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

Sectoral fiches for Cohesion Policy

April 2013

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1. SECTORAL FICHE 1: BUILDINGS

1.1. Introduction

By aiming to improve social inclusion through improved infrastructure including public housing schools, health care centres and other public sector institutions, funding for the buildings sector is an important part of Cohesion Policy expenditure. This fiche provides a summary of the main threats to buildings from climate change, and indicates the approximate amount of Cohesion Policy expenditure on buildings in Member States during the 2007-2013 funding period. It also provides advice on possible options that might be used to increase the resilience of buildings to future climate change.

The fiche can be used alongside the guidance for climate proofing across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for authorities responsible for infrastructure investments that involve buildings, particularly in the housing and social infrastructure sectors. It gives a short, concise overview of why and how climate change impacts are relevant for the buildings sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes. This and other Sectoral Fiches have been prepared for the EU-27; using this structure as a guide, authorities can supplement the information here with national and/or regional details.

1.2. How will climate change impact buildings in the EU?

The sensitivity of buildings to damage from climate change has implications for Cohesion Policy expenditure; this will require well-informed regional and development planning. Climate change will lead to increased levels of damage to the residential, industrial and commercial built stock, as a result of floods and storms.

1.2.1. Climate threats to buildings

A review of the available evidence suggests that buildings are likely to be subject to a number of threats as a result of changing climatic conditions. Overall, the threats to the building sector reflect in part macro-estimates about the distribution of climate threats across the EU, with the most substantial impacts in the North and North-West regions.

The analysis below briefly summarises the main threats to buildings, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions using the EEA analysis of climate threats across the main EU climatic regions.[1]

[1] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen
North = FI, SE, EE, LV, LT
North-West = DK, NL, FR, BE, IE, UK
Mediterranean = ES, PT, IT, CY, MT, EL
Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

The review of evidence indicates that impacts are expected from flooding (**Error! Reference source not found.**). Regionally, the assessment shows that the impacts from climate change are likely to be highest in the North and North-West regions, where there are already some existing adaptive measures to mitigate climate risks. The lowest risk to buildings is expected in the Mediterranean region.

Table 1: Assessment of the relative scale of impacts on buildings from climate change-related events/factors across EU climate regions, to 2020

Region	Flooding – Coastal	Flooding - River	Storms	Temperature increase
North	Medium	High	Medium	Low
North-West	High	Medium	Medium	Low
Mediterranean	Low	Medium	Low	Medium
Central & Eastern	Low	High	Low	Low

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

Table 2: Assessment of the relative scale of overall climate change impacts on buildings across EU climate regions, to 2020

Region	Damage to buildings
North	High
North-West	High
Mediterranean	Low
Central & Eastern	Medium

Source: Own assessment

1.2.2. Damage costs for the building sector

The major impacts to buildings as a result of climate change are likely to be a result of coastal and river flooding. The assessed impacts of damage costs cover a range of impacts to different receptors. In the case of flooding from sea level rise, the assessment is based on the costs to people forced to move and the loss of land. These impacts provide a rough first approximation of the costs of damage to or loss of buildings and are estimated at €5 billion (2005 prices) a year for the chosen scenario, in the 2020s. In the case of river floods, the damage to residential,

industrial and commercial buildings has been estimated at €20 billion (2006 prices) for the chosen scenario, in the 2020s.[2]

Building owners and users also face higher costs as a result of increases in demand for energy due to higher temperatures, although in northern regions these costs will be offset (at least in part) by the reduced demand for energy in the winter due to milder winters

1.2.3. Relative spread of damage costs by region

The assessment suggests that the overall climate change-related risks to buildings will reflect the distribution of flood and storm risks. These are highest in the North and North-West regions, but river flood risks are also high in the Central & Eastern region. The Mediterranean region is less affected, with main impacts resulting from higher temperatures and the consequent increase in demand for cooling.

North

The highest risks from river flooding are likely to occur in the North region. The region is also likely to face threats from storms. Rising temperatures are likely to increase cooling and air-conditioning requirements in the summer; however these are likely to be offset by lower energy use in winter due to milder temperatures.

North-West

Risks from coastal flooding are likely to be substantially higher in the North-West region than other regions. Threats from river flooding and storms are also relatively high. Similar to the Northern region, rising temperatures will decrease heating required in the winter, and increase cooling requirements in the summer.

Mediterranean

The impact of rising temperatures is likely to be most prevalent in the Mediterranean and Central & Eastern regions. Rising temperatures will lead to a greater use of air conditioning in buildings, bringing about a net increase in energy demand and related costs for building owners and users.

Central & Eastern

Along with the Northern region, the Central & Eastern region is facing high risks from river flooding. The Central & Eastern region is also likely to experience the impacts of rising temperatures, and a corresponding increase in cooling requirements.

1.2.4. Cohesion Policy expenditure

The table below shows funding allocations for housing infrastructure in the 2007-2013period. Note that this figure is indicative, as expenditure for buildings exists in many other categories, such as health, education and tourism.

Table 3: Building infrastructure Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Infrastructure	EUR m
78	Housing infrastructure	893.4

[2] The total capital value of all housing in EU27 in 2011 is approximately €634 billion. The annual flood damage represents approximately 3% of total capital value. If the value of housing is depreciated over 100 years (€6 billion), then the damage represents around three times the annual depreciation.

Source: Expenditure category data from DG Regional Policy

For 2014-2020, the buildings sector will remain relevant for Cohesion Policy funding. Thematic objective (9) *promoting social inclusion and combating poverty,* will fund housing infrastructure and other types of social infrastructure such as for education and health care. Investments in buildings can also carried out as part of support to SMEs (Thematic objective 3) and to address energy demand from buildings under Thematic objective (4) *supporting the shift towards low-carbon economy in all sectors*.

1.3. How do these impacts affect Cohesion Policy/CAP programmes and projects in my Member State?

The table below provides specialised information for each Member State on the potential extent of the threat to buildings and capacity to address it, relative to other countries in the EU.

Aggregated climate impacts from all threats are presented for each climatic region[3], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to buildings by the Member State for 2007-2013 and the per cent share of buildings in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national information platforms; technological resources in terms of the percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation. The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impacts, higher percentages of funds dedicated to the buildings sector and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

Table 4: Overview of relative impacts and Cohesion Policy risk by Member State for housing infrastructure

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	

[3] The score 'high', 'medium' or 'low' is assigned to the Member State based on the region (North, North-West, Mediterranean, Central & Eastern) to which it belongs.

Austria	Medium	0.0	0.0%	High
Belgium	High	0.0	0.0%	High
Bulgaria	Medium	32.3	0.5%	Low
Cyprus	Low	0.0	0.0%	Low
Czech Republic	Medium	0.0	0.0%	Medium
Denmark	High	0.0	0.0%	High
Estonia	High	7.92	0.2%	Medium
Finland	High	0.0	0.0%	High
France	High	0.0	0.0%	High
Germany	Medium	0.0	0.0%	High
Greece	Low	0.0	0.0%	Low
Hungary	Medium	123.7	0.5%	Medium
Ireland	High	0.0	0.0%	Medium
Italy	Low	111.2	0.4%	Low
Latvia	High	30.0	0.7%	Low
Lithuania	High	206.0	3.0%	Low
Luxembourg	Medium	0.0	0.0%	Medium
Malta	Low	0.9	0.1%	Low
Netherlands	High	0.0	0.0%	High
Poland	Medium	243.2	0.4%	Low
Portugal	Low	6.2	0.0%	Medium
Romania	Medium	111.8	0.6%	Low
Slovakia	Medium	17.8	0.2%	Low
Slovenia	Medium	0.0	0.0%	Medium
Spain	Low	0.0	0.0%	Medium
Sweden	High	0.0	0.0%	High
UK	High	0.0	0.0%	High

1.4. What are some of the best ways to build resilience of buildings using Cohesion Policy expenditure?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some ideas on how Cohesion Policy Programmes can build in resilience to future impacts of climate change.

This is not an exhaustive list but a menu of possible adaptation options for the buildings sector. The main aim is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored to individual needs.

The options were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

Options are summarised here for the building sector. A searchable database of options for all Cohesion Policy and CAP sectors is available on the European Climate Adaptation Platform - CLIMATE-ADAPT.

1.4.1. Adaptation Options for the Building Sector

Adaptation Option:	**Energy efficient adaptation of homes against heat**
Higher average summer temperatures and the increased incidence of heat waves will have adverse health effects, especially in highly populated areas. To alleviate these effects, homes should be fitted against heat with energy efficient cooling systems. Energy efficient cooling systems include systems like passive cooling, based on renewable energies. More information on relevant technical solutions can be found in these options: 'Cooling of Hospitals' and 'Higher energy efficiency of ventilation systems'.	
Climate threat addressed:	Temperature extremes, heat
Urgency:	Short-term, up to 2020: Especially in regions with high risk of increasing temperatures, the option needs to be implemented in

	the short-term up to 2020. The fact that buildings have a long renewable cycle increases this need.
Effectiveness (considering different climate scenarios)	Energy-efficient adaptation of homes has the potential to avoid a large share of climate-change induced health costs (due to indoor activities). Especially in Southern regions, it is already effective under a business-as-usual scenario with existing climate variability (no-regret). The option is however not very robust to extreme climate scenarios (> 4°C): especially passive cooling systems are not sufficient under extreme heat.
Expenditure Category(ies):	059 EE in existing housing
Coherence with other policy objectives	This option has synergies with climate mitigation, especially all activities on energy-efficiency in buildings.
Coherence with other adaptation options	The overall effectiveness of this option is increased if combined with adaptation options focusing on preventing health effects due to outdoor activities, e.g. *'Green and blue spaces, incl. green roofs'*. For optimizing synergies with mitigation policy, a combination with the option '*Higher energy efficiency of ventilation systems*' is recommended.

Adaptation Option:	**Energy efficient adaptation of offices, industrial plants to heat**
Higher average summer temperatures and the increased incidence of heat waves will have adverse health effects, especially in highly populated areas. To mitigate these effects, and to avoid losses to labour productivity. Offices and industrial buildings should be fitted against heat. A cooling of buildings can provide stable working conditions and can thus ensure that the full labour capacity is provided. Energy efficient cooling systems include systems like passive cooling, based on renewable energies. (e.g. geothermal heat exchanger, concrete core activation, night ventilation systems).	
Climate threat addressed:	Heat
Urgency:	Short-term, up to 2020: As heat waves can already be observed under current climate conditions (especially in Southern countries) and as the lifetime of cooling systems is rather long, implementation is urgent and should be considered in the next programming period up to 2020.
Effectiveness (considering different climate scenarios):	Energy-efficient cooling of offices has the potential to avoid a large share of productivity losses due to heat. Especially in Southern regions, it is already effective under a business-as-usual scenario with existing climate variability (no-regret). The option is however not very robust to extreme climate scenarios (> 4°C): especially passive cooling systems are not

	sufficient under extreme heat.
Expenditure Category(ies):	060 EE in SMEs
Coherence with other policy objectives:	If passive cooling systems are implemented, the option is in line with EU mitigation policies (especially energy-efficiency).
Coherence with other adaptation options:	In order to create synergies with mitigation policies, the option needs to be combined with '*Higher energy efficiency of ventilation systems*'. It also has a close link to options focusing on improving outdoor air quality, e.g. '*Green and blue spaces, incl. green roofs*'.

Adaptation Option:	**Protection of buildings to storms, extreme precipitation**
Due to climate change, the patterns of precipitation will become more volatile and uncertain. The objective of this option is to protect buildings and their interior against extreme precipitation and storms. The option focuses especially on buildings with a high relevance for population and industry, e.g. power stations, hospitals, etc. For example, the roof and the outer shell of buildings have to be built in a manner that is resistant against these events. Furthermore, drainage systems have to be adapted against flooding and flash floods (see below a list of options focusing on water infrastructures that could provide co-benefits).	
Climate threat addressed:	Increase in precipitation
Urgency:	Short/medium-term, up to 2020 in some cases: The urgency depends on the type of building and the underlying climate threat. Some regions will face increasing storms and precipitation already in the short-term up to 2020. Here, the option should be implemented in the next programming period. If uncertainties around climate change scenarios are still high, implementation could be postponed beyond 2020, as most elements can be implemented rather quickly.
Effectiveness (considering different climate scenarios)	The option will be able to prevent a considerable share of climate change related damage costs to buildings in a medium scenario with a 2°C temperature increase. As it is not necessary under existing climate conditions, it is not robust in a business-as-usual scenario. Effectiveness also seems to be limited under extreme climate change scenarios (> 4°C).
Expenditure Category(ies):	059 EE in existing housing

Adaptation Option:	**Protection of buildings to storms, extreme precipitation**
Coherence with other policy objectives	The option supports the general objectives of the EU to prevent natural and man-made disasters.
Coherence with other adaptation options	The option has synergies with all adaptation options focusing on preventing damages from coastal flooding: '*Flood gates*', '*Dike reinforcement and heightening*' and '*Soft coastal defenses*'. To prevent further accumulation of assets in vulnerable areas, it should also be combined with '*Strategic urban and regional planning*'. To prevent damages from extreme precipitation, the option could also be combined with adaptation options that reduce the vulnerability to flooding, e.g. '*Additional rain overflow basins to adapt sewage system against flooding*' and '*River restoration (buffer zone), restoration of wetlands'*.

Adaptation Option:	**More water-efficient building constructions**
One of the effects of climate change will be the increase in the incidence of drought due to changing precipitation patterns. This adaptation option focuses on the reduction of water demand due to water-efficient building constructions. For example, rain water can be collected and used through a split water cycle for drinking and grey water. This option could also include harvesting of rainwater for 'grey' water uses (e.g. flushing of toilets), a water-efficient design of plumbing systems or an adjustment of water pressure.	
Climate threat addressed:	Water scarcity, drought
Urgency:	Medium-term, up to 2030: Urgency is categorized as medium so that implementation can be planned up to 2030. However, in regions that are already facing drought problems, the option could be implemented in the short-term up to 2020.
Effectiveness (considering different climate scenarios)	Implementation of this option will reduce problems with climate-change induced drought. Especially in dry regions, it is already effective under a business-as-usual scenario with current climate variability. Under extreme climate scenarios (> 4°C), effectiveness seems however limited – especially during long drought periods.
Expenditure Category(ies):	076 Community-led local development in urban/rural areas
Coherence with other policy objectives	This option has synergies with other EU activities to protect citizens from drought (especially Communication on water scarcity and drought).

Coherence with other adaptation options	Effectiveness is improved if implemented together with '*Demand management (rationale water use, restriction of groundwater consumption, etc.)*'.

1.5. List of further resources

- Adaptation Wizard, UKCIP (2010) 5-step process to assess vulnerability to current climate and future climate change, identify options to address key climate risks, and help to develop and implement a climate change adaptation strategy.
- AdaptME toolkit, UKCIP (2011) Climate change adaptation and monitoring toolkit, to help evaluate current adaptation activities.
- AdOpt, UKCIP (2011) Information on the range of adaptation options and practical examples. Includes a checklist of key principles for good adaptation decisions. Intended for decision- and policy-makers in identifying and appraising the effectiveness of climate risk adaptation measures.
- AMICA Adaptation Tool; PIK-Potsdam, Interreg IIIC (2005-2006) A Matrix of adaptation measures and a list of evaluated practice examples.
- Brown S, Nicholls R. J, Vafeidis A, Hinkel J, and Watkiss P (2011). The Impacts and Economic Costs of Sea-Level Rise on Coastal Zones in the EU and the Costs and Benefits of Adaptation. Summary of Results from the EC RTD ClimateCost Project. In Watkiss, P (Editor), 2011. The ClimateCost Project. Final Report. Volume 1: Europe. Published by the Stockholm Environment Institute, Sweden, 2011.
- Business savings in a changing climate; Sefton Council UK (2011) Adaptation support for businesses in Sefton, UK. A guide (leaflet) and a checklist on climate change adaptation for businesses to become more aware of climate change impacts and become more climate resilient.
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2. SECTORAL FICHE 2: ENERGY[4]

2.1. Introduction

By aiming to improve energy efficiency and the transition to low-carbon and climate resilient economy, and as a significant input provider for all economic activity, the energy sector is an important part of Cohesion Policy expenditure. This fiche provides a summary of the main threats to the EU energy sector from climate change, and indicates the approximate amount of Cohesion Policy expenditure on energy infrastructure in Member States during the 2007-2013 funding period. It also provides advice on possible options that might be used to increase the resilience of the EU energy infrastructure to future climate change.

The fiche can be used alongside the guidance for climate proofing across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for authorities responsible for the energy sector. It gives a short, concise overview of why and how climate change impacts are relevant for the energy sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes. This and other Sectoral Fiches have been prepared for the EU-27; using this structure as a guide, authorities can supplement the information here with national and/or regional details.

2.2. How will climate change impact the energy sector in the EU?

Cohesion Policy is used to finance investment in the energy sector, through ERDF and the Cohesion Fund. For 2007-2013, energy investments are aimed at stimulating regional development and, through the TEN-E network, further development of the Single Market. For 2014-2020, energy investments will focus on supporting a shift towards a low-carbon and climate resilient economy, and investments supporting the internal market will be funded through the Connecting Europe facility. This fiche covers climate threats to the energy sector as a whole.

All types of energy infrastructure are affected by weather events, but installations for renewable energy, thermal facilities, offshore or coastal facilities, and energy infrastructure resting on melting permafrost are particularly vulnerable. The sensitivity of the energy sector will be largely influenced by the life-times of energy plants and distribution systems. The costs of retro-fitting to build resilience are potentially very high.

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[4] Discussion of climate impacts and damage costs refers to disruptions in energy infrastructure installations that would affect the supply of energy. Cohesion Policy funding for the energy sector for 2007 – 2013 is mainly oriented towards energy generation, transmission and distribution, but does cover the demand side through investments in energy efficiency.

2.2.1. Climate threats to the eu energy supply system

Table 1 shows the extent of the range of threats that EU energy infrastructure is likely to be subject to as a result of changing climatic conditions. Given the wide distribution of EU energy systems, the threats reflect the general distribution of climatic threats across the EU.

The analysis below briefly summarises the main threats to the energy system, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions using the EAA analysis of climate threats across the main EU climatic regions.[5]

The review of evidence indicates that major impacts are expected from temperature increases over time and from extreme weather events; this is in part due to the impacts of higher temperatures on operating loads and the need for cooling. The potential scarcity of water for cooling, combined with increases in demand due to climate change, exacerbates the problem.

Energy plants that are especially reliant on continued water supply are at risk, if the climate effects on water resources lead to reduced availability and river flows. This could have a disproportionate effect on renewables such as hydropower, concentrating solar power (CSP) and biomass.

Regionally, the assessment shows that the impacts from climate change are likely to be highest in the Mediterranean and the Central and Eastern European regions, where the temperature related effects are largest, and lowest in the North and North-West region, partly because there are already some existing adaptive measures to mitigate climate risks in North and North-West regions, especially from flooding.

[5] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen
North = FI, SE, EE, LV, LT
North-West = DK, NL, FR, BE, IE, UK
Mediterranean = ES, PT, IT, CY, MT, EL
Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

Table 1: Assessment of the relative scale of impacts on energy infrastructure from climate change-related events/factors, across EU climate regions, to 2020

Region	Flooding – Coastal	Flooding - River	Water scarcity – continuous/ drought	Storms	Winter/ Snowfall	Temperature extremes including fires	Temperature increase
North	Medium	High	Low	Low	Low	Low	Low
North-West	High	Medium	Low	Low	Low	Low	Low
Mediterranean	Low	Low	High	Low	Low	High	High
Central & Eastern	Low	High	High	Low	Low	High	Medium

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

Table 2: Table 2: Assessment of the relative scale of overall climate change impacts on energy infrastructure across EU climate regions, to 2020

Region	Impacts on energy supply
North	Low
North-West	Low
Mediterranean	High
Central & Eastern	High

Source: Own assessment

2.2.2. Damage costs for the Energy sector

Various components of the energy sector are venerable to climate change. In particular, vulnerable structures include:

- **Renewable energy**

Hydropower will be adversely affected by water scarcity as a result of climate change. In periods of water scarcity, demands for water use from different sectors (such as electricity production, agriculture, industry etc.) may exacerbate supply shortages.

- **Thermal facilities**

Thermal generation facilities all need to be protected from flooding and need cooling (Rademaekers et al., 2010). Thermal power plants require a reliable supply of cooling water. Increased water temperatures and decreased runoffs may constrain availability. The absence of cooling water is the main problem for concentrating solar power (CSP). This problem can be more severe than for conventional thermal technologies, as CSP plants are usually suited to and located in areas already suffering from water shortages. However, thermal plants with a long remaining life may be subject to significant loss of efficiency over time due to reduced cooling capacity.

- **Offshore or coastal production and facilities**

Coastal production or refining facilities can be subject to flooding by sea level rise and increased exposure to winds, storms and storm surges.

- **Energy transmission systems and related grids**

Storm damage to transmission lines and the operation of energy grids is expected to increase. This damage may account for a quarter of all damage to the energy supply sector, including the damage to energy plants. Higher wind speeds, more intense rainfall and temperature changes are all expected to cause damage.

- **Energy infrastructure in cold climates, resting on melting permafrost**

Although the European arctic is relatively small and sparsely populated, energy facilities (pipelines, power lined, switch stations, etc.) located there may be affected by subsidence due to melting permafrost.

2.2.3. Relative spread of damage costs by region

<u>North</u>

The main damage to the energy sector in the North is expected from changes in snow and glacial conditions. Melting permafrost and storms are the main concern. Temperature increases of 2°C could lead to a decrease of 6% in efficiency of solar cells in Scandinavia, as a result of reduced reflection due to less snow cover and changes in solar irradiation.

On the other hand, according to Rademaekers et al. (2010), the potential for hydropower in the North region will increase as a result of increased runoff and river discharge. The potential is likely to be increased by 25 per cent in 2050, and up to 30 per cent in 2070. Also Pryor et al. (2005) project increased wind energy densities over large parts of the North region, particularly during wintertime.

North-West

Storms have led to serious damage to transmission and distribution networks in the North-West region (for example in France in 1999 and 2003, the Netherlands in 2010), although how far these past events can be attributed to climate change is uncertain. Likely future threats are going to be caused by coastal and river flooding.

Mediterranean

The Mediterranean region can expect a general decline in water availability. As a consequence, threats to CSP and thermal power plant infrastructure located in Southern Europe are expected to increase. According to the Rademaekers et al. (2010) study, the potential for hydropower is likely to decrease by up to 25 per cent in 2050 and 50 per cent in 2070.

Temperature increases of 2°C could lead to a decrease of 1% in efficiency of solar cells in the Mediterranean, thereby negatively affecting solar power in this region. According to the ESPON study, effects of climate change (higher temperatures and less precipitation) will severely impair the potential for biocrop production in Southern Europe (parts of France, Portugal, Greece and especially Spain) (ESPON). On the other hand, Alcamo et al. (2007) estimates that a decrease in energy heating requirements of 10% and increase of 30% in cooling requirements is expected by 2030.

Central & Eastern

The Central & Eastern region is likely to be vulnerable to the variability in water supply—the region is vulnerable both to droughts and water shortages as well as flooding (especially river flooding). In addition, the Central & Eastern region will be susceptible to impacts from temperature increase.

Other

Hydrofacilities such as dams, turbines and reservoirs are generally designed on the assumption that the climate (e.g. precipitation patterns) and the resulting run-off vary within predictable ranges. Climate change is projected to alter those ranges. Public authorities might need to keep a lower level in storage reservoirs so that they can absorb more rain water, thus reducing the productivity of hydropower stations.

In the Pyrenees, depending on the altitude, the maximum accumulated snow water equivalent may decrease by up to 78% and the period of snow cover will shorten considerably. The most affected area are the central and southern (Spanish) Pyrenees, where snow plays an important role in releasing high and regular spring river flows to the main tributaries of the Ebro River, which, in turn will affect some important power stations in the region. In the Alps, increased aridity may affect hydropower production, which is one of the key energy sources there (EURAC, 2011).

2.2.4. Cohesion Policy expenditure

In the current funding period (2007-2013) Cohesion Policy expenditure for energy covers mainly the supply side or energy production, transmission and distribution, and includes electricity, natural gas, petroleum products, renewables, and energy efficiency (DG Regional Policy

expenditure categories 33-43). Some investment in energy efficiency under category 43 also addresses the demand side.

Investments in hydropower facilities, particularly installations at rivers and streams were flows depend on glacial run-off, may become vulnerable. Investments in power plants may be sensitive to reduced productivity. The table below shows funding allocations for the 2007 – 2013 period. A total of €11.1 billion has been allocated across the EU 27 from Cohesion Policy funds for energy supply infrastructure, representing 3.2% of total available funding.

Table 3: Energy infrastructure Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Infrastructure	EUR m
33	Electricity	272.2
34	Electricity (TEN-E)	315.3
35	Natural gas	616.2
36	Natural gas (TEN-E)	415.1
37	Petroleum Products	173.7
38	Petroleum Products (TEN-E)	2.2
39	Renewable energy: wind	734.9
40	Renewable energy: solar	1,087.5
41	Renewable energy: biomass	1,865.8
42	Renewable energy: hydroelectric, geothermal and other	1,123.9
43	Energy efficiency, co-generation and energy management	4,468.1

Source: Expenditure category data from DG Regional Policy.

Energy infrastructure is expected to continue to be important in spending for the 2014-2020, because of its large impacts on all sectors of the economy. In the Commission document on the Common Strategic Framework[6], the energy sector can contribute to a number of the 11 thematic objectives. It can, for instance, contribute to thematic objectives (4) *supporting the shift towards a low-carbon economy in all sectors*, and (6) *promoting the environment and promoting resource efficiency.*

2.3. How do these impacts affect Cohesion Policy programmes and projects in my Member State?

The table below provides specialised information for each Member State on the potential extent of the threat to the energy sector and capacity to address it, relative to other EU Member States.

[6] Proposal for specific provisions regulation on the ERDF, EC Com(2011) 614 final, p13 and Commission Staff Working Document Elements for a Common Strategic Framework 2014 to 2020 Annexes, pp 17-18.

Aggregated climate impacts from all threats are presented for each climatic region[7], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to the energy sector by the Member State for 2007-2013 and the per cent share of energy in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national information platforms; technological resources in terms of the percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation. The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impacts, higher percentages of funds dedicated to the energy sector and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

Table 4: Overview of relative impacts and Cohesion Policy risk by Member State in the energy sector

Member State	**Climate Impacts**	**Cohesion Policy expenditure 2007 - 2013**		**Overall adaptive capacity**
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
Austria	High	31.2	2.6%	High
Belgium	Low	30.8	1.5%	High
Bulgaria	High	300.0	4.5%	Low
Cyprus	High	6.0	1.0%	Low
Czech Republic	High	1313.9	5.0%	Medium
Denmark	Low	0.0	0.0%	High
Estonia	Low	28.8	0.8%	Medium
Finland	Low	44.9	2.8%	High

[7] The score 'high', 'medium' and 'low' is assigned to the Member State based on the region (North, North-West, Mediterranean, Central & Eastern) to which it belongs.

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
France	Low	619.1	4.6%	High
Germany	High	518.1	2.0%	High
Greece	High	28.8	0.1%	Low
Hungary	High	359.1	1.4%	Medium
Ireland	Low	25.0	3.3%	Medium
Italy	High	1876.5	6.7%	Low
Latvia	Low	127.4	2.8%	Low
Lithuania	Low	478.0	7.1%	Low
Luxembourg	High	2.3	4.6%	Medium
Malta	High	34.8	4.1%	Low
Netherlands	Low	63.4	3.8%	High
Poland	High	2230.5	3.4%	Low
Portugal	High	269.4	1.3%	Medium
Romania	High	603.8	3.1%	Low
Slovakia	High	168.8	1.5%	Low
Slovenia	High	159.9	3.9%	Medium
Spain	High	438.8	1.3%	Medium
Sweden	Low	61.5	3.8%	High
UK	Low	313.1	3.2%	High

2.4. What are some of the best ways to build resilience into the energy sector using Cohesion Policy expenditure?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some concrete technical options that can be funded by Cohesion Policy programmes to 1) improve adaptive capacity through research and planning; 2) adapt infrastructure to make it more resilient to future impacts of climate change.

This is not an exhaustive list but a menu of possible adaptation options for the energy infrastructure. The main aim is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored

to individual needs. In addition to adaptation options for energy infrastructure, options addressing energy efficiency and demand are also included.

The options were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

Options are summarised below for the energy sector. A searchable database of options for all Cohesion Policy and CAP sectors is available on the European Climate Adaptation Platform - CLIMATE-ADAPT.

2.4.1. Adaptation Options for the energy Sector

2.4.1.1.Energy infrastructure

Adaptation Option:	**Increasing robustness of transmission grids**
Transmission grids are especially affected by extreme storms. Because of their importance for the population and industries, grids have to be adapted to a higher intensity of storms. Specifically pylons and lines should be strengthened, (alternately, lines can be put underground, significantly increasing the costs of the option).Furthermore, storm predictions should be taken into account when scoping the location of new power lines. Some existing power lines may need to be relocated.	
Climate threat addressed:	Storms
Urgency:	Short-term, up to 2020: The urgency of this option is high due to the long lifetime of the electricity transmission and distribution infrastructure (50-100 years) as well as long planning processes. The options should thus be implemented or at least initiated up to 2020.
Effectiveness (considering different climate scenarios):	Damages to the energy system can be largely prevented under a medium climate-change scenario (i.e. 2°C). Under existing climate conditions, the option would not be necessary so that effectiveness is not given under a BAU-scenario. Effectiveness under extreme scenarios (> 4°C)

	depends on the specific design, e.g. underground transmission cables will remain effective.
Expenditure Category(ies):	02 Energy infrastructure 061 Smart grids
Coherence with other policy objectives:	Supports the overall EU objective of further developing the trans-European energy network (TEN-E). The option supports the general principle of guaranteeing energy supply.
Coherence with other adaptation options:	Effectiveness is improved if implemented together with '*Installation of additional network capacities (smart grids)*'.

Adaptation Option:	**Installation of additional network capacities (smart grids)**
Due to higher summer temperatures and increase in the number of hot days, there will be an increase in demand for cooling across a range of sectors. Correspondingly, the demand for electricity will increase in the summer months. To cope with the higher electricity demand additional networks (transmission and distribution) have to be established. The installation of smart grids offers the additional opportunity to stabilize the transmission of electricity and to better cope with extreme climate events as well.	
Climate threat addressed:	Storms, higher temperatures
Urgency:	Short-term, up to 2020: As this option is closely interlinked with the option "*Increasing robustness of transmission grids*", it is also categorized as high urgency option and should be implemented or at least initiated up to 2020.
Effectiveness (considering different climate scenarios):	Additional network capacities increase the resilience to climate change related threats. As smart grids improve the overall robustness of the electricity network, they are also effective in a business-as-usual scenario under current climate variability. Depending on their design, effectiveness (especially of very local systems) can even be given under extreme climate scenarios (> 4°C).
Expenditure Category(ies):	02 Energy infrastructure 061 Smart grids
Coherence with other policy objectives:	The installation of additional network capacities has synergies with mitigation policies (especially improved integration of renewable energies).

Coherence with other adaptation options:	There is a close link to the option '*Increasing robustness of transmission grids*' and '*Installation of additional storage facilities to adapt to higher volatility in base load*'.

Adaptation Option:	**Cooling of thermal power plants**
Hotter summers and extended periods of heat days will cause the demand for cooling to increase. For thermal power plants, a way to adapt to the lower availability of cooling water will be to make use of a cooling tower and dual systems. Power plants equipped with cooling towers do not depend on river water for cooling purposes and are thus not affected by increasing temperatures in rivers. For dual systems the traditional water cooling is supplemented by cooling tower systems which can also work under higher ambient temperatures.	
Climate threat addressed:	Heat, water scarcity, drought
Urgency:	Short-term, up to 2020: The option should be implemented in the short-term up to 2020, due to short-term impacts of climate change related to heat, water scarcity and drought as well as the long planning processes in the energy system.
Effectiveness (considering different climate scenarios):	With the installation of cooling towers or dual systems, the cooling of thermal power plants, even under extreme scenarios (> 4°C), can be guaranteed. Effectiveness is however not robust in a business-as-usual scenario with current climate variability as investments are directly related to the changing climate.
Expenditure Category(ies):	02 Energy Infrastructure
Coherence with other policy objectives:	The option generally supports the EU objectives of guaranteeing secure and affordable energy.
Coherence with other adaptation options:	There are no direct links to other adaptation options as this option focuses specifically on thermal power plants.

** For this option, necessary investment costs have been estimated, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Targeted retrofitting to increase robustness of thermal power plants in coastal areas**
For thermal power plants in coastal areas advanced flood protection by heightened and strengthened constructions is needed (especially in the case of nuclear power plants). This can include the construction of additional dikes or protective infrastructures to avoid damages from coastal flooding.	

Climate threat addressed:	Flooding
Urgency:	Short/medium-term, up to 2020-2030: Even if threats from coastal flooding are expected in the medium time-frame only, the option involves a long-implementation timeframe. Planning should thus start in the short-term within the next programming period.
Effectiveness (considering different climate scenarios):	Damages to thermal power plants in coastal areas can be largely prevented under a medium climate-change scenario (i.e. 2°C). Under existing climate conditions without any sea-level rise, the option would not be necessary so that effectiveness is not given under a BAU-scenario. Effectiveness under extreme scenarios (> 4°C) with very high sea-level rise and risk of storm surges depends on the specific design, e.g. the height and strength of protective dikes.
Expenditure Category(ies):	02 Energy Infrastructure
Coherence with other policy objectives:	The option generally supports the EU objectives of guaranteeing secure and affordable energy.
Coherence with other adaptation options:	There are no direct links to other adaptation options as this option focuses on thermal power plants in coastal areas.

Adaptation Option:	**Hydropower reservoir power stations: Increase dam height to allow for higher variability in water availability**
Hydropower reservoir stations can play a significant role in protecting from river flooding as they can store excess water (either from snow-melt or extreme precipitation events). Higher variability in water availability needs to be considered in the design of hydropower stations. For existing stations, it might be necessary to increase dam height, to allow for higher variability in the water level	
Climate threat addressed:	Floods
Urgency:	Short-term, up to 2020: The option addresses threats from climate change that become relevant in the short-term up to 2020. In addition, planning of hydropower stations faces long decision making processes. It is thus necessary to start implementation during the next programming period.
Effectiveness (considering different climate scenarios):	The option is effective under a medium (i.e. 2°C) climate scenario as it will prevent a considerable share of flood-related damages. Depending on the design of the reservoirs and the increase of dam height, it also remains effective

	under more extreme scenarios with even higher precipitation (related to a climate scenario > 4°C). The option is however not robust under a business-as-usual scenario without changing climate.
Expenditure Category(ies):	057 RES: Hydro, geothermal and marine energy
Coherence with other policy objectives:	The option can be linked to the objectives of creating a trans-European Energy network (TEN-E). Well-functioning hydropower-stations also support the low-carbon economy roadmap and the energy roadmap.
Coherence with other adaptation options:	Effectiveness of the option can be optimized if combined with further options aiming at flood prevention, e.g. '*River restoration (buffer zone), restoration of wetlands*' or '*Flood gates*'.

Adaptation Option:	**Adjustments in design standards for wind turbine generators (consideration of extreme storm)**
A higher intensity of storms can reduce the security of electricity production. Installations most affected by extreme winds are off-shore wind parks and wind turbines in very high altitudes. The design standard can be adapted to increase the robustness of different components of the wind turbine, e.g. rotor blade.	
Climate threat addressed:	Storms
Urgency:	Short-term, up to 2020: As extreme storms are a short-term threat and as the planning and installation of off-shore wind parks has a long implementation time, the option should be taken forward during the next programming period.
Effectiveness (considering different climate scenarios):	Depending on the design standards, effectiveness is given under a medium as well as extreme climate scenario (> 4°C). As the adjustment in design standards for wind turbine generators is only due to increasing storm intensity, this option is not necessary and thus not robust to a business-as-usual scenario.
Expenditure Category(ies):	054 RES: wind
Coherence with other policy objectives:	The option is in line with the renewable energy targets of the EU (Climate and Energy Package, energy roadmap).
Coherence with other adaptation options:	The option focuses specifically at wind turbines and has thus no direct link to other adaptation options.

Adaptation Option:	**Installation of additional storage facilities to adapt to higher volatility in base load.**
To adjust the electricity grid to different weather events and a higher variability in the amount of produced electricity, further electricity storage facilities should be installed. For example, elevated water reservoirs are a well-known type of storage facilities. Other systems like batteries or using hydrogen storage could also be used.	
Climate threat addressed:	All threats
Urgency:	Short/medium term, up to 2020-2030: As this option aims at guaranteeing energy supply under more volatile demand and weather patterns and as it is closely interlinked with the option "increasing robustness of transmission grids", it has a high urgency and should be implemented or at least initiated up to 2020.
Effectiveness (considering different climate scenarios):	Depending on the amount of additional storage facilities, effectiveness is given under a medium as well as extreme climate scenario (> 4°C). Based on the objectives to increase the share of renewable energies, the options is also effective under a business-as-usual climate scenario to cope with more volatile energy supply (especially from photovoltaic and wind).
Expenditure Category(ies):	054 RES: wind 955 RES: solar
Coherence with other policy objectives:	The installation of additional network capacities has synergies with mitigation policies (especially improved integration of renewable energies).
Coherence with other adaptation options:	Effectiveness is improved if implemented together with '*Increasing robustness of transmission grids*' and '*Installation of additional network capacities (smart grids)*'.

Adaptation Option:	**Awareness raising and information sources, especially for small-scale project developers**
This adaptation option would entail actions that promote awareness on the consequences of climate change. The aim is to achieve an integration of climate change impacts in the planning of electricity networks, transmission grids and the design of new power production plants, including renewable energies, e.g. wind turbines. Information can be delivered by websites, information brochures, workshops, etc.	
Climate threat addressed:	All threats
Urgency:	Short-term, up to 2020: As this option can be seen as first

	step to some of the other adaptation options in the energy sector, it has a high urgency and should be implemented in the next programming period.
Effectiveness (considering different climate scenarios):	This option has the potential to be highly effective. However, it depends on the implementation of subsequent steps. Awareness rising alone will not prevent any damages from climate change. The campaigns and information sources thus need to enable project developers to take up specific options.
Expenditure Category(ies):	077 Improving the delivery of policies and programmes
Coherence with other policy objectives:	The option generally supports the EU objectives of guaranteeing secure and affordable energy. It is also in line with mitigation policies as it strengthens the role of renewable energies.
Coherence with other adaptation options:	The option needs to be implemented together with other options illustrated for the energy sector. For small-scale project developers especially '*Adjustments in design standards for wind turbine generator*' and '*Installation of additional storage facilities to adapt to higher volatility in base load*'.

2.4.1.2.Energy demand

Adaptation Option:	**Higher energy efficiency of ventilation systems**
Due to increased amount and intensity of heat waves and higher average summer temperatures, the demand for ventilation systems for cooling purposes will increase. Energy efficient ventilation systems, e.g. passive cooling systems, or air-conditioning with low energy use, can help slow down the increase of electricity consumption due to cooling.	
Climate threat addressed:	Heat
Urgency:	Short-term, up to 2020: As increasing heat and heat waves will become relevant in the short-term and as some cooling and ventilation systems (especially based on environmental energies) have a long life-time, the option needs to be implemented in the short term up to 2020.
Effectiveness (considering different climate scenarios):	This option is effective under all climate scenarios. Higher efficiency of ventilation systems is also important under mitigation objectives and thus already effective under existing climate conditions.

Expenditure Category(ies):	02 Energy infrastructure 060 EE in SMEs
Coherence with other policy objectives:	The installation of additional network capacities has synergies with mitigation policies (especially energy-efficiency as stated in the Low Carbon Economy Roadmap or the Energy Roadmap).
Coherence with other adaptation options:	This option has a close link to all adaptation options that deal with adaptation of buildings to heat: '*Energy efficient adaptation of offices, industrial plants to heat*', '*Energy efficient cooling of hospitals*' and '*Energy efficient adaptation of homes against heat*'.

2.5. List of further resources

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3. SECTORAL FICHE 3: HEALTH

3.1. Introduction

By aiming to improve social inclusion and access to health services through improved health infrastructure, funding for the health sector is an important part of Cohesion Policy expenditure. This fiche provides a summary of the main threats to health from climate change, and indicates the approximate amount of Cohesion Policy expenditure on health in Member States during the 2007-2013 funding period. It also provides advice on possible options that might be used to increase the resilience of health to future climate change.

The fiche can be used alongside the guidance for climate proofing investments across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for sectoral authorities responsible for health. It gives a short, concise overview of why and how climate change impacts are relevant for the health sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes.

3.2. How will climate change impact health in the EU?

In comparison to other Cohesion Policy sectors vulnerable to climate change, the amount of direct spending on health infrastructure is relatively low. However, depending on the methods used to value health risk, costs from climate change impacts on health can be far greater than to any other sector. Consequently, risks to human health may have implications for a wide range of Cohesion Policy expenditure, which should be considered with regard to wider adaptation strategies designed to minimise health risks from climate change overall.

3.2.1. Climate threats to health in the EU

The analysis below briefly summarises the main threats to health, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions, using the EEA analysis of climate threats across the main EU climatic regions.[8]

The most significant impacts to health are expected from temperature extremes including fires, the associated decline in air quality, temperature change over time and disease. The highest impacts are expected to occur from temperature increases in the Mediterranean and the Central & Eastern regions.

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[8] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen

North = FI, SE, EE, LV, LT

North-West = DK, NL, FR, BE, IE, UK

Mediterranean = ES, PT, IT, CY, MT, EL

Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

Table 1: Assessment of the relative scale of impacts on health from climate change-related events/factors across EU climate regions, to 2020

Region	Flooding – Coastal	Flooding - River	Air quality	Diseases	Storms	Temperature extremes including fires	Temperature change over time
North	Medium	High	Low	Low	Low	Medium	Low
North-West	High	Medium	Low	Low	Low	Medium	Low
Mediterranean	Low	Low	Medium	Medium	Low	High	High
Central & Eastern	Low	Low	Medium	Medium	Low	High	High

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

Table 2: Table 2: Assessment of the relative scale of overall climate change impacts on health across EU climate regions, to 2020

Region	Damage to health
North	Low
North-West	Low
Mediterranean	High
Central & Eastern	High

Source: Own assessment

3.2.2. Damage costs for the Health sector

Climate change is associated with rising sea level, resulting in higher risks of coastal flooding. The physical hazards from coastal flooding, more extensive episodes of flooding and increasingly severe storm surges can pose direct risks to health. Indirect risks related to sea level rise include poor water quality due to the salination of freshwater supplies, and changes in breeding habitats for coastal-dwelling mosquitoes. The ClimateCost study (Brown et al., 2011) estimated an EU damage cost from sea level rise of approximately €5.2 billion per year (2005 prices), by the 2020s (A1B climate change scenario) representing a doubling of baseline costs estimated for the year 2000.

A study examining the health impacts form climate change (Kovats, Hunt and Watkiss, 2011) estimated that the welfare costs, estimated as the value of prevented fatalities (VPF)[9], is approximately €77 million per year (2010 prices) in the 2020s (A1B climate change scenario), assuming no adaptation.

The study by Feyen and Watkiss (2011) estimates the damage costs from river flooding. The report suggests that the damage costs are €20 billion a year in the 2020s (including the impacts from socio-economic trends) compared to current (1980-2010) costs of only €7 billion (2006 prices). The estimates exclude direct effects on fatalities and injuries and any indirect damage to health (e.g. from diseases following floods). Other costs potentially can arise from climate change impacts on the incidence of cardiovascular disease (from extreme temperatures), increasing air pollution, UV-related health outcomes, including cancers, food-borne diseases, vector-borne diseases, and mental diseases.

Table 3: Costs from climate change attributable heat related mortality (Value of Life Years Lost)[10], with and without acclimatisation (€m/year, 2010 prices), Scenario A1B

Region[11]	**2020s**		**2050s**		**2080s**	
	No Acclimatise	Acclimatise	No Acclimatise	Acclimatise	No Acclimatise	Acclimatise
EE	176	50	464	174	602	170
NE	74	37	251	110	457	85
SE	329	183	1,221	657	1511	542
WE	247	135	846	437	1401	447
Total	826	405	2,782	1,379	3,972	1,244

Source: Kovats et al. (2011)

3.2.3. Relative spread of damage costs by region

North

[9] VPF is calculated in a similar way to estimates of the value of statistical life (VSL)

[10] Value of Life Years Lost (VOLY) is based on a different method to VSL and seeks to take into account the age of those affected. And produces substantially lower estimates (by a factor four in 2020s and a factor of 50 in 2050s)

[11] Note that the regions of the table are not the same as throughout the fiche.

In the North, adverse health risks are likely to be associated with flooding. Given the importance of acclimatisation that can cut damage costs by half, extreme events such as heat waves may have relatively larger effects than in other regions.

North-West

Reference to the regional assessment of climate change threats suggests relatively higher threats to health from flooding. Threats from extreme events are also potentially significant.

Mediterranean

The regional variations in climate induced changes in air pollution and its impacts appear to be most closely associated with the regional variations in temperature increase. Increasing temperature will occur across the EU, but may be relatively higher in Mediterranean and Central & Eastern regions. Also increased threats from disease are potentially associated with longer-term trends in higher temperatures.

Central & Eastern

Along with the Northern region, the Central & Eastern region is expected to experience risks of river flooding. The Central & Eastern region potentially faces threats from increasing temperatures, increase in disease and in air pollution.

Regarding heat-related mortality, the RESPONSES project study (2011) found that for a scenario of climate change (2011-2040) that the largest impact was predicted in Central & Eastern Europe (southern Poland, Czech Republic, Slovakia and Hungary). According to Ciscar et al. (2009) mortality in hotter EU countries is less dependent on high temperatures than in the Central and Eastern region. This may be because the Southern European populations are already well acclimatised to high temperatures, though there are also many other reasons why these differences could occur e.g. socio-economic factors and additional adaptation. In the longer-term (2041-2070), risks are assessed to spread through most of the EU, but with continuing peaks in Eastern Europe.

3.2.4. Cohesion Policy expenditure

In the 2007 – 2013 funding period direct Cohesion Policy expenditure in the health sector includes investment in services and applications for citizens such as e-health; health infrastructure; and other social infrastructure. Two of these categories of investment—in health infrastructure and in other social infrastructure—have the potential to be vulnerable to climate change impacts; however this will be very much dependent on the region and specific location of investments. The table below shows funding allocations for the 2007 – 2013 funding period. A total of € 5.3 billion has been allocated across the EU 27 from Cohesion Policy funds for health infrastructure, representing 1.5% of total available funding. Additionally, € 4.2 billion have been allocated across the EU from Cohesion Policy funds for health-related services and applications representing 1.2% of total available funding. A total of €295.6 million of the €9.5 billion allocated for health-related expenditure have been used in financing cross-border cooperation in the area of health.

Table 4: Health sector Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Infrastructure	EUR m

13[12]	Services and applications for citizens (e-health, e-government, e-learning etc.)	2,648.4
53[13]	Risk Prevention	1,109.7
54[14]	Other measures to preserve the environment and prevent risks	422.8
76	Health infrastructure	5,293.6

Source: Expenditure category data from DG Regional Policy; calculations for health sector by consultant.

The Commission document on the Common Strategic Framework[15] outlines the 11 thematic objectives for the next programming period. The health sector can contribute to a number of these objectives, for example objective (9) *promoting social inclusion and combating poverty.*

3.3. How do these impacts affect Cohesion Policy/CAP programmes and projects in my Member State?

The table below provides specialised information for each Member State on the potential extent of the threat to health and capacity to address it, relative to other EU Member States.

Aggregated climate impacts from all threats are presented for each climatic region[16], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to the health sector by the Member State for 2007-2013 and the per cent share of health in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national information platforms; technological resources in terms of the percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation. The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impact, higher percentages of funds dedicated to the health sector and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector. As noted above, climate change impacts to health will affect other sectors as well as direct spending for health infrastructure.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

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[12] 50% share of total amount for category 13 is allocated for health

[13] 20% share of total amount for category 53 is allocated for health

[14] 25% share of total amount for category 54 is allocated for health

[15] Proposal for specific provisions regulation on the ERDF, EC Com(2011) 614 final, p13 and Commission Staff Working Document Elements for a Common Strategic Framework 2014 to 2020 Annexes, pp 17-18.

[16] The score 'high', 'medium' and 'low' is assigned to the Member State based on the region (North, North-West, Mediterranean, Central & Eastern) to which it belongs.

Overview of relative impacts and Cohesion Policy risk by Member State in the health sector

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
Austria	High	1.9	0.2%	High
Belgium	Low	0.0	0.0%	High
Bulgaria	High	125.8	1.9%	Low
Cyprus	High	7.7	1.3%	Low
Czech Republic	High	784.3	3.0%	Medium
Denmark	Low	0.0	0.0%	High
Estonia	Low	201.5	5.9%	Medium
Finland	Low	26.0	1.6%	High
France	Low	175.7	1.3%	High
Germany	High	165.8	0.7%	High
Greece	High	913.9	4.5%	Low
Hungary	High	1728.8	6.9%	Medium
Ireland	Low	0.0	0.0%	Medium
Italy	High	485.9	1.7%	Low
Latvia	Low	214.1	4.8%	Low
Lithuania	Low	278.6	4.1%	Low
Luxembourg	High	0.0	0.0%	Medium
Malta	High	51.2	6.1%	Low
Netherlands	Low	6.1	0.4%	High
Poland	High	1608.4	2.5%	Low
Portugal	High	576.3	2.7%	Medium
Romania	High	330.9	1.7%	Low
Slovakia	High	584.6	5.1%	Low
Slovenia	High	73.3	1.8%	Medium

Spain	High	814.7	2.4%	Medium
Sweden	Low	4.8	0.3%	High
UK	Low	19.1	0.2%	High

3.4. What are some of the best ways to build resilience into the health sector using Cohesion Policy expenditure?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some concrete technical options that can be funded by Cohesion Policy programmes to 1) improve adaptive capacity through research and planning; 2) adapt infrastructure to make it more resilient to future impacts of climate change.

This is not an exhaustive list but a menu of possible adaptation options for the health sector, with an indication of potential co-benefits with adaptation options in other sectors. The main aim is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored to individual needs.

The options were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

Options are summarised here for the health sector. A searchable database of options for all Cohesion Policy and CAP sectors is available on the Climate-Adapt platform.

3.4.1. Adaptation Options for the health Sector

Adaptation Option:	**Energy efficient cooling of hospitals**
Increasing average temperatures and number of heat days will have adverse health effects on vulnerable groups of the population. To address these, the cooling of hospitals will be necessary. For hospital employees, the cooling of hospitals will ensure good working conditions and allow avoiding loss of productivity due to heat. Energy efficient	

Adaptation Option:	**Energy efficient cooling of hospitals**
cooling systems include not only energy-efficient ventilation systems but aim at the broader cooling and ventilation system. Passive cooling systems are based on renewable energies (e.g. geothermal heat exchanger, concrete core activation, night ventilation systems).	
Climate threat addressed:	Heat, higher temperatures
Urgency:	Short-term, up to 2020: As heat waves can already be observed under current climate conditions (especially in Southern countries) and as the lifetime of cooling systems is rather long, implementation is urgent and should be considered in the next programming period up to 2020.
Effectiveness (considering different climate scenarios):	Energy-efficient cooling of hospitals has the potential to avoid a large share of climate-change induced health costs in hospitals (both productivity of employees and health of patients). Especially in Southern regions, it is already effective under a business-as-usual scenario with existing climate variability (no-regret). The option is however not very robust to extreme climate scenarios (> 4°C): especially passive cooling systems are not sufficient under extreme heat.
Expenditure Category(ies):	028 Health infrastructure
Coherence with other policy objectives:	This option supports the EU strategy on public health
Coherence with other adaptation options:	The overall effectiveness of this option is increased if combined with adaptation options focusing on preventing health effects due to outdoor activities, e.g. '*Green and blue spaces, incl. green roofs*'. For optimizing synergies with mitigation policy, a combination with the option '*Higher energy efficiency of ventilation systems*' is recommended.

** For this option, necessary investment costs have been estimated, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Green and blue Spaces, incl. green roofs**
The proposed option aims to reduce the temperature increase in inner cities. It is especially relevant against the urban heat island effect. Green spaces are, e.g. parks, urban forests and other vegetated areas in the city areal. Blue spaces regard to lakes, ponds and rivers. Green roofs are, i.e. roof tops covered with some sort of vegetation on private and public buildings in the city. In combination, these measures are able to provide fresh-air corridors for urban areas.	

Climate threat addressed:	Heat, flooding, flash floods
Urgency:	Short-term up to 2020: Even if some of the related climate threats might only become relevant beyond 2020, this options needs to be implemented today as strategic option. Green and blue spaces need to be secured now to become fully effective with increasing climate impacts.
Effectiveness (considering different climate scenarios):	Effectiveness of green and blue spaces as well as green roofs is given under both medium and extreme climate scenarios (> 4°C). However, they will not be able to avoid all health impacts. The effectiveness under a business-as-usual scenario with existing climate conditions depends on the specific situation: in most cases there are considerable co-benefits (green spaces improve quality of life, improve biodiversity, etc.), so that the option is also effective under a business as usual scenario.
Expenditure Category(ies):	075 Integrated schemes for urban and rural development
Coherence with other policy objectives:	This option is in line with the Thematic Strategy on the Urban Environment.
Coherence with other adaptation options:	There is a close inter-linkage with options reducing heat indoors, e.g. '*Energy-efficient cooling of hospitals*'. Also, the option is closely interlinked with '*Sustainable Urban Drainage Systems*' as green roofs and green urban spaces also have a drainage function.

** For this option, necessary investment costs have been estimated, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Heat Warning System**
Heat Warning Systems use weather forecasts to predict heat situations with potential adverse effects for human health. The Warning System should be accompanied by announcements via media, direct information for groups of vulnerable people and institutions who take care of vulnerable people.	
Climate threat addressed:	Heat
Urgency:	Short-term, up to 2020: This option is a pre-condition for many other adaptation options and thus needs to be implemented as soon as possible. Heat waves are already relevant under existing climate conditions, especially in

Adaptation Option:	**Heat Warning System**
	Southern countries.
Effectiveness (considering different climate scenarios):	The effectiveness of this option depends on its combination with other specific options. Effectiveness is high if the heat warning system is able to trigger specific adaptation responses (e.g. additional care for vulnerable citizens). In this case, the effectiveness is independent of the underlying climate scenario.
Expenditure Category(ies):	067 Civil protection and disaster management systems and infrastructures
Coherence with other policy objectives:	This option supports the EU strategy on public health.
Coherence with other adaptation options:	This option has a close link to other options related to guaranteeing public health, especially "*Additional care and support of vulnerable citizens through health infrastructure*".

Adaptation Option:	**Information and Monitoring system on spread and relevance of vector-borne, food-borne diseases**
Due to higher average temperatures and heat waves an increase of vector-borne and food-borne diseases, like salmonellas, is expected. For adequate warning, information and monitoring systems should be established. The information systems would concern the general population, the health sector, and industry, especially enterprises involved in food production and retail.	
Climate threat addressed:	Heat, higher temperatures, flooding
Urgency:	Short/medium-term, up to 2020s-2030s: The spread of vector and food-borne diseases is predicted for the medium time-period (2030s). However, as the set-up of information and monitoring-systems requires a long period, the implementation could already be initiated during the next programming period.
Effectiveness (considering different climate scenarios):	The effectiveness of this option is given only if it is able to trigger specific responses (e.g. adjustments in hospitals to cope with new vector or food-borne diseases). If combined with specific options, the effectiveness is independent of the underlying climate scenario.
Expenditure Category(ies):	067 Civil protection and disaster management systems and infrastructures
Coherence with other policy objectives:	This option supports the EU strategy on public health.

Coherence with other adaptation options:	No direct links to other adaptation options have been identified. However, effectiveness depends on the take-up of targeted measures in the health sector.

Adaptation Option:	**Additional care and support of vulnerable citizens through health infrastructure (workers, buildings)**
For the protection of vulnerable groups, e.g. elderly persons, the health care system has to be prepared for extreme events, especially heat waves. Health infrastructure should enable health workers to visit vulnerable people on a more regular basis. In public buildings cool rooms can be established where persons can stay during the day. The option should be combined with Heat Warning Systems.	
Climate threat addressed:	Heat
Urgency:	Short-term, up to 2020 in some cases: The urgency of the option depends on region and the underlying climate threats. Especially in cases where heat waves are already relevant today and will increase up to 2020, the option should be implemented in the next programming period.
Effectiveness (considering different climate scenarios):	Effectiveness is given under both medium and extreme scenarios (> 4 °C). As additional care and support of vulnerable citizens through an improved health infrastructure is only necessary due to increasing climate change threats, the option is however not robust in a business-as-usual scenario with current climate conditions in most regions.
Expenditure Category(ies):	028 Health infrastructure
Coherence with other policy objectives:	This option supports the EU strategy on public health.
Coherence with other adaptation options:	The option is directly linked to '*Heat Warning Systems*' as these will trigger the additional care and support services.

Adaptation Option:	**Further adaptation in disaster management organisations (e.g. education, disaster plans)**
Disaster protection organisations have to prepare for a higher quantity and intensity of different extreme events. To assure the functioning of disaster management organisations in the case of extreme events the members need to be further educated. Climate Change and adaptation to climate change need to be integrated in educational programmes. Furthermore, there needs to be sufficient awareness of disaster plans for regions, especially among the most affected stakeholders.	
Climate threat	All threats

addressed:	
Urgency:	Short-term, up to 2020 in some cases: As this option addresses all threats from climate change as some of these threats will become relevant until 2020, the option should be taken forward as soon as possible to allow adjustments in educational programmes and their realization.
Effectiveness (considering different climate scenarios):	This option is effective under all climate scenarios. Additional advanced training for disaster management organizations is relevant also for existing natural and man-made disasters and is thus effective under existing conditions as well.
Expenditure Category(ies):	076 Community-led local development in urban/rural areas 089 and 090 - Investing in education, skills and life-long learning
Coherence with other policy objectives:	The option supports the general objectives of the EU to prevent natural and man-made disasters.
Coherence with other adaptation options:	This option can be seen as independent option from other preventive adaptation options.

3.5. List of further resources

- Adaptation Wizard, UKCIP (2010) 5-step process to assess vulnerability to current climate and future climate change, identify options to address key climate risks, and help to develop and implement a climate change adaptation strategy.
- AdaptME toolkit, UKCIP (2011) Climate change adaptation and monitoring toolkit, to help evaluate current adaptation activities.
- AdOpt, UKCIP (2011) Information on the range of adaptation options and practical examples. Includes a checklist of key principles for good adaptation decisions. Intended for decision- and policy-makers in identifying and appraising the effectiveness of climate risk adaptation measures.
- AMICA Adaptation Tool; PIK-Potsdam, Interreg IIIC (2005-2006) A Matrix of adaptation measures and a list of evaluated practice examples.
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- European RESPONSES to climate change, Institute for Environmental Studies (IVM), FP7, ongoing The objective of the ongoing project and the content of the current output is to identify and assess integrated EU climate-change policy responses that achieve ambitious mitigation and environmental targets and, at the same time, reduce the Union's vulnerability to inevitable climate-change impacts.

- Evaluación preliminar de los impactos en Espana por efecto del cambio climático, Ministerio del Medio Ambiente (2005) Description of the impacts of climate change on diverse sectors, e.g. water, forest, biodiversity, health, tourism. There is also a brief overview of potential adaptation measures per sector.
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4. SECTORAL FICHE 4: TOURISM

4.1. Introduction

By aiming to generate employment and support local economies, funding for tourism is an important part of Cohesion Policy expenditure. This fiche provides a summary of the main threats to tourism in the EU from climate change, and indicates the approximate amount of Cohesion Policy expenditure on tourism infrastructure in Member States during the 2007-2013 funding period. It also provides advice on possible options that might be used to increase the resilience of the EU tourism sector to future climate change.

The fiche can be used alongside the guidance for climate proofing across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for sectoral authorities responsible for investments in the protection and development of natural heritage and other tourism-related activities. It gives a short, concise overview of why and how climate change impacts are relevant for the tourism sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes. This and other Sectoral Fiches have been prepared for the EU-27; using this structure as a guide, authorities can supplement the information here with national and/or regional details.

4.2. How will climate change impact tourism in the EU?

Tourism infrastructure and the attraction of visitors are affected by weather events. The impacts are varied across the regions of the EU, and depend to a large extent on the life-cycle of the investment, where vulnerability to climate threats increases with the length of the life-cycle of the investment.

4.2.1. Climate threats to tourism in the EU

A review of the available evidence suggests that the EU tourism sector is likely to be subject to a number of threats as a result of changing climatic conditions. These threats reflect in part the distribution of climatic threats across the EU.

The analysis below summarises the main threats to the tourism sector, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions using the EEA analysis of climate threats across the main EU climatic regions.[17]

The review of evidence indicates that impacts of water scarcity will have to be considered in the Mediterranean; changes in winter conditions and snowfall will be important for the tourism

[17] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen
North = FI, SE, EE, LV, LT
North-West = DK, NL, FR, BE, IE, UK
Mediterranean = ES, PT, IT, CY, MT, EL
Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

sector in the North and the Central & Eastern regions, and temperature extremes (including fires), will need to be addressed in the Mediterranean.

Table 1: Assessment of the relative scale of impacts on the tourism sector from climate change-related events/factors across EU climate regions, to 2020

Region	Water scarcity – continuous/ drought	Winter/ snowfall	Temperature extremes including fires
North	Low	Medium	Low
North-West	Low	Low	Low
Mediterranean	Medium	Low	High
Central & Eastern	Low	Medium	Low

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

Table 2: Table 2: Assessment of the relative scale of overall climate change impacts on the tourism sector across EU climate regions, to 2020

Region	Impacts on tourism
North	Low
North-West	Low
Mediterranean	High
Central & Eastern	Medium

Source: Own assessment

4.2.2. Damage costs for the tourism sector

The main impacts affecting the tourism sector noted in previous studies have been increased temperatures and extreme temperatures along with decreased precipitation, likely to lead to water scarcity and drought, with an impact on the tourism sector. Increased temperatures will also lead to decreased snowfall, affecting the winter sports industry.

No EU estimates of the damage costs to tourism from reduced snow cover have been identified.

For increasing temperatures, based on adopted climate scenarios, climate change is not considered to induce changes in the total tourism volumes in Europe, but rather to lead to seasonal and geographical redistribution (Table 3, Ciscar et al., 2009). This supports the view that over time the Mediterranean region is most likely to be adversely affected by climate change.

Table 3: Change in annual expenditure receipts in the 2080s (€ million, 2009 prices), flexible seasonal demand

Region[18]	B2 HadAM3H 2.5°C	A2 HadAM3h 3.9°C	B2 ECHAM4 4.1°C	A2ECHAM 5.4°C
Northern Europe	344	465	1,122	1,507
British Isles	529	664	2,375	3,105
Central Europe N	429	558	1,729	2,322
Central Europe S	413	857	3,772	5,003
Southern Europe	-1,715	-2,544	-8,997	-11,937
EU	0	0	0	0

Source: Ciscar (2009)

4.2.3. Relative spread of damage costs by region

North

Snow reliability in Scandinavia will remain higher than in many parts of the Alps. As a result, the Scandinavian countries are likely to increase their market share in ski tourism (Ehmer E. and Heymann P., 2008). In the summer months, the North can expect an improvement in weather conditions.

North-West

In summer months, the zone of good conditions expands towards the North. The increasingly favorable conditions in the North might lead to more domestic tourism in North-West Europe.

Mediterranean

Expansion of droughts and arid environments are most likely to occur in the non-mountainous areas of Southern Europe. These areas might be particularly susceptible to decreased tourism in peak seasons; some or all of this effect could be absorbed by increased tourism in the spring or autumn.

By 2030, the Mediterranean region will have a noticeable increase in the number of days with temperatures above 40°C (Ehmer E. and Heymann, P., 2008). Increasing average temperatures and increasing probability of heat waves and decreasing precipitation will be disadvantageous to the tourism industry in the Mediterranean. According to Ciscar et al (2009), the improved conditions in the Mediterranean in the spring and autumn and an increase in visitors to mountainous areas during summer months are unlikely to fully compensate for the deterioration in conditions in summer.

[18] Please not that regions for table 3 differ from the rest of the document
Northern Europe: SE, FI, EE, LV, LT
British Isles: IE, UK
Central Europe North: BE, NL, DE, PL
Central Europe South: FR, AT, CZ, SL, SK, HU, RO
Southern Europe: PT, ES, IT, EL, BU

Central & Eastern

In the Central & Eastern region, the skiing industry is likely to be disrupted by significant reductions in natural snow cover especially in the beginning and the end of the ski season.

Other

Due to reduced snow cover and reduced snow reliability, the economic viability of many winter sports resorts at lower and medium elevations is threatened (CLISP, 2009). Temperatures in the Alps are increasing at a rate more than twice the global average. The change has serious ramifications not only for the alpine climate itself, but also for the broad swath of Europe that relies on the water these mountains collect and deliver (EEA, 2009).

4.2.4. Cohesion Policy expenditure

In the 2007-2013 funding period Cohesion Policy expenditure in the tourism sector includes the promotion, protection and development of natural assets; and other assistance to improve tourist services (DG Regional Policy expenditure categories 55-57). All of these expenditures under Cohesion Policy have the potential to be sensitive to climate change impacts; however this will be very much dependent on the region and specific location of investments. The table below shows funding allocations for the 2007 – 2013 funding period. A total of EUR 6.3 billion has been allocated across the EU 27 from Cohesion Policy funds for tourism infrastructure, representing 1.8% of total available funding.

Table 4: Tourism infrastructure Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Infrastructure	EUR m
55	Promotion of natural assets	1,147.8
56	Protection and development of natural heritage	1,408.0
57	Other assistance to improve tourist services	3,742.4

Source: Expenditure category data from DG Regional Policy

Financing tourism infrastructure is expected to continue to be important for the 2014-2020 period, because of its large impact on local economies. In the Commission document on the Common Strategic Framework[19], the tourism sector can contribute to a number of the 11 thematic objectives; for instance, to thematic objectives (3) *enhancing the competitiveness of small and medium-sized enterprises (SMEs)*, (4) *supporting the shift towards a low-carbon economy in all sectors*, (6) *promoting the environment and promoting resource efficiency*, and (9) *promoting social inclusion and combating poverty.*

4.3. How do these impacts affect Cohesion Policy/CAP programmes and projects in my Member State?

The table below provides specialised information for each Member State on the potential extent of the threat to tourism and capacity to address it, relative to other countries in the EU.

[19] Proposal for specific provisions regulation on the ERDF, EC Com(2011) 614 final, p13 and Commission Staff Working Document Elements for a Common Strategic Framework 2014 to 2020 Annexes, pp 17-18.

Aggregated climate impacts from all threats are presented for each climatic region[20], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to tourism by the Member State for 2007-2013 and the per cent share of tourism in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national information platforms; technological resources in terms of the percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation. The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impact, higher percentages of funds dedicated to the tourism and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

Table 5: Overview of relative impacts and Cohesion Policy risk by Member State in the Tourism sector

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
Austria	Medium	13.0	1.1%	High
Belgium	Low	31.9	1.5%	High
Bulgaria	Medium	85.4	1.3%	Low
Cyprus	High	0.0	0.0%	Low
Czech Republic	Medium	672.6	2.6%	Medium
Denmark	Low	12.3	2.4%	High
Estonia	Low	104.3	3.1%	Medium
Finland	Low	51.0	3.2%	High

[20] The score 'high', 'medium' and 'low' is assigned to the Member State based on the region (North, North-West, Mediterranean, Central & Eastern) to which it belongs.

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
France	Low	255.7	1.9%	High
Germany	Medium	361.2	1.4%	High
Greece	High	172.1	0.9%	Low
Hungary	Medium	447.8	1.8%	Medium
Ireland	Low	3.5	0.5%	Medium
Italy	High	897.8	3.2%	Low
Latvia	Low	42.4	0.9%	Low
Lithuania	Low	116.5	1.7%	Low
Luxembourg	Medium	0.0	0.0%	Medium
Malta	High	24.2	2.9%	Low
Netherlands	Low	32.1	1.9%	High
Poland	Medium	979.1	1.5%	Low
Portugal	High	231.6	1.1%	Medium
Romania	Medium	437.2	2.3%	Low
Slovakia	Medium	78.9	0.7%	Low
Slovenia	Medium	79.9	1.9%	Medium
Spain	High	429.1	1.2%	Medium
Sweden	Low	23.6	1.5%	High
UK	Low	121.4	1.2%	Low

4.4. What are some of the best ways to build resilience in the tourism sector using Cohesion Policy expenditure?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some ideas on how Cohesion Policy Programmes can build in resilience to future impacts of climate change.

The main aim of the section is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored to individual needs.

The option for the tourism sector and adaptation options in other sectors with potential co-benefits were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

The concept of diversification of tourist offers to reflect changing climate conditions is summarized below. The tourism sector can also benefit from synergies with a range of adaptation options in other sectors such as industry, transport, and water. A searchable database of options for all Cohesion Policy and CAP sectors is available on the European Climate Adaptation Platform - CLIMATE-ADAPT.

4.4.1. Adaptation Option for the tourism Sector

Adaptation Option:	**Diversification of tourist offers in different regions**
Depending on their current characteristics, target groups and flexibility, tourism destinations will experience different effects from climate change: winter tourism will suffer from less reliable snow conditions, Mediterranean regions might face a reduced demand during high-peak summer season and other regions might profit from more favorable climatic conditions. Some tourist destinations might also suffer from less reliable weather conditions during spring and autumn. To remain competitive - also with respect to overseas destination - it will be important to diversify tourist offers and services, e.g. by constructing new infrastructures like indoor sports activities in hot or very rainy regions or new bike paths to provide alternative sport opportunities.	
Climate threat addressed:	All threats
Urgency:	Short-term, up to 2020 for some: The urgency of this option depends on the specific underlying threat and tourism region. Some threats (e.g. changing snowfall patterns in Alpine regions) will be relevant in the short-term so that adaptation options need to be taken forward during the next programming period. Other option might only become relevant beyond 2020 but could be initiated already today

Adaptation Option:	Diversification of tourist offers in different regions
	(especially more strategic options).
Effectiveness (considering different climate scenarios):	The effectiveness of this option depends on the specific design of the option. Diversification of services will probably not be able to fully address and offset all climate change impacts. As a high diversification of possible tourist services is not only a response to a changing climate but also increases the tourist sector's economic competitiveness; this option is also effective under existing climate conditions.
Expenditure Category(ies):	55 Promotion of natural assets 56 Protection and development of natural heritage 57 Other assistance to improve tourist services
Coherence with other policy objectives:	This option is in line with the EU Agenda for a sustainable and competitive European tourism.
Coherence with other adaptation options:	Co-benefits with other options depend on the specific situation, e.g. some general and crosscutting adaptation options (e.g. to prevent sea-level rise) have co-benefits with specific options for tourism.

** For this option, necessary investment costs have been estimated, including information at the Member State level. Information can be found in the database on the CLIMATE ADAPT platform.*

4.5. List of further resources

- ADAM digital compendium, PIK-Potsdam (2009). An online catalogue for Adaptation and Mitigation Strategies. Adaptation options applicable to four extreme events: drought, flooding, heat waves, sea-level rise.
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- Amelung B. and Viner D. (2006), Mediterranean tourism: Exploring the future with the tourism climatic index. Journal of Sustainable Tourism 14, 349-366.

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- ASTRA project; Geological Survey of Finland, Interreg IIIB (2005-2007) Regional impacts of climate change and strategies and policies for climate change adaptation; information and recommendations on how to develop adequate adaptation strategies to deal with climate change in the Baltic Sea Region.
- Business savings in a changing climate; Sefton Council UK (2011) Adaptation support for businesses in Sefton, UK. A guide (leaflet) and a checklist on climate change adaptation for businesses to become more aware of climate change impacts and become more climate resilient.
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- ClimChAlp, 2008, Climate Change, Impacts and Adaptation Strategies in the Alpine Space
- CLISP, 2009, Final Results of CLISP (Climate Change Adaptation by Spatial Planning in the Alpine Space), Available: http://www.clisp.eu/content/sites/default/files/CLISP-FINAL_BOOKLET+Rec..pdf
- EEA (2008) Impacts of Europe's changing climate – 2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, 246p, Copenhagen
- EEA (2009) cited in Altvater, S., van de Sandt, K., Marinova, N., de Block, D.,Klostermann, J., Swart, R., Bouwma, I., McCallum, S., Dworak, T. & D. Osberghaus (2011a): Assessment of the most significant threats to the EU posed by the changing climate in the short, medium and long term - Task 1 report, Ecologic, Berlin.
- Ehmer, E., and Heymann, P., (2008), Climate Change and Tourism: Where will the journey lead?, Deutsche Bank Research, Available: http://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000222943.pdf
- Evaluación preliminar de los impactos en Espana por efecto del cambio climático, Ministerio del Medio Ambiente (2005) Description of the impacts of climate change on diverse sectors, e.g. water, forest, biodiversity, health, tourism. There is also a brief overview of potential adaptation measures per sector.
- Mishev, P., and Mochurova, M., 2008, Climate change impacts on tourism, presented at the international conference "Global Environmental Change: Challenges to Science and Society in South-eastern Europe", May 2008, Bulgaria
- Norway Sectoral Responsibility, Norway Ministry of Environment, (2009) Online platform for climate adaptation in specific sectors. Sections per sector: news, case studies and research.

- OECD, 2007, Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management, Available: http://www.oecd-ilibrary.org/docserver/download/fulltext/9707061e5.pdf?expires=1334670263&id=id&accname=guest&checksum=9D95EDCC162D14AB4E094CCD24702C8F
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5. SECTORAL FICHE 5: TRANSPORT

5.1. Introduction

Developed and sustainable transport infrastructure is essential for regional development and therefore a significant portion of Cohesion Policy expenditure. This fiche provides a summary of the main threats to the transport sector from climate change, and indicates the approximate amount of Cohesion Policy expenditure on transport infrastructures in Member States during the 2007 – 2013 funding period. It also provides advice on possible options that might be used to increase the resilience of transport infrastructure to future climate change.

The fiche can be used alongside the guidance for climate proofing across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for sectoral authorities responsible for investments in transport infrastructures. It gives a short, concise overview of why and how climate change impacts are relevant for the transport sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes. This and other Sectoral Fiches have been prepared for the EU-27; using this structure as a guide, authorities can supplement the information here with national and/or regional details.

5.2. How will climate change impact transport in the EU?

Cohesion Policy is used to finance transport investment, through ERDF and the Cohesion Fund. Transport investments are aimed at stimulating regional development and, through the TEN-T network further development of the Single Market.

Transport infrastructure is affected by weather events. All transport modes are affected, but because of the scale of past investment the road network and also the rail network are especially exposed to climate threats. Where investment in transport systems is made on a regular relatively short life-cycle of around 20 years or less, as in many road systems, then there is scope to respond to changes in climate. Where investment cycles are longer (for example in high speed rail networks, or bridges and tunnels, or ports), the scope to respond is limited, and there is a greater need to consider the potential future resilience of transport investments to climate change.

5.2.1. Climate threats to the EU transport system

A review of the available evidence suggests that the EU transport system is likely to be subject to a number of threats as a result of changing climatic conditions. These threats reflect in part the distribution of climatic threats across the EU. Given the wide distribution of EU transport systems, it is this distribution of threats more than the general distribution of transport infrastructure that may lead to differences between broad EU regions in the risks to transport from climate change.

The analysis below summarises the main threats to the transport system, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions using the EEA analysis of climate threats across the main EU climatic regions.[21]

The review of evidence indicates that all transport modes will be affected. Major impacts are expected from flooding, storms and winter extremes and related risks of soil erosion (Table 1). Regionally, the assessment shows that the impacts from climate change are likely to be highest in the Central and Eastern European region. The lowest risk to transport infrastructure is expected in the Mediterranean region, partly because there are already some existing adaptive measures to mitigate climate risks in North and North-West regions.

[21] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen
North = FI, SE, EE, LV, LT
North-West = DK, NL, FR, BE, IE, UK
Mediterranean = ES, PT, IT, CY, MT, EL
Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

Table 1: Assessment of the relative scale of impacts on the transport sector from climate change-related events across EU climate regions, to 2020

Region	Flooding – Coastal	Flooding - River	Water scarcity	Soil erosion	Storms	Ice/Snow (Winter extremes)	Temperature extremes incl fires	Temperature change over time
North	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
North-West	High	Medium	Low	Low	Medium	Medium	Low	Low
Mediterranean	Low	Low	Low	Low	Low	Low	Medium	Low
Central & Eastern	Low	High	Medium	Medium	Low	Medium	Medium	Low

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

Table 2: Table 2: Assessment of the relative scale of overall climate change impacts on the transport sector across EU climate regions, to 2020

Region	Damage to transport
North	Medium
North-West	Medium
Mediterranean	Low
Central & Eastern	High

Source: Own assessment

5.2.2. Damage costs for the transport sector

The major impacts to transport infrastructure as a result of climate change are likely to be a result of flooding, storms, extreme events and snow-ice conditions. The overall scale of current (2010) annual EU weather-related damage costs to the transport sector is estimated at €2.5 billion per year. This is projected to increase by 20% in the period to 2050 (Enei, 2011, WEATHER Project), as shown in Table 3 below. Economic impacts are closely related to the frequencies of damage, disruption and transport restriction events and the availability of transport alternatives. The WEATHER project has examined the following categories of damages for each of the four modes (road, rail, waterborne and air):

- **Infrastructure (assets and operations):** damages and impacts on infrastructure maintenance, wear and tear and operations, e.g. snow removal, cleaning, small-scale repair measures, etc
- **Vehicle fleet (assets and operations):** damages and impacts on the costs of service provision, e.g. additional personnel, energy costs or vehicle preparation
- **User time:** travel time costs, including time for freight movements, and perceived service quality, e.g. reliability, crowding and temperatures in vehicles
- **Traffic safety**, i.e. the number of killed, severely and slightly injured transport users

Some impacts have not been estimated due to lack of information, for example the costs suffered by the rail transport system because of extremely cold days.

Table 3: Generalization of the costs of extreme weather events for the European transport system (annual data in EUR m), 2010

Extreme weather event		Infrastructure assets	Infrastructure operations	Vehicle assets	Vehicle operations	User time	Travel safety	Total
Storm	Road	76.1	22.6	5.1	1.4	63	5.9	174.1
	Rail	0.07		12.05		6.28		18.39
	Maritime			2.1	17.98			20.08
	Intermodal	0.53					0.72	1.25
	Air			53.8	34.3	38.4	28.3	154.8
Winter	Road	248.8	126.3	81.3	12.5	125.5	164.9	759.3
	Rail	0.04		3.38		1.6		5.02
	Intermodal	0.21					0.21	0.42

	Air		11.2	12	57.7	64.6	1.9	147.4
Flood	Road	630.1	21.9	24.4	30.01	93.7	21.5	821.61
	IWW					4.87		4.87
	Rail	103.66		11.6		67.3		282.55
	Air			3.2	26.5	29.6	0.2	59.5
	Intermodal	0.32					0.1	0.42
Heat and drought	Road						46.9	46.9
Total		1059.82	182	308.92	180.39	494.84	270.63	2496.6

Source: WEATHER Project, 2011. Note that project data is still subject to further research and validation

Includes Norway and Switzerland

5.2.3. Relative spread of damage costs by region

North

Regional assessment suggests that the greatest increase in the threat of storms is in the North and North-West regions. Also, increased temperature leading to less snowfall and melting of permafrost will largely affect regions in the North region, particularly Scandinavia.

North-West

The major threat from coastal flooding is in the North-West region. Transport infrastructure located in river catchment areas is also susceptible to river flooding. Increased precipitation in the region is likely to lead to soil erosion. Regional assessment also suggests that the Northand North-West regions will experience the greatest increase in the threat of storms.

Mediterranean

Ports in South Europe will be susceptible to changes in the sea level as many are designed for only small tidal ranges. The Mediterranean region might also be susceptible to extreme temperatures in the summer, including related fires.

Central & Eastern

The Central & Eastern regions are likely to experience greater variability of precipitation patterns ranging from reduced to increased precipitation resulting in a wide range of impacts. Together with the North-West, the Central & Eastern regions are most at risk from river flooding. Transport infrastructure located in river catchment areas will be more susceptible to river flooding and overall effects on transport are likely to be more significant than from coastal flooding. Because of increased precipitation in some parts of the region, soil erosion might occur. The increase in the threat of increased extremes in winter as well as summer temperatures may be greatest in the Central & Eastern region.

On the other hand, water scarcity might have adverse effects on the ports and navigation systems of the region, because of reduced carrying capacity. Particular impacts might be expected because of projected increase in reduced rainfall and higher temperatures, and the use made of inland waterways.

Other

Transport infrastructure located in coastal areas of Europe will be more susceptible to coastal flooding. Regarding roads, the thawing of permafrost will enhance the risk of rock slides and avalanches in Alpine regions, leading to interruptions in road traffic.

5.2.4. Cohesion Policy expenditure

In the 2007-2013 funding period Cohesion Policy expenditure in the transport sector includes motorways, national and regional roads, railways, airports, ports inland waterways, urban and multimodal transport and cycle tracks (DG Regional Policy expenditure categories 16-32 and 52). All of these expenditures under Cohesion Policy have the potential to be sensitive to climate change impacts; however this will be very much dependent on the region and specific location of investments.

The table below shows funding allocations for transport infrastructure in the 2007 – 2013 funding period. A total of EUR 81.7 billion has been allocated across the EU 27 from Cohesion Policy funds for transport infrastructure, representing 23.7% of total available funding.

