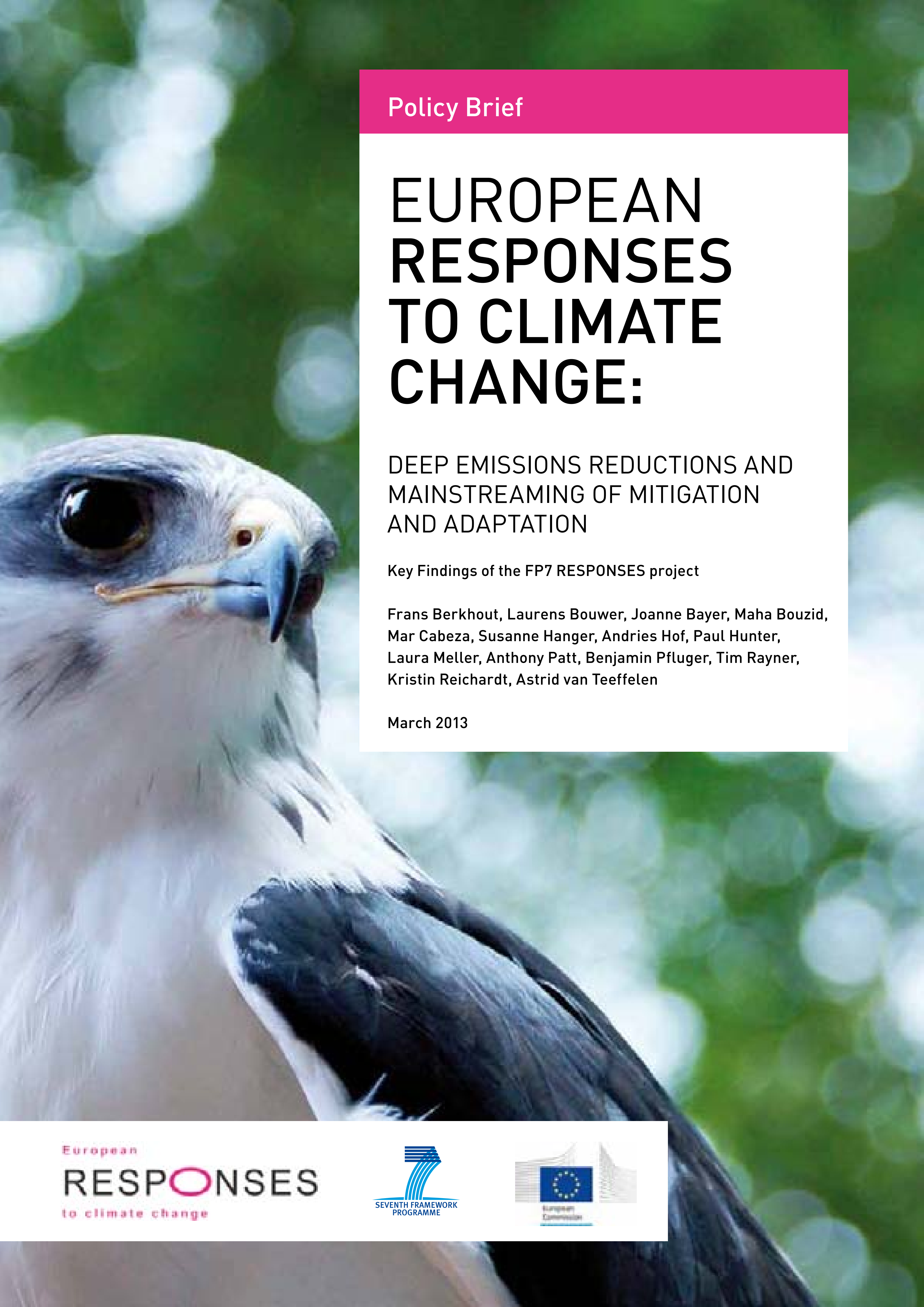

Policy Brief

EUROPEAN RESPONSES TO CLIