands and fens, which are species rich and could function as flooding area, but are also important for maintaining water balance. The focus is on the establishment of green corridors which enable species to move, e.g. in the north according to higher temperatures and climate shifts.</i>		
Climate threat addressed:	threat	all threats
Urgency:	This option addresses a number of other pressing environmental needs in the area of biodiversity protection and water protection, and should be implemented already in the short term up to 2020.	
Effectiveness (considering different climate scenarios)	The measure can increase resilience in a medium scenario with a 2°C temperature. Due to existing problems it is already necessary under current climate conditions (no-regret). It is also robust under extreme climate change scenarios (> 4°C).	
Expenditure Category(ies):	RD Regulation Proposal Articles 29, 18, 31	
Coherence with other policy objectives	Strong synergies with biodiversity protection, water protection, as well as climate change mitigation.	
Coherence with other adaptation options	This measure is linked to a number of other options, especially grassland protection, buffer strips, and floodplain restoration.	

Adaptation Option:	Conservation soil tillage	
<i>Under conservation tillage the soil is still tilled, but is disturbed less. Reduced / conservation tillage can take many forms including ridge tillage (in which ridges are made in the field), shallow ploughing and rotovation or scarification of the soil surface. The measure has important carbon sequestration effect, leads to reduced erosion, can also reduce soil compaction, and increases soil water holding capacity.</i>		
Climate threat addressed:	threat	soil erosion, storms, flooding, flash floods
Urgency:	Due to the already existing problem of soil erosion and additional problematic soil fertility the measure should be taken short-term up to 2020.	
Effectiveness (considering different climate scenarios):	Conservation soil tillage is a measure with a high positive effect on resilience of farm level production regarding climate risk. It is already effective under a business-as-usual scenario with existing climate variabilities (no-regret). The measure is also robust under extreme climate scenarios (> 4°C).	

Adaptation Option:	Conservation soil tillage
Expenditure Category(ies):	RD Regulation Proposal Article 29
Coherence with other policy objectives	The option has a positive effect on climate mitigation and the objectives of the Water Framework Directive (WFD).
Coherence with other adaptation options	The measure shows especially synergies with improved cropping practices, such as intercropping, plant winter cover, residue management, etc. Further there are positive effects with organic farming and different soil management measures.

Adaptation Option:	Reduce grazing pressure to reduce risk of erosion from flash flooding
<i>When grazing pressure is too large (expressed in increasing number of livestock units per hectare), this leads to negative effects on the soil water retention capacity and thereby increases risk for runoff and erosion. Reduced grazing promotes the rehabilitation of indigenous vegetation in many places and contributes to soil conservation and the regulation of water flows, helping to reduce flash flooding from heavy rains.</i>	
Climate threat addressed:	soil erosion, flash floods, storms
Urgency:	The option needs to be implemented already in the short-term, especially in areas most prone to soil erosion (in particular highly sloping areas) which are also areas prone to extreme rainfall events. The option has multiple benefits for several environmental policy objectives.
Effectiveness (considering different climate scenarios)	The option is effective under a business-as-usual scenario with existing climate variabilities (no regret). The measure may be less robust under extreme climate scenarios (> 4°C) as it may not sufficiently address increased risks of erosion in the most vulnerable sloping areas, which may require change in land use (no grazing, or additional measures such as agroforestry, for example).
Expenditure Category(ies):	RD Regulation proposal Article 29
Coherence with other policy objectives	Reduced grazing pressure can benefit biodiversity (composition of species in the grassland) and it protects water quality by reducing soil erosion.
Coherence with other adaptation options	The option can be combined with other options related to livestock husbandry, such as livestock diversification or use of native breeds.

Adaptation Option:	Maintenance / reintroduction of terraces
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Adaptation Option:		Maintenance / reintroduction of terraces
<p><i>The measure includes maintenance and reintroduction of terraces which had been removed to increase field-plot size, have been converted to other land use (for example, hedges into grassland), or have not been maintained due to reduced labour availability or reduced cultivation. Terracing on sloping land is important for reducing soil erosion and surface run-off. Terraces, which are labour intensive to maintain, help to preserve soil productive capacity, maintain landscape values, reduce risk of flooding and reduce pressures on water quality. Terraces are also important for nature and habitat protection (stone-walls and hedges used in terracing, for example, create valuable habitats).</i></p>		
Climate addressed:	threat	soil erosion, storms, flooding, flash floods
Urgency:	<p>The option needs to be implemented already in the short-term, especially in areas most prone to soil erosion (in particular highly sloping areas) which are also areas prone to extreme rainfall events. The option has multiple benefits for several environmental policy objectives.</p>	
Effectiveness (considering different climate scenarios)	<p>The option is effective already at present under a business-as-usual scenario with existing climate variabilities (no-regret). The option is robust under a medium scenario and extreme scenario.</p>	
Expenditure Category(ies):	RD Regulation proposal Articles 18, 19, 29	
Coherence with other policy objectives	<p>The option has synergies with climate mitigation (where terraces include planting of hedges, for example) because it allows for sequestration of carbon in biomass above ground, for protection of water quality, as well as protection of valuable habitats.</p>	
Coherence with other adaptation options	<p>The option effectiveness can be increased when combined with other measures to protect against soil erosion and flooding, such as, for example, winter plant cover or conservation soil tillage.</p>	

Adaptation Option:		Diversified crop rotations
<p><i>Increasing the diversity of crop rotations consists of the inclusion of additional crop types in a planned sequence of crops on the same piece of land. It has benefits for productivity, reduced runoff and erosion, increased organic matter and carbon sequestration, improved soil quality, pest management, and better moisture efficiency. Crop rotations provide habitat and food to different species, thus promoting greater biodiversity.</i></p>		
Climate addressed:	threat	soil erosion, droughts, flooding, disease/pest outbreak, temperature extremes
Urgency:	<p>The measure should be implemented immediately in the period up to 2020, as it brings multiple benefits for the</p>	

Adaptation Option:	Diversified crop rotations
	overall productivity and sustainability of farming (in particular soil productivity and avoided pest problems) over the long term.
Effectiveness (considering different climate scenarios):	This multiple-benefit measure has several proven positive effects under business-as-usual scenario (a no-regret measure). It also has high robustness under medium and extreme scenario due to its implication on the maintenance of productivity, pest management, and soil productivity.
Expenditure Category(ies):	RD Regulation Proposal Article 29, Greening Payments Pillar 1
Coherence with other policy objectives	Crop rotations help to achieve objectives of the Nitrates Directive and pesticide legislation through reducing pollution in water and soil, and reducing soil erosion. The measure contributes to landscape and wildlife enhancement, biodiversity, climate change and soil protection. There are strong synergies with Water Framework Directive.
Coherence with other adaptation options	Synergies with the following adaptation measures are particularly relevant: organic farming practices, intercropping, plant cover in winter, pest/disease monitoring and integrated pest management, irrigation efficiency.

Adaptation Option:	Intercropping
<i>Intercropping consists of growing two or more crops in proximity in the same field during a growing season in order to promote interaction between them. It can support yield improvement and stability, by increasing resilience, protection against pests and diseases.</i>	
Climate threat addressed:	soil erosion, storms, flooding, flash floods, disease
Urgency:	Intercropping is an option which should be started short-term up to 2020 due to the already existing soil erosion problems. Furthermore, a slight increase of extreme events is already expected in the next years.
Effectiveness (considering different climate scenarios):	Intercropping has a high positive effect on resilience of farm level production regarding climate risk. It is already effective under a business-as-usual scenario with existing climate variabilities (no-regret). The measure is also robust under extreme climate scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Article 29
Coherence with other policy objectives	Co-benefits are especially strong with Water Framework Directive (WFD).
Coherence with other	Synergies exist with other cropping related options,

Adaptation Option:	Intercropping
adaptation options	especially catch crops and plant winter cover.

Adaptation Option:	Plant winter cover
<i>Farmers can choose from a variety of winter cover crops to add nitrogen, control weeds, protect soil and/or increase soil organic matter. Utilizing winter plant cover is not only a preventative measure to mitigate climate change impacts, it is also an important method to improve soil structure, and cost savings by reducing farmers' reliance on fertilizer.</i>	
Climate threat addressed:	soil erosion, storms, flooding, flash floods, droughts
Urgency:	Political processes to implement the measure and raising awareness among farmers also require time. Given the high current rates of diffuse nutrient pollution and soil erosion, the measure should be implemented immediately.
Effectiveness (considering different climate scenarios):	There is high certainty that the measure can effectively reduce nutrient run-off and leaching, as well as erosion and have secondary beneficial effects. The measure is effective under all scenarios.
Expenditure Category(ies):	RD Regulation Proposal Article 29
Cost-Benefit assessment:	Available
Coherence with other policy objectives	The measure helps to achieve the objectives of the Water Framework Directive, the Nitrates and the Floods Directive, through protecting water quality by preventing nitrate pollution in ground and surface waters and reducing potential damages of floods.
Coherence with other adaptation options	Winter plant cover can be implemented alongside buffer strips, and combined with catch crops, intercropping, and diversified crop rotations and organic farming.

Adaptation Option:	Organic farming
<i>Organic production methods and practices comprise many of the land management options highlighted as priorities for climate adaptation and can also contribute to climate mitigation, for example those relating to improving soil organic matter, soil fertility and improving the water-holding capacity of the soil. The use of crop rotations should help avoid issues of pests and diseases associated with monocultures. Through these sorts of management practices farmland should be more resilient to the impacts of climate change..</i>	
Climate threat	soil erosion, flooding, storms, temperature extremes,

Adaptation Option:	Organic farming
addressed:	droughts
Urgency:	Organic farming should be implemented already short-term up to 2020. First climate change impacts are seen already today and will increase in the next years. Through organic farming the resilience of farms for different impacts and challenges which already occur at the moment, can be increased.
Effectiveness (considering different climate scenarios):	The option will increase the resilience of farm production regarding climate change in a medium scenario with a 2°C temperature. Due to existing problems it is already necessary under existing climate conditions (no-regret). It is also robust under extreme climate change scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Article 30
Coherence with other policy objectives	There are synergies with the Water Framework Directive (WFD), Nitrates Directive and biodiversity policies.
Coherence with other adaptation options	Many co-benefits for other adaptation options exist. E.g. options regarding soil erosion like conservation soil tillage. Furthermore, land use options and cropping practices have synergies with organic farming, e.g. intercropping, crop diversification, residue management, etc.

Adaptation Option:	Use of adapted crops
<i>The measure involves the use of crops which can deliver more stable yields under changing climate conditions, or which have lower water demand. Depending on the local climate and soil conditions, this may involve the switch in varieties of crops, but also the switch from one type of crop to another. Policy support may be given as a stimulus to farmers to select crops which have more stable yields but lower maximum yield, or which have significant environmental benefits in terms of reduced pesticide or water use.</i>	
Climate threat addressed:	temperature extremes, water scarcity, droughts, storms, disease
Urgency:	Much of crop switching occurs autonomously on farms as a standard practice. Additional support should be provided in the immediate period up to 2020 to deal with rapid changes that farmers do not address autonomously.
Effectiveness (considering different climate scenarios)	This is a no-regret option. It is already effective under business-as-usual scenario. Under extreme scenario, crop adaptation will still be effective, but it would require more severe changes in the choice of crops.
Expenditure Category(ies):	RD Regulation Proposal Article 29

Adaptation Option:	Use of adapted crops
Coherence with other policy objectives	The use of adapted crops can have benefits for other environmental objectives, including mitigation (if this includes inclusion of catch crops, for example).
Coherence with other adaptation options	The measure is closely linked and can reinforce the benefits of other cropping adaptation measures such as diversified crop rotations, intercropping, and winter plant cover.

Adaptation Option:	Use of native breeds to promote genetic diversity
<i>The measure supports the use and preservation of native livestock breeds. These may be better adapted to regional conditions, increase the genetic diversity of livestock population, and thus provide a potential pool of genetic material which may be very valuable for future breeding purposes and for increasing adaptability and resilience of production. Given changes in climate, native breeds that are adapted to the likely future climate of the area need to be prioritised. These may not be the same as the breeds that have traditionally been used in a particular region.</i>	
Climate threat addressed:	Temperature extremes, diseases, indirect: drought
Urgency:	The measure should be implemented in the period up to 2020, to avoid further loss of native breeds
Effectiveness (considering different climate scenarios):	The measure is effective under business-as-usual scenario as it contributes to the preservation of biodiversity. Local breeds may also be used as part of marketing strategy by farms to add value to their production. The measure is further important and robust under medium (2°C) and extreme scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Articles 29, 19
Coherence with other policy objectives	The measure has strong link to biodiversity protection.
Coherence with other adaptation options	The measure has synergies with livestock diversification, improved animal rearing conditions (some breeds may be better adapted to local weather conditions and thus their inclusion would reinforce the effect of improved conditions).

Adaptation Option:	Pest/disease monitoring and integrated pest management
<i>Integrated pest management is a multidisciplinary, ecologically based pest management system which will allow growers to minimise the use of pesticides and thereby reduce the risk of chemical run-off and water pollution; it can facilitate responses to increased risk of pest and disease occurrence under climate change. Monitoring is a necessary requirement to react quickly to pest and disease occurrence to minimize damage to crops.</i>	
Climate threat	Temperature extremes, disease/pest outbreak

Adaptation Option:	Pest/disease monitoring and integrated pest management
addressed:	
Urgency:	The measure should be implemented immediately as it addresses pressing problems of pesticide pollution of water bodies and damage caused to biodiversity.
Effectiveness (considering different climate scenarios)	The measure is effective under business-as-usual scenario, and its importance increases under medium and extreme climate change.
Expenditure Category(ies):	RD Regulation Proposal Articles 29, 19
Coherence with other policy objectives	The measure is linked to the implementation of Pesticide Directive, Water Framework Directive and biodiversity protection.
Coherence with other adaptation options	The measure is closely linked to cropping practices such as diversified crop rotations and intercropping, as well as buffer strips and farm advice.

Adaptation Option:	Afforestation (e.g. of cropland and grassland)
<i>Afforestation is the process of establishing a forest or stand of trees in an area where there is not currently one. Targeted planting can reduce pollutant sources and interrupt pollutant pathways as well as assist in sediment control, flood alleviation, carbon sequestration and the provision of recreational opportunities, amongst other benefits. For the measure to be beneficial and not have negative effects on other environmental objectives (especially biodiversity), species planted must be native and planting has to be situated in appropriate locations and NOT on natural/semi-natural grassland.</i>	
Climate threat addressed:	flooding, flash floods, storms, soil erosion
Urgency:	Targeted afforestation can address existing problems with water pollution, soil erosion and flooding, and should be implemented already in the period up to 2020.
Effectiveness (considering different climate scenarios)	It is effective under a business-as-usual scenario with existing climate variabilities where it is appropriately located and using native species. The option has positive impacts on different environmental objectives also in a medium scenario with a 2°C temperature and is robust under extreme climate scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Articles 23, 22
Coherence with other policy objectives	When appropriately placed, it has synergies exist with objectives under Water Framework Directive (WFD).
Coherence with other adaptation options	The option is closely linked to buffer strips (where these are larger strips and planted with trees), as well as flood alleviation measures.

Adaptation Option:	Establishment of agroforestry systems	
<i>Growing farmland trees (tree crops, shelterbelts, hedgerow, alley cropping) is a practice of allowing trees and crops to grow together. The species, location, layout, and density of the planting depend on the purpose and planned function of the practice. The measure is a multipurpose measure contributing to reducing wind erosion, protection of crops, and provision of shelter for structure and livestock, habitat creation for wildlife and carbon sequestration.</i>		
Climate threat addressed:		flooding, flash floods, storms, soil erosion
Urgency:	The measure is multipurpose measure, addressing existing environmental problems which also affect farm resilience, and should be implemented already in the period up to 2020.	
Effectiveness (considering different climate scenarios)	It is effective under a business-as-usual scenario with existing climate variabilities when appropriately designed. The option also has benefits for soil protection and flood protection in a medium scenario with a 2°C temperature and depending on the design and location of the system is robust under extreme climate scenarios (> 4°C).	
Expenditure Category(ies):	RD Regulation Proposal Articles 24, 19, 35	
Coherence with other policy objectives	The measure has multiple benefits for other environmental objectives, including biodiversity, water protection and carbon sequestration.	
Coherence with other adaptation options	It has synergies with flood protection measures, improved animal rearing conditions and soil management measures.	

2.1.1. Infrastructure Options

Adaptation Option:	Improvement of animal rearing conditions (shading, sprinkler to cool livestock)	
<i>This includes shading, shelters and sprinklers to cool livestock outside in order to decrease the stress that animals experience during hot weather, thereby safeguarding their productive capacities (in terms of quality and quantity of production).</i>		
Climate threat addressed:		Temperature extremes, hail, storm
Urgency:	Especially in regions with high risk of increasing temperatures, the option needs to be implemented in the short-term up to 2020. Furthermore, for green options (growing of trees) some years after initiating are needed to reach the effect.	
Effectiveness (considering different climate scenarios):	The effectiveness is medium, because the option can reduce the air temperature, but only by limited amount of degrees. In the most European regions the options is not necessary under a business-as-usual scenario with existing climate	

Adaptation Option:	Improvement of animal rearing conditions (shading, sprinkler to cool livestock)
	variabilities. The option is however not very robust to extreme climate scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Articles 18, 34, 23, 29
Coherence with other policy objectives	Synergies exist with options regarding animal health and welfare, especially the 2012-2015 European Commission's Strategy for the Welfare and Protection of Animals and the European Convention for the Protection of Animals Kept for Farming Purposes and the corresponding Council Directives for the animal health rules governing production, processing, distribution and introduction of products of animal origin for human consumption.
Coherence with other adaptation options	The option shows positive effects on other options regarding animal health and welfare such as pest and disease management and livestock diversification.
Cost-Benefit assessment:	Available

Adaptation Option:	Cooling of stables
<i>Includes passive cooling through the design of housing and active cooling through cooling pads and other technologies.</i>	
Climate threat addressed:	Temperature extremes
Urgency:	Especially in regions with high risk of increasing temperatures, the option needs to be implemented in the short-term up to 2020.
Effectiveness (considering different climate scenarios):	In the most European regions the options is not necessary under a business-as-usual scenario with existing climate variabilities. The option is however not very robust to extreme climate scenarios (> 4°C), especially passive cooling systems have a limited effect by extreme heat.
Expenditure Category(ies):	RD Regulation Proposal Articles 18
Coherence with other policy objectives	Synergies exist with options regarding animal health and welfare, especially the 2012-2015 European Commission's Strategy for the Welfare and Protection of Animals and the European Convention for the Protection of Animals Kept for Farming Purposes and the corresponding Council Directives for the animal health rules governing production, processing, distribution and introduction of products of animal origin for human consumption.

Adaptation Option:	Cooling of stables
Coherence with other adaptation options	The option shows positive effects on other options regarding animal health and welfare such as disease management and livestock diversification.

Adaptation Option:	Irrigation efficiency
<i>A shift from the gravity irrigation to modern pressurised systems (e.g. drip and sprinkler irrigation) and improved conveyance efficiency provide an opportunity for reduced water demand in irrigation.</i>	
Climate threat addressed:	water scarcity, droughts
Urgency:	Especially in regions with already existing periods of water scarcity the option should be implemented in short-term (up to 2020). Furthermore, the renewable cycle of irrigation systems has to be taken into account.
Effectiveness (considering different climate scenarios):	The option will strongly increase the resilience of farm production regarding climate change in a medium scenario with a 2°C temperature. It is already effective under a business-as-usual scenario with existing climate variabilities (no-regret) due to the existing water scarcity problematic. The measure is not robust to extreme climate scenarios (> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Article 18
Coherence with other policy objectives	High synergies exist with Water Framework Directive (WFD).
Coherence with other adaptation options	Synergies are seen with other water-related options, like water metering and on farm harvesting of water.

Adaptation Option:	On farm harvesting and storage of rainwater (small scale reservoirs, methods for water collection, waste water reuse)
<i>System designs for rainwater harvesting range from a simple barrel at the end of a downspout to a complex multiple end-use system using a large cistern. The measure helps to mitigate flooding by reducing runoff at times of high rainfall and reduces pressures on water resources during times of water scarcity. Implementing rainwater harvesting systems also reduces non-point source pollution such as pesticides, fertilizers and petroleum products that contaminate rivers and groundwater.</i>	
Climate threat addressed:	water scarcity, droughts, flooding/flash floods
Urgency:	Especially in regions with already existing periods of water scarcity the option should be implemented in short-term (up