Table 4: Transport infrastructure Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Infrastructure	EUR m	Code	Infrastructure	EUR m
16	Railways	4.002	25	Urban transport	1.835
17	Railways (TEN-T)	18.819	26	Multimodal transport	1.629
18	Mobile rail assets	559	27	Multimodal transport (TEN-T)	449
19	Mobile rail assets (TEN-T)	694	28	Intelligent transport systems	1.066
20	Motorways	5.135	29	Airports	1.830
21	Motorways (TEN-T)	17.247	30	Ports	3.352
22	National roads	7.728	31	Inland waterways (regional and local)	273
23	Regional/local roads	9.800	32	Inland waterways	598

				(TEN-T)	
24	Cycle tracks	6.180	52	Promotion of clean urban transport	6.109

Source: DG Regional Policy

Transport infrastructure is also expected to have a prominent role in spending for the 2014 – 2020 funding period. In the proposed ERDF regulation and the Commission document on a Common Strategic Framework, Thematic Objective (7) *Promoting sustainable transport and removing bottlenecks in key network infrastructures* envisions continued support for the transport sector, with a focus on sustainable forms of transport and investing in areas with the greatest European added value, the Trans-European Networks. For these investments, the Commission emphasises that 'Investments should consider the vulnerability of infrastructure with regard to natural and man-made risks and climate change'.[22]

5.3. How do these impacts affect Cohesion Policy/CAP programmes and projects in my Member State?

The table below provides specialized information for each Member State on the potential extent of the threat to transport and capacity to address it, relative to other countries in the EU.

Aggregated climate impacts from all threats are presented for each climatic region[23], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to transport by the Member State for 2007-2013 and the per cent share of transport in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national information platforms; technological resources in terms of the percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation.[24] The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impact, higher amounts of funding allocated to transport and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

[22] Commission Staff Working Document *Elements for a Common Strategic Framework 2014 to 2020*, SWD(2012) 61 Annex I Thematic Objectives, p 24.

[23] The score 'high', 'medium' and 'low' is assigned to the Member State based on the region (North, North-West, Mediterranean, Central & Eastern) to which it belongs.

Overview of relative impacts and Cohesion Policy risk by Member State

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	Aggregated score
Austria	High	6.3	0.5%	High
Belgium	Medium	59.5	2.9%	High
Bulgaria	High	2025.1	30.3%	Low
Cyprus	Low	89.6	14.6%	Low
Czech Republic	High	7769.3	29.5%	Medium
Denmark	Medium	0.0	0.0%	High
Estonia	Medium	704.2	20.7%	Medium
Finland	Medium	36.4	2.3%	High
France	Medium	1122.8	8.3%	High
Germany	High	3175.2	12.5%	High
Greece	Low	6260.1	31.0%	Low
Hungary	High	6997.2	28.1%	Medium
Ireland	Medium	83.3	11.1%	Medium
Italy	Low	4246.9	15.2%	Low
Latvia	Medium	1219.4	27.1%	Low
Lithuania	Medium	1578.5	23.3%	Low
Luxembourg	High	0.0	0.0%	Medium
Malta	Low	188.3	22.4%	Low
Netherlands	Medium	50.4	3.0%	High
Poland	High	25638.9	39.3%	Low
Portugal	Low	3032.4	14.2%	Medium
Romania	High	5371.1	28.0%	Low
Slovakia	High	3446.8	30.0%	Low
Slovenia	High	989.8	24.1%	Medium
Spain	Low	7831.6	22.6%	Medium

Sweden	Medium	80.5	5.0%	High
UK	Medium	489.3	4.9%	High

5.4. What are some of the best ways to build resilience into the transport system using Cohesion Policy expenditures?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some concrete technical options that can be funded by Cohesion Policy programmes to 1) improve adaptive capacity through research and planning; 2) adapt infrastructure to make it more resilient to future impacts of climate change.

This is not an exhaustive list but a menu of possible adaptation options for the transport sector. The main aim is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored to individual needs.

The options were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

Options are summarised here for the transport sector. A searchable database of options for all Cohesion Policy and CAP sectors is available on the European Climate Adaptation Platform - CLIMATE-ADAPT.

5.4.1. Adaptation Options for the Transport Sector

5.4.1.1.Road options

Adaptation Option:	**Heat-resistant asphalt and adjustment of maintenance**
Extreme heat and greater temperature variability overall will put a larger strain on road pavements, leading to cracks, rotting or pavement blow-ups. These pose additional risks to transport users. New construction materials can be used to cope with these	

Adaptation Option:	**Heat-resistant asphalt and adjustment of maintenance**
effects and to make pavement more heat resistant (e.g. new, heat-resistant paving materials, more common use of polymer-modified bitumen, improvement in pavement technology, using polymeric grids to avoid rutting, using materials on the surface which reflect solar radiation).	
Climate threat addressed:	Temperature extremes
Urgency:	Short-term, up to 2020 in some cases: The urgency of the option depends on the underlying climate-threats. In regions with increasing temperatures extremes up until 2020, the option should be implemented in the short-term during the next programming period. Overall, it should be considered to implement the option in the regular maintenance cycle.
Effectiveness (considering different climate scenarios):	This option is able to avoid a large share of climate change impacts on roads from increasing heat under a medium scenario (i.e. 2°C). However, some of the heat-resistant materials will also not be robust to a more extreme scenario (i.e. 4°C) so that some risks remain regarding such a scenario. Some of the materials also increase the lifetime of road pavements and are thus also robust under a business-as-usual scenario without climate change.
Expenditure Category(ies):	010 – TEN-T motorways and roads - core 011 – TEN-T motorways and roads - comprehensive 012 – secondary roads and nodes 013 – other national and regional roads 014 – local access roads
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T).
Coherence with other adaptation options:	This option should be combined with "*Remote sensing and satellite imagery for early warning systems*" to allow spontaneous adaptation options (e.g. reduction of speed limits during heat waves).

** For this option, a detailed cost-benefit analysis has been conducted, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Shifting of road alignments beyond areas at risk**
Extreme events, especially those that lead to coastal and river flooding, can lead to flooding of roads and make the roads impassable. For roads in areas at risk of coastal and river flooding, one option is to find another route, so that the road alignment can be shifted over middle or long term. For planning of new roads, the element of local	

Adaptation Option:	**Shifting of road alignments beyond areas at risk**
vulnerability to weather extremes needs to be considered within a life cycle cost benefit analysis. The options would include the construction of new roads and the removal of old infrastructure.	
Climate threat addressed:	Flooding – Coastal, Flooding – River
Urgency:	Short-term, up to 2020: Options should be initiated in the short-term up to 2020, due to the long implementation time required to shift the road infrastructure. Political, technical implementation and also to build up local acceptance would need time. Furthermore, the option should be timed along the regular maintenance cycle.
Effectiveness (considering different climate scenarios):	As this is a preventive measure, the option would be fully effective under the considered climate change scenario. If extreme scenarios are considered, effectiveness is also given in this case. As the option addresses climate change threats, it would not be necessary in a business-as-usual scenario with current climate conditions.
Expenditure Category(ies):	010 – TEN-T motorways and roads - core 011 – TEN-T motorways and roads - comprehensive 012 – secondary roads and nodes 013 – other national and regional roads 014 – local access roads
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T).
Coherence with other adaptation options:	This option has inter-linkages with other preventive options, especially regarding flooding "*Flood gates*" and "*Dike reinforcement and heightening*". Being a strategic option, this option also is in line with "*Strategic urban and regional planning to prevent further accumulation of assets in vulnerable areas*".

Adaptation Option:	**Retrofitting existing road infrastructure concerning increased precipitation**
Damages from flash floods and extreme precipitation events can be avoided through proper and scheduled maintenance of drainage. In some regions, where intensive precipitation is likely to increase, an upgrading of drainage should be considered.	
Climate threat addressed:	Coastal and/or river flooding

Urgency:	Short-term, up to 2020: The options should be begun in the short-term up to 2020, due to the long implementation time required for road construction and the short-term threats from increasing precipitation in most regions. It includes high investment costs and should be included in the regular maintenance cycle.
Effectiveness (considering different climate scenarios):	This option is fully effective under a medium climate-change scenario (i.e. 2°C). Effectiveness under a more extreme scenario (4°C) depends on the specific design of drainage systems but seems possible. As the option addresses climate change threats, it would not be necessary in a business-as-usual scenario with current climate conditions.
Expenditure Category(ies):	010 – TEN-T motorways and roads - core 011 – TEN-T motorways and roads - comprehensive 012 – secondary roads and nodes 013 – other national and regional roads 014 – local access roads
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T).
Coherence with other adaptation options:	This option should be combined with "*Remote sensing and satellite imagery for early warning systems*" to allow spontaneous adaptation (e.g. reduction of speed limits during heat waves). Effectiveness is enhanced if combined with "*Vegetation management along roads and rails*".

** For this option, a detailed cost-benefit analysis has been conducted, including information on MS level. Information can be found in the database.*

5.4.1.2.Rail options

Adaptation Option:	**Adjustments of maintenance of rail infrastructure**
Depending on location, rail infrastructure is potentially vulnerable to all climate change threats. To mitigate the adverse effects of these threats, more frequent and tailored maintenance might be necessary. For example, maintenance of rail track (including replacement in time) reduces rail buckling during heat periods. Maintenance of embankments and drains guarantees the functioning of these systems if heavy rains or floods occur. Frequent inspection of bridges (especially corrosion) reduces damage and destruction risk due to heavy rains.	
Climate threat addressed:	Flooding – Coastal, Flooding River, Soil erosion, Storms, Ice/Snow (Winter extremes), Temperature extremes including fires
Urgency:	Short-term to long-term, depending on necessity: The impacts of climate change will occur in the short- and mid-

Adaptation Option:	Adjustments of maintenance of rail infrastructure
	to long-term. The option can be implemented and will show effects in a very short time period, so implementation should be regularly adjusted to climate change impacts as they occur.
Effectiveness (considering different climate scenarios):	The adjust of maintenance is fully flexible, it can become effective under all climate change conditions.
Expenditure Category(ies):	06 – Railways (TEN-T core) 07 – Railways (TEN-T comprehensive) 08 – other railways
Coherence with other policy objectives:	The option supports the functioning and security of European rail infrastructures.
Coherence with other adaptation options:	To limit additional maintenance costs, the option should be combined with "*Adaptation of rail infrastructure to heat and temperature change*"

Adaptation Option:	Adaptation of rail infrastructure to heat and temperature change
Extreme heat may lead to rail buckling. During extreme temperatures, trains have to run slower to minimise risk derailment. Adapting the rail system to cope with great temperature variability can include adjustment of the maximum temperature that rails are designed to cope with, possibly through the use of different types of steel. This may also avoid the need for stressing.	
Climate threat addressed:	Temperate extremes, temperature change over time
Urgency:	Short-term, up to 2020 in some cases: The option should be begun in the short term up to 2020. The option has a long implementation period, and concerns a climate change impact that is projected to occur in the short term.
Effectiveness (considering different climate scenarios):	The option's effectiveness regarding different climate scenarios depends on the specific design and adjustment of infrastructures. It could also be designed to be effective under an extreme climate scenario (i.e. 4°C). As the option addresses climate change threats, it would not be necessary in a business-as-usual scenario with current climate conditions.
Expenditure Category(ies):	06 – Railways (TEN-T core) 07 – Railways (TEN-T comprehensive)

	08 – other railways
Coherence with other policy objectives:	The option supports the functioning and security of European rail infrastructures and is in line with the TEN-T objectives.
Coherence with other adaptation options:	To prevent remaining risks, this options needs to be combined with "*Adjustments of maintenance of rail infrastructures*".

** For this option, a detailed cost-benefit analysis has been conducted, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Retrofitting air-conditioning systems in trains for increased temperatures**
Not all trains are currently equipped with air-conditioning systems or systems that can cope with outside temperatures above 35 degrees Celsius. To prevent health risks for passengers from increased temperatures and heat waves, it will be important to either install efficient air-conditioning systems in trains or to adjust existing systems to handle higher temperatures.	
Climate threat addressed:	Temperature extremes, temperature change over time
Urgency:	Short-term, up to 2020: The option should be implemented in the short-term up to 2020 as it addresses a short-term climate threat. Trains have a long life-time and the retrofitting of air-conditioning systems should be included if new trains are bought or trains are routinely redesigned.
Effectiveness (considering different climate scenarios):	The option can be designed to be effective under a broad range of climate scenarios, including extreme heat. Under current climate conditions, the option would only be effective in regions that already face heat waves.
Expenditure Category(ies):	09 Mobile rail assets
Coherence with other policy objectives:	This option increases or secures the attractiveness of rail passenger transport and thus supports the objectives for a modal shift from road to rail.
Coherence with other adaptation options:	This option should be combined with "*Heat warning systems*" to allow for additional adjustments. To encourage synergies with climate change mitigation policies, it should also be linked to "*Higher energy efficiency of ventilation systems*".

5.4.1.3.Air transport options

Adaptation Option:	**Retrofitting airports against heat**
Extreme heat and greater overall temperature variability will increase strain on airport runways, leading to cracks, rotting or pavement blow-ups. These pose additional risks to outgoing or incoming planes. New construction materials can be used to cope with these effects and to make pavement more heat resistant (e.g. new, heat-resistant paving materials, more common use of polymer-modified bitumen, improvement in pavement technology, using polymeric grids to avoid rutting, using materials on the surface which reflect solar radiation).	
Climate threat addressed:	Temperate extremes, temperature change over time
Urgency:	Short-term, up to 2020 in some cases: Especially in regions with increasing temperatures up until 2020, the option should be implemented in the short-term. Safe runways are especially important for a secure air transportation system, so the option needs to be implemented rather sooner than later.
Effectiveness (considering different climate scenarios):	This option is able to avoid a large share of climate change impacts on airports from increasing heat under a medium scenario (i.e. 2°C). However, some of the heat-resistant materials will also not be robust to a more extreme scenario (i.e. 4°C) so that some risks remain regarding such a scenario. Some of the materials also increase the lifetime of runway pavements and are thus also robust under a business-as-usual scenario without climate change.
Expenditure Category(ies)	017 – Airports 018 – other airports
Coherence with other policy objectives:	The option supports the functioning and security of the European aviation system.
Coherence with other adaptation options:	There are no direct links to other options.

Adaptation Option:	**Retrofitting airports against higher precipitation**
Damage from flash floods and extreme precipitation events can be avoided through proper and scheduled maintenance of drainage of airport runways. In some regions, where intensive precipitation events are likely to increase, an upgrading of drainage for airport runways should be considered.	
Climate threat addressed:	Temperate extremes, temperature change over time
Urgency:	Short-term, up to 2020: The options should be begun in the short-term up to 2020, due to the short-term threats from

Adaptation Option:	Retrofitting airports against higher precipitation
	increasing precipitation in most regions. It includes high investment costs and should be included in the regular maintenance cycle.
Effectiveness (considering different climate scenarios):	This option is fully effective under a medium climate-change scenario (i.e. 2°C). Effectiveness under a more extreme scenario (4°C) depends on the specific design of drainage systems but seems possible. As the option addresses climate change threats, it would not be necessary in a business-as-usual scenario with current climate conditions.
Expenditure Category(ies):	017 – Airports 018 – other airports
Coherence with other policy objectives:	The option supports the functioning and security of the European aviation system.
Coherence with other adaptation options:	There are no direct links to other options.

5.4.1.4.Inland water transport options

Adaptation Option:	Retrofitting existing infrastructure of shipping concerning extreme events
Several options can be used to ensure stable conditions for inland water transport, especially a stable river-bed. For example, river groynes are rigid hydraulic structures that interrupt water flow, limit the movement of sediment and protect coastal areas or river banks. These structures are built from an ocean shore (in coastal engineering) or from a bank (in rivers)	
Climate threat addressed:	Coastal and/or river flooding
Urgency:	Short-term, up to 2020 in some cases: As extreme events from coastal and/or river flooding can occur in the short-term in some of the regions and as the planning and implementation time is long, the option should be implemented in the short-term up to 2020.
Effectiveness (considering different climate scenarios):	The effectiveness under different climate scenarios depends on the specific retrofitting options. It could also be designed to be effective under more extreme climate scenarios (i.e. 4°C). In most of the cases, the options would however not be necessary under current climate conditions and would thus not be robust under a BAU-scenario.
Expenditure	021 – Inland waterways and ports (TEN-T)

Adaptation Option:	**Retrofitting existing infrastructure of shipping concerning extreme events**
Category(ies):	022 – Inland waterways and ports (regional and local)
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T) and to strengthen inland water transport (as outlined in the Transport White Paper).
Coherence with other adaptation options:	This option is closely interlinked with other preventive options, especially regarding flooding "*Flood gates*" and "*Dike reinforcement and heightening*". It also is in line with "*Strategic urban and regional planning to prevent further accumulation of assets in vulnerable areas*".

Adaptation Option:	**Improvement of water-flow management, including creation of water storage facilities**
Increased frequency of coastal and river flooding is likely to pose challenges for water management. Installation of flood gates (grey) or depoldering (relocation of a polder land inwards) would protect against flooding, especially river flooding, and can help to secure a sufficient level of water for shipping.	
Climate threat addressed:	Coastal and/or river flooding
Urgency:	Short-term, up to 2020 in some cases: As extreme events from coastal and/or river flooding can occur in the short-term in some of the regions and as the planning and implementation time is long, the option should be implemented in the short-term up to 2020.
Effectiveness (considering different climate scenarios):	The option can be designed to be effective under different climate scenarios, including extreme scenarios (> 4°C). Some of the measures, especially the green options regarding polder land, are also effective regarding biodiversity management and are thus also effective under current climate conditions.
Expenditure Category(ies):	021 – Inland waterways and ports (TEN-T) 022 – Inland waterways and ports (regional and local)
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T) and to strengthen inland water transport (as outlined in the Transport White Paper). It also has synergies with biodiversity management.
Coherence with other adaptation options:	This option is closely interlinked with the previous option "*Retrofitting existing infrastructure of shipping concerning*

Adaptation Option:	Improvement of water-flow management, including creation of water storage facilities
	extreme events" as well as other preventive options, especially regarding flooding "*Flood gates*" and "*Dike reinforcement and heightening*".

5.4.1.5.General transport options

Adaptation Option:	Adequate design and maintenance of bridges and tunnels
Increase in the frequency of extreme weather events should be taken account when reviewing design and maintenance codes for bridges and tunnels. Climate change impacts may require an increase in the frequency of maintenance works. To avoid catastrophes, it is recommended to compare the predicted impact of future extreme events to current and past design codes.	
Climate threat addressed:	Heat, flooding, flash floods
Urgency:	Short-term, up to 2020: The option should be implemented in the short-term up to 2020 as bridges and tunnels will already face climate change impacts in this time-period.
Effectiveness (considering different climate scenarios):	In most cases, the option can be designed in a flexible way and be adjusted to different climate-scenarios. Especially for infrastructures with long-lifetimes, it might be useful to consider an upper climate scenario in the construction/reconstruction phase. In most of the cases, the options would however not be necessary under current climate conditions and would thus not be robust under a business as usual scenario.
Expenditure Category(ies):	All road and railways relevant categories (i.e. between 06 and 014)
Coherence with other policy objectives:	This option is line with the overall objectives to implement a transeuropean transport system (TEN-T).
Coherence with other adaptation options:	There are no direct links to other options.

Adaptation Option:	Vegetation management along roads and rails
Vegetation (trees and plants) located along roads and railways can be problematic for both the safety and proper functioning of transport infrastructure during extreme events, especially storms. Options for managing vegetation to better cope with the impacts of climate change include cutting down trees that are at risk of falling during extreme storms, and choosing the right vegetation for changing climatic conditions. In some cases, the right vegetation type can stabilize the soil along roadsides and railway tracks	

Adaptation Option:	Vegetation management along roads and rails
and prevent mudslides and erosion.	
Climate threat addressed:	Storms, flooding, flash floods
Urgency:	As extreme events can occur already in the short-term up to 2020 and are already relevant today, the option should be implemented in the next programming period.
Effectiveness (considering different climate scenarios):	As this is a rather flexible option, it can be designed in a very targeted way and can thus be effective under all climate scenarios. As it increases the security of European transport infrastructures, it is already relevant under existing climate-conditions and thus robust under a business as usual scenario.
Expenditure Category(ies):	All road and railways relevant categories (i.e. between 06 and 014)
Coherence with other policy objectives:	This option is line with the overall objectives to implement a trans-European transport system (TEN-T).
Coherence with other adaptation options:	This option should be combined with the other options that secure the functioning of the transport network, especially "*Retrofitting existing road infrastructure concerning increased precipitation*".

5.5. List of further resources

- AdaptAlp, 2011 Climate Adaptation and Natural Hazard Management in the Alpine Space, Final Report
- Adaptation Wizard, UKCIP (2010), 5-step process to assess vulnerability to current climate and future climate change, identify options to address key climate risks, and help to develop and implement a climate change adaptation strategy.
- AdaptME toolkit, UKCIP (2011), Climate change adaptation and monitoring toolkit, to help evaluate current adaptation activities.
- AdOpt, UKCIP (2011), Information on the range of adaptation options and practical examples. Includes a checklist of key principles for good adaptation decisions. Intended for decision- and policy-makers in identifying and appraising the effectiveness of climate risk adaptation measures.
- Altvater, S., van de Sandt, K., Marinova, N., de Block, D.,Klostermann, J., Swart, R., Bouwma, I., McCallum, S., Dworak, T. & D. Osberghaus (2011): Assessment of the most significant threats to the EU posed by the changing climate in the short, medium and long term - Task 1 report, Ecologic, Berlin

- AMICA Adaptation Tool; PIK-Potsdam, Interreg IIIC (2005-2006), A Matrix of adaptation measures and a list of evaluated practice examples.
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- Defra Advice for Infrastructure Companies; UK (2011). A report on how to make infrastructure and its companies more climate resilient; includes climate change impacts, adaptation options, potential opportunities, potential barriers, and relevant stakeholders.
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- Environment agency "Adapting to climate change programme", UK (2011); Sectorial resources and tools to help map out climate vulnerabilities, the benefits of adapting, and ways to increase resilience to climate change.
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- Marcos, M., Jordà, G., Gomis, D., Pérez, B., 2011, Changes in storm surges in southern Europe from a regional model under climate change scenarios, Global and Planetary Change 77, pgs 116–128

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- Red de Ciudades por el Clima, Federation Espanola de Municipios Y Provincias (2010) Network of cities, with the goal to ensure that regional adaptation strategies do not run against the overall objectives of the National Adaptation Strategy. Good practice and guidance on sustainable development and climate protection. Focus is actually on mitigation, not adaptation.
- Swedish Government Official Reports, (2007). Sweden facing climate change – threats and opportunities. Final report from the Swedish Commission on Climate and Vulnerability Available at: www.regeringen.se/sb/d/108/a/94595 (in English)

6. SECTORAL FICHE 6: WATER

6.1. Introduction

By aiming to preserve water quality and resources in regions and cities through improved waste water treatment plants, water supply and water efficiency, funding for the water sector is an important part of Cohesion Policy expenditure. This fiche provides a summary of the main threats to water infrastructures from climate change, and indicates the approximate amount of cohesion Policy expenditure on water infrastructures in Member States during the 2007 – 2013 funding period. It also provides advice on possible options that might be used to increase the resilience of buildings to future climate change.

The fiche can be used alongside the guidance for climate proofing across the Cohesion Policy programme cycle. The general information about impacts and threats is useful at the strategic level – for designing the development strategies that are part of Operational Programmes and Partnership Agreements. The adaptation options provide an orienting overview of what might be done in terms of actual investment projects. Where relevant, they can be suggested as input to Operational Programmes or as support for project developers.

The fiche is also useful on its own, as a source of information for sectoral authorities responsible for investments in water infrastructure. It gives a short, concise overview of why and how climate change impacts are relevant for the water sector, and provides concrete ideas on how the impacts can be addressed in the context of Cohesion Policy programmes. This and other Sectoral Fiches have been prepared for the EU-27; using this structure as a guide, authorities can supplement the information here with national and/or regional details.

6.2. How will climate change impact the water infrastructure in the EU?

Cohesion Policy expenditure in the water sector includes management and distribution of drinking water and treatment of waste water. Investments in new and existing infrastructure in these expenditure categories may be sensitive to the risk of climate change related events, especially flooding as infrastructure is often located near to coasts or rivers; and to changes in demand for water services, with implications for water distribution systems.

Overall, there are a number of projected impacts on the water sector as a result of climate change related weather events. Likely effects include increased flooding, storms, salinization, higher temperatures and lower rainfall. These impacts tend to be related and it might be difficult to separate out the relative impacts of different threats.

6.2.1. Climate threats to the EU water system

A review of the available evidence suggests that the EU water system is likely to be subject to a number of threats as a result of changing climatic conditions. These threats reflect in part the distribution of climatic threats across the EU.

The analysis below summarises the main threats to water infrastructure, and seeks to provide an initial assessment of the relative difference in the scale of the threat between regions using the EEA analysis of climate threats across main the EU climatic regions.[25]

Major impacts are expected from flooding, water scarcity and changes in water quality and salinity (Table 1). Regionally, the assessment shows that the impacts from flooding are likely to be highest in the North and the North-West. Impacts from changes in water quality and water scarcity will be highest in the Central &Eastern and in the Mediterranean regions.

[25] EEA (2008) Impacts of Europe's changing climate—2008 indicator-based assessment, Joint EEA-TRC-WHO report. EEA Report No 4/2008, Copenhagen

North = FI, SE, EE, LV, LT

North-West = DK, NL, FR, BE, IE, UK

Mediterranean = ES, PT, IT, CY, MT, EL

Central & Eastern = LU, DE, PL, HU, CZ, SK, SI, AU, BG, RO

Table 1: Assessment of the relative scale of impacts on the water sector from climate change-related events/factors across EU climate regions, to 2020

Region	Flooding – Coastal	Flooding - River	Water scarcity	Water quality/ salinity	Storms	Temperature extremes incl fires
North	Medium	High	Low	Low	Low	Low
North-West	High	Medium	Low	Medium	Low	Low
Mediterranean	Low	Low	High	High	Low	High
Central & Eastern	Low	Medium	High	High	Low	High

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

Table 2: Assessment of the relative scale of overall climate change impacts on the water sector across EU climate regions, to 2020

Region	Damage to water infrastructure
North	Low
North-West	Low
Mediterranean	High
Central & Eastern	High

Source: Own assessment

6.2.2. Damage costs for the water sector

The major impacts and damage costs in the water sector are likely to include:

- Damage to water infrastructure in areas located close to river or coasts.
- Damage to water quality and salinity in areas experiencing temperature increases, extremes and reduced rainfall.

  The PESETA project (Richard & Nicholls, 2009) found that, in the absence of adaptation, damage costs of salinization across the EU would reach €600 million per year (1995 prices) by the 2020s, under the A2 climate change scenario, assuming medium sea level rise.

  The ClimWatAdapt study found that droughts which occurred once every 50 years in the 20th century are now expected to occur more frequently, approximately every 10 years across the EU. Water quality will also be affected by increased water withdrawals from low-quality sources during drought periods.
- Higher infrastructure and operating costs are expected, associated with the need to expand water storage and to extend distribution systems to supply water scare areas from water rich areas.
- The study by Mima and Criqui (2012) as part of the ClimateCost research programme, estimated an increase in energy costs to the water sector of some €3.5 billion annually by 2100 across the EU (an increase of about €0.5 billion a year by the 2020s).

A comprehensive study that would estimate the current or potential costs to the EU water infrastructure as a result of climate change has not been found.

6.2.3. Relative spread of damage costs by region

<u>North</u>

The North region is expected to experience increase in the frequency and intensity of extreme precipitation events, where increasing flood risk is an issue.

<u>North-West</u>

Regional assessment of climate change threats suggests that the risks from coastal flooding as well as river flooding are likely to be substantially higher in the North-West region than in other EU regions.

<u>Mediterranean</u>

Climate change will reduce water availability in the Mediterranean for all significant sectors, such as domestic water supply, hydropower production and agricultural irrigation. The Mediterranean region might also be susceptible to extreme temperatures in the summer, including related fires implying a substantial increase in demand for water. The Mediterranean region is also prone to risks of reduced water quality. Higher infrastructure costs for storage and distribution are likely.

<u>Central & Eastern</u>

Alongside the North-West region, the Central & Eastern region faces a relatively higher risk of river flooding when compared to other regions in the EU. In the winter, extreme precipitation events are expected to increase in frequency and intensity. The region is also susceptible to adverse changes in water quality and salinity. Another risk to the region is posed by the conjunction of water scarcity and heat waves.

6.2.4. Cohesion Policy expenditure

In the 2007-2013 funding period Cohesion Policy expenditure in the water sector includes waste water treatment and drinking water management and distribution (DG Regional Policy expenditure categories 45 and 46). All of these expenditures under Cohesion Policy have the potential to be sensitive to climate change impacts. The table below shows funding allocations for the 2007 – 2013 period. A total of EUR 22.1 billion has been allocated across the EU 27 from Cohesion Policy funds for water infrastructure, representing 6.4% of total available funding.

Additional investment and higher operating costs of abstraction, distribution and treatment is likely to increase investment needs for water infrastructure in the next programming period.

Table 4: Water infrastructure Cohesion Policy funding allocations 2007 – 2013, EU 27

Code	Water infrastructure	EUR m
45	Management and distribution of water (drink water)	8,054.6
46	Water treatment (waste water)	14,048.1

Source: DG Regional Policy

Water infrastructure is expected to continue to be important in spending for the 2014-2020. Funding for the water sector is envisaged under thematic objective (6) *promoting the environment and promoting resource efficiency*.

6.3. How do these impacts affect Cohesion Policy/CAP programmes and projects in by Member State?

The table below provides specialised information for each Member State on the potential extent of the threat to water infrastructure and capacity to address it, relative to other EU Member States.

Aggregated climate impacts from all threats are presented for each climatic region[26], taken from Table 1 above. It was not possible to differentiate the scale of the threat by Member State based on the research available, but the region is a good indicator. The Cohesion Policy expenditure data are the funds allocated to water infrastructure by the Member State for 2007-2013 and the percent share of water infrastructure in the Member State's overall Cohesion Policy funding portfolio.

Adaptive capacity is the overall ability of the country to adapt to climate change. For Cohesion Policy sectors, adaptive capacity was evaluated based on the following criteria: national

[26] The score 'high', 'medium' and 'low' is assigned to the Member State based on the region (North, North-West, , Mediterranean, Central & Eastern) to which it belongs.

information platforms; technological resources in terms of percentage of GDP spent on research and development and number of patents; GDP per capita as a proxy for economic resources; national adaptation strategies; and government effectiveness based on a World Bank evaluation.[27] The resulting scores for each Member State are given below.

The table therefore can be read as an overall message with regard to the extent of the impacts (high, medium or low); the amount of funding at stake and its priority within overall spending; and the potential capacity to adapt. Member States with higher impact, higher share of funding allocated to the water sector and lower adaptive capacity are the ones that need to take the greatest action with regard to climate proofing the sector.

The information provided here is indicative and in some cases relative to the EU performance overall and should therefore be taken with caution. It may be useful particularly in raising awareness about the need to consider climate change adaptation more seriously.

Overview of relative impacts and Cohesion Policy risk by Member State in the water sector

Member State	**Climate Impacts**	**Cohesion Policy expenditure 2007 - 2013**		**Overall adaptive capacity**
	Aggregated impacts (all threats)	**In Mio. €**	**% MS total expenditure**	
Austria	High	0.0	0.0%	High
Belgium	Low	1.0	0.0%	High
Bulgaria	High	934.9	14.0%	Low
Cyprus	High	8.5	1.4%	Low
Czech Republic	High	1745.5	6.6%	Medium
Denmark	Low	0.0	0.0%	High
Estonia	Low	407.8	12.0%	Medium
Finland	Low	9.5	0.6%	High
France	Low	274.9	2.0%	High
Germany	High	377.5	1.5%	High
Greece	High	1398.2	6.9%	Low
Hungary	High	1958.6	7.9%	Medium
Ireland	Low	13.0	1.7%	Medium
Italy	High	574.9	2.1%	Low
Latvia	Low	563.0	12.5%	Low

Member State	Climate Impacts	Cohesion Policy expenditure 2007 - 2013		Overall adaptive capacity
	Aggregated impacts (all threats)	In Mio. €	% MS total expenditure	
Lithuania	Low	343.6	5.1%	Low
Luxembourg	High	0.0	0.0%	Medium
Malta	High	61.5	7.3%	Low
Netherlands	Low	2.0	0.1%	High
Poland	High	3663.8	5.6%	Low
Portugal	High	1439.4	6.7%	Medium
Romania	High	2776.5	14.5%	Low
Slovakia	High	890.6	7.7%	Low
Slovenia	High	450.3	11.0%	Medium
Spain	High	4053.8	11.7%	Medium
Sweden	Low	0.0	0.0%	High
UK	Low	0.0	0.0%	High

6.4. What are some of the best ways to build resilience into the transport system using Cohesion Policy expenditures?

Climate impacts, threats, costs and capacity to adapt are theoretical concepts. They pose a risk to a programme or sector, but what exactly is to be done? This section provides some concrete technical options that can be funded by Cohesion Policy programmes to 1) improve adaptive capacity through research and planning; 2) adapt infrastructure to make it more resilient to future impacts of climate change.

This is not an exhaustive list but a menu of possible adaptation options for the water sector. The main aim is getting the thinking started about how - concretely - to build resilience into investments in this sector, and starting a dialogue between adaptation experts and relevant sectoral authorities. Clearly these options will need to be further developed and tailored to individual needs. Different adaptation options are listed for waste water systems and for drinking water systems. In addition, potential co-benefits with other adaptation options have been indicated.