Adaptation Option:	On farm harvesting and storage of rainwater (small scale reservoirs, methods for water collection, waste water reuse)
	to 2020).
Effectiveness (considering different climate scenarios):	The option will increase the resilience of farm production regarding climate change in a medium scenario with a 2°C temperature. It is effective under a business-as-usual scenario with existing climate variabilities only in a limited amount of European regions where water scarcity is already a problem and enough rain exists in winter. The measure has a limited robustness to extreme climate scenarios (> 4°C) depending on winter rainfall.
Expenditure Category(ies):	RD Regulation Proposal Article 18
Coherence with other policy objectives	High synergies exist with Water Framework Directive (WFD).
Coherence with other adaptation options	Synergies are seen with other water-related options, like water metering and irrigation efficiency.
Cost-Benefit assessment:	Available

2.2. Farm Management

Adaptation Option:	Livestock diversification
<i>Livestock diversification can reduce farm vulnerability and help to generate new income. At farm level, diversification can be implemented by introducing new species and breeds. Moreover, improving the suitability of local breeds to new environmental conditions through crossing is a more systemic task of agricultural research.</i>	
Climate threat addressed:	Temperature extremes, diseases
Urgency:	Livestock diversification at farm level should already be implemented in the immediate period up to 2020 as a means of economic diversification, as well as to address overgrazing in some areas.
Effectiveness (considering different climate scenarios):	The measure is effective under all scenarios, and its relevance increases with medium (2°C) and extreme scenarios ((> 4°C).
Expenditure Category(ies):	RD Regulation Proposal Article 29
Coherence with other policy objectives	The measure has strong link to biodiversity protection.
Coherence with other adaptation options	The measure has synergies with use of native breeds to promote genetic diversity, the measure reducing grazing pressure (for example, by shifting from cattle to sheep or goats) and improved animal rearing conditions (some breeds

Adaptation Option:	Livestock diversification
	and species may be better adapted to local weather conditions and thus their inclusion would reinforce the effect of improved conditions).

Adaptation Option:	Insurance schemes
<i>Insurance schemes are a specific category of economic instruments. Their aim is to take away the burden of losses due to climate or weather extremes and make the impacts of such events bearable.</i>	
Climate threat addressed:	all threats
Urgency:	Insurance schemes can be implemented quite quickly, so that at first (up to 2020) insurance schemes should be provided for those areas where high damages costs are expected in the immediate future (e.g. for hailstorms which can destroy the whole yield of a vulnerable region, or for flooding events).
Effectiveness (considering different climate scenarios):	The increased resilience is medium, due to the limitations on the insurance sum. For some events and regions insurance schemes may be necessary already under a business as usual scenario, but for the most events and regions that is not the case. Due to limited insurance sums the option has a limited robustness.
Expenditure Category(ies):	RD Regulation Proposal Articles 38, 37, 39
Coherence with other policy objectives	-
Coherence with other adaptation options	Synergies exist with adaptation options regarding use of other crops or diversification of crops. Furthermore insurances show positive effects for the adaptation of buildings.

2.3. Advice

Adaptation Option:	Farm Advice
<i>Provision of information and guidance tailored to the needs of individual farmers enable improved decision-making capacities in response to climate change risks.</i>	
Climate threat addressed:	all threats
Urgency:	The delivering of information and guidance is short-term option which should be implemented up to 2020.
Effectiveness (considering different	The effect of the option is high, if the information and guidance reach the target group and an implementation of practical measures are performed. Due to already existing

Adaptation Option:	Farm Advice
climate scenarios):	problems, e.g. regarding soil erosion and soil fertility, the options is necessary under existing climate conditions and under a business-as-usual scenario (no-regret). The effect of the option is kept also under extreme climate scenarios (> 4°C), but the effect also depends on robustness of the suggested measures.
Expenditure Category(ies):	RD REGULATION PROPOSAL Articles 16, 15, Farm Advisory Service Pillar 1
Coherence with other policy objectives	Synergies are strong with different environmental objectives, including Water Framework Directive (WFD).
Coherence with other adaptation options	Farm Advice has positive effects on many different measures, which can be promoted by providing guidance for farmers, e.g. cropping practices, soil and water related options.