The options were identified through the analysis of climate impacts and damage costs covered in the main project report. They are based on a review of relevant EU policy documents and recent

academic and non-academic literature on the topic. The options included in this and the other sectoral fiches were identified and selected by a team of experts to meet the following criteria:

- Options are likely to benefit from **EU Cohesion Policy support** in some Member States, and cannot be delivered by the private and or domestic sectors alone
- Options are relatively **urgent**; they should be implemented or initiated within the next Cohesion Policy period, e.g. by 2020
- Options are **effective**; they are likely to effectively reach intended objectives and appear robust under varying implementation scenarios, including socio-economic and climate change conditions.
- Options are **coherent** with current EU policy objectives and can have synergies with other options.
- Options are **efficient**; they can reach objectives in a cost-effective way versus benefits.

Options are summarised here for the water sector. A searchable database of options for all Cohesion Policy and CAP sectors is available on the European Climate Adaptation Platform - CLIMATE-ADAPT.

6.4.1. Adaptation Options for the water Sector

6.4.1.1. Waste water systems

Adaptation Option:	**Additional rain overflow basins to adapt sewage system against flooding, enhancing water storage capacity of reservoirs**
The increase in the incidence of precipitation will lead to more floods and flash floods. Extending the capacities of storm retention reservoirs increases the ability to cope with more intense precipitation events and to prevent damages from intra-urban flooding. To avoid a leak of sewage water, additional storm water retention reservoirs could be built to store water during high precipitation events. These include both combined sewer overflow (CSO) tanks and storm water holding tanks (without overflow).	
Climate threat addressed:	Floods, flash floods
Urgency:	Short-term, up to 2020: This option addresses impacts that become relevant in the short-term up to 2020. As the construction of water infrastructures face long planning processes, urgency is high.
Effectiveness (considering different climate scenarios):	The option has the potential to avoid a considerable share of damages related to urban flooding in a medium climate change scenario (i.e. 2°C). Depending on the design of the additional reservoir capacity, effectiveness under an extreme climate scenario (> 4°C) is however limited as the risk of water overflow remains. In most cases, the implementation of additional reservoir capacities is not necessary under a business as usual scenario.

Expenditure Category(ies):	05 Waste water
Coherence with other policy objectives:	This option supports objectives of the Water Framework Directive to reach good water quality in European water bodies as well as the Flooding Directive.
Coherence with other adaptation options:	This option can be seen as complementary with strategic urban planning practices, especially the options '*Strategic urban and regional planning to prevent further accumulation of assets in vulnerable areas*', '*Green and blue Spaces, incl. green roofs*' as well as the option '*Sustainable Urban Drainage Systems*' which has a similar function to this option.

** For this option, necessary investment costs have been estimated, including information on MS level. Information can be found in the database.*

Adaptation Option:	**Adaptation to sewage systems against droughts and low-water level**
The option focuses on the adjustment of sewage systems (including sewage treatment, pipe transportation network and pump stations to a reduced water passage that leads to erosion of pipes as well as unpleasant odors. All the different components have to be adapted to potential droughts and low-water level, e.g. the transportation network has to be adjusted to lower water levels and has to be flushed with fresh-water on a regular basis to compensate the lower water passage. Where possible during construction or main maintenance of such systems drought situations should be taken into account.	
Climate threat addressed:	Water scarcity/drought
Urgency:	Short-term, up to 2020 in some cases: Urgency depends on the timing of climate impacts. Especially in the Southern regions, water scarcity and drought will become more relevant in the short-term up to 2020. In some other regions, adaptation of sewage systems might be postponed beyond 2020. Due to long lifetimes of water infrastructures, future climate change impacts should however already be considered in the planning of new networks or repair work.
Effectiveness (considering different climate scenarios):	The option is especially effective under a medium climate scenario (i.e. 2°C temperature increase). Effectiveness under an extreme scenario with extreme droughts is limited as the problems for sewages systems cannot fully be avoided. As this option also addresses the trend to lower water uses (increased efficiency together with demographic change in some regions), the option is also partly effective under a business-as-usual scenario.

Adaptation Option:	**Adaptation to sewage systems against droughts and low-water level**
Expenditure Category(ies):	05 Waste water
Coherence with other policy objectives:	This option is in line with the Water Framework Directive.
Coherence with other adaptation options:	This option has no direct links to other adaptation options.

Adaptation Option:	**River restoration (buffer zone), restoration of wetlands**
The measure focuses on increasing the flow capacity of the river system during flood events, and/or on reducing the speed of water flow. This option also aims to help increase habitat quality and groundwater recharge. This option can be implemented in the frame of river and/or ecosystem restoration projects undertaken by local or regional water management agencies (e.g. in the frame of River Basin Management Plans under the WFD).	
Climate threat addressed:	Flooding
Urgency:	Short-term, up to 2020: Even if this option does not necessarily address short-term impacts, it needs to be taken forward during the next programming period. River restoration project shave a long implementation timeframe and need to be seen as strategic option.
Effectiveness (considering different climate scenarios):	Effectiveness is given under medium as well as extreme climate-scenarios (> 4°C). As the option has co-benefits for other EU policy objectives and is especially closely linked to the WFD, it also needs to be considered effective under a business as usual scenario.
Expenditure Category(ies):	05 Waste water
Coherence with other policy objectives:	This option supports objectives of the Water Framework Directive to reach good water quality in European water bodies as well as the Flooding Directive.
Coherence with other adaptation options:	This option has close inter-linkages with other green options, which are partly implemented in the agricultural sector, e.g. '*Enhance floodplain management (re-creation of flood meadows)*', '*Afforestation (e.g. of cropland and grassland)*' as well as '*Buffer strips*'. It also has links with options focusing on biodiversity '*Maintaining and improving habitat management*'.

6.4.1.2.Drinking water systems

Adaptation Option:	**Leakage control in water distribution system**
Changing precipitation patterns will lead to water scarcity and drought in some regions of the EU. To prevent the loss of water, this option will prevent water leakage from extensive and aging municipal water distribution systems. This includes improved maintenance of water distribution systems as well as replacement of leaking parts.	
Climate threat addressed:	Water scarcity
Urgency:	Short-term, up to 2020 in some cases: Urgency depends on the timing of climate impacts. Especially in the Southern regions, water scarcity and drought will become more relevant in the short-term up to 2020. In some other regions, adaptation of sewage systems might be postponed beyond 2020.
Effectiveness (considering different climate scenarios):	As this is a flexible option focusing on repair of climate-change related damages it can be seen as effective under all climate scenarios.
Expenditure Category(ies):	04 Drinking water
Coherence with other policy objectives:	This option is in line with the Water Framework Directive.
Coherence with other adaptation options:	This option is in line with the adaptation option '*Demand management (rational water use, restriction of groundwater consumption, etc.)*' in the water sector.

Adaptation Option:	**Demand management (rational water use, restriction of groundwater consumption, etc.)**
Climate change will lead to change in the patterns of precipitation and to consequent water scarcity in some areas of the EU. To address water scarcity, authorities should optimize water demand management strategies. The objectives of water demand management are to reduce water consumption from the status quo levels; to reduce the loss and waste of water; to improve efficiency in the use of water; to document the level of recycling and reuse in the water supply; and to extend the life of current water supplies by reducing the rate of growth in demand, e.g. with recycling of water for non-drinking purposes.) This option needs to be implemented by local water management authorities in co-operation with local business as well as private households (e.g. through using financial incentives).	
Climate threat addressed:	Water scarcity, drought

Adaptation Option:	**Demand management (rational water use, restriction of groundwater consumption, etc.)**
Urgency:	Short-term, up to 2020: Demand management is seen as an urgent measure and should be implemented during the next programming period. If a rationale water use and restricted groundwater consumption are conducted today high damage costs in the future can be avoided.
Effectiveness (considering different climate scenarios):	Effectiveness is high under all climate scenarios – also under a business-as-usual scenario with existing climate conditions. A more efficient use of water is a general objective that also leads to lower water bills.
Expenditure Category(ies):	04 Drinking water
Coherence with other policy objectives:	This option is in line with the Water Framework Directive.
Coherence with other adaptation options:	Several other options support or enable water demand management, e.g. '*Leakage control in water distribution system*' and '*More water-efficient building constructions*'.

Adaptation Option:	**Desalination of water**
Desalination is the process of removing salt from water to make it useable for a range of 'fit for use' purposes including drinking. Desalination of water is a way to address a possible decrease in water supply and increase in water demand due to likely climate change events. Advancing technologies could render desalination more energy efficient and reduce operating cost. It could become a viable and weather independent alternative for urban drinking and non-drinking water supplies in the future. The most common methods are multistage flash evaporation (MSF), multi effect distillation (MED), vapour compression (VC) incl. mechanical (MVC) and thermal (TVC) as well as reverse osmosis (RO).	
Climate threat addressed:	Water scarcity, drought
Urgency:	Short/medium-term, up to 2020-2030: Even if the climate change impacts only become relevant in the medium term up to 2030, the option has a high urgency due to the long implementation timeframe of water infrastructures.
Effectiveness (considering different climate scenarios):	The option is effective in regions with high problems of water scarcity and drought in a medium as well as extreme climate scenario (> 4°C). However, it is not effective under a

Adaptation Option:	**Desalination of water**
	business-as-usual scenario as it is currently not necessary.
Expenditure Category(ies):	04 Drinking Water
Coherence with other policy objectives:	There are no direct links to other policy objectives.
Coherence with other adaptation options:	The option has co-benefits for the agricultural sector and is linked to several adaptation options, e.g. '*Intercropping*', '*Plant winter cover*', '*Irrigation Efficiency*' and '*Water metering*'.

6.4.1.3.Cross-cutting

Adaptation Option:	**Installation and retrofitting of environmental infrastructures to prevent natural disasters (e.g. protection against snow slips)**
Changing precipitation and snowfall patterns, especially during extreme events, will lead to an increasing risk of natural hazards: like avalanches, mudslides, landslide and rock fall, etc.. The installation of additional protective infrastructures can reduce these risks, e.g. by installing rock fall nets, avalanche protection.	
Climate threat addressed:	Soil erosion, storms, extreme snowfall
Urgency:	Short-term, up to 2020 in some cases: Urgency depends on the specific situation and type of environmental infrastructure. If underlying climate threats will become relevant in the short-term up to 2020, the option should be taken forward now.
Effectiveness (considering different climate scenarios):	Environmental infrastructures are mostly designed to meet a specific climate event (e.g. to hold a rock-fall of a specific volume or weight). In this case, they are fully effective. Effectiveness is however limited under extreme scenarios with more extreme natural disasters or under a scenario with lower impacts.
Expenditure Category(ies):	02 Management of household and industrial waste 03 Management and distribution of water (drinking water) 05 Water treatment (waste water) 65 Adaptation to climate change and natural risk prevention
Coherence with other policy objectives:	The option supports the general objectives of the EU to prevent natural and man-made disasters.

Adaptation Option:	**Installation and retrofitting of environmental infrastructures to prevent natural disasters (e.g. protection against snow slips)**
Coherence with other adaptation options:	This option has a direct link to '*Remote sensing and satellite imagery for early warning systems: for extreme weather events*' as well as '*Strategic urban and regional planning to prevent further accumulation of assets in vulnerable areas*'.

Adaptation Option:	**Sustainable urban drainage systems**
Drainage systems will face the problem of sewage overflow due to extreme precipitation evens and can be improved by shifting to Sustainable Drainage Systems (SUDS), whose installation mimics natural drainage patterns to attenuate surface water run-off, encourage the recharging of groundwater, provide significant amenity and wildlife enhancements, and protect water quality. It includes several elements like permeable pavements or green roofs which can absorb run-off or rainwater harvesting systems or rainwater butts. Some of these elements need to be implemented by municipalities, others lie within the responsibility of private households but could be supported by municipal programmes.	
Climate threat addressed:	Storms, flooding, flash floods
Urgency:	Short-term, up to 2020: This options needs to be implemented in the short-term up to 2020 due to long implementation timeframes. Especially the more strategic elements like green roofs, green urban spaces need to be taken forward now.
Effectiveness (considering different climate scenarios):	As this is a rather flexible option, it needs to be seen effective under all climate scenarios. As the green elements of SUDS also reduce the heat-island effect it is also an effective measure to deal with increasing temperatures in urban environments.
Expenditure Category(ies):	CF (under heading "Waste water infrastructures"
Coherence with other policy objectives:	This option is in line with the Water Framework Directive as well as the Floods Directive.
Coherence with other adaptation options:	There is a close link to other options focusing on water infrastructures and the urban environment, especially '*Green and blue spaces, incl. green roofs*' and '*Additional rainwater overflow basins*'.

** For this option, necessary investment costs have been estimated, including information on MS level. Information can be found in the database.*

6.5. List of further resources

- ADAM digital compendium, PIK-Potsdam (2009) An online catalogue for Adaptation and Mitigation Strategies. Adaptation options applicable to four extreme events: drought, flooding, heat waves, sea-level rise.
- ADAPT - Towards an integrated decision tool for adaptation measures, Belgian Science Policy (2007) This project is aimed at developing and demonstrating an efficient management tool being a cost-benefit analysis based instrument for the integrated assessment of adaptation measures. It consists of a "general introductory study" and of a "case study.
- AdaptatieScan, Klimaat voor ruimte (2009) Online tool gathering potential effects of climate change and corresponding adaptation measures.
- Adaptation Wizard, UKCIP (2010) 5-step process to assess vulnerability to current climate and future climate change, identify options to address key climate risks, and help to develop and implement a climate change adaptation strategy.
- AdaptME toolkit, UKCIP (2011) Climate change adaptation and monitoring toolkit, to help evaluate current adaptation activities.
- AdOpt, UKCIP (2011) Information on the range of adaptation options and practical examples. Includes a checklist of key principles for good adaptation decisions. Intended for decision- and policy-makers in identifying and appraising the effectiveness of climate risk adaptation measures.
- Altvater, S., van de Sandt, K., Marinova, N., de Block, D., Klostermann, J., Swart, R., Bouwma, I., McCallum, S., Dworak, T. & D. Osberghaus (2011): Assessment of the most significant threats to the EU posed by the changing climate in the short, medium and long term - Task 1 report, Ecologic, Berlin.
- AMICA Adaptation Tool; PIK-Potsdam, Interreg IIIC (2005-2006) A Matrix of adaptation measures and a list of evaluated practice examples.
- ASTRA project; Geological Survey of Finland, Interreg IIIB (2005-2007), Regional impacts of climate change and strategies and policies for climate change adaptation; information and recommendations on how to develop adequate adaptation strategies to deal with climate change in the Baltic Sea Region.

- Bouwer L.M. (2010). Disasters and climate change Analyses and methods for projecting future losses from extreme weather.
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- Dankers R. and Feyen L. (2009) Climate change impact on flood hazard in Europe: An assessment based on high-resolution climate simulations, Journal of Geophysical Research.
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- Defra Advice for Infrastructure Companies; UK (2011), A report on how to make infrastructure and its companies more climate resilient; includes climate change impacts, adaptation options, potential opportunities, potential barriers, and relevant stakeholders.
- Environment agency "Adapting to climate change programme", UK (2011) Sectorial resources and tools to help map out climate vulnerabilities, the benefits of adapting, and ways to increase resilience to climate change.
- ESPACE Guidance, Hampshire County Council, Interreg IIIB (2008), Recommendations on ways to incorporate adaptation within spatial planning mechanisms at local, regional, national and European levels.
- European RESPONSES to climate change, Institute for Environmental Studies (IVM), FP7, ongoing, The objective of the ongoing project and the content of the current output is to identify and assess integrated EU climate-change policy responses that achieve ambitious mitigation and environmental targets and, at the same time, reduce the Union's vulnerability to inevitable climate-change impacts.
- Evaluación preliminar de los impactos en Espana por efecto del cambio climático, Ministerio del Medio Ambiente (2005), Description of the impacts of climate change on diverse sectors, e.g. water, forest, biodiversity, health, tourism. There is also a brief overview of potential adaptation measures per sector.
- Feyen, L. and Watkiss, P. (2011). Technical Policy Briefing Note 3. The Impacts and Economic Costs of River Floods in Europe, and the Costs and Benefits of Adaptation. Results from the EC RTD ClimateCost Project. In Watkiss, P (Editor), 2011. The ClimateCost Project. Final Report. Published by the Stockholm Environment Institute, Sweden, 2011.
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- Ganoulis J.& Skoulikaris C. (2011) Impact of Climate Change on Hydropower Generation and Irrigation: A Case Study from Greece, Climate Change and its Effects on Water Resources, Volume 3, 87-95.

- Guidance on Water and Adaptation to Climate Change, UN Economic Commission for Europe (2009), Description of adaptation strategies and measures in water management introducing the importance of timing of options; quantification of costs/benefits in case studies in water management.
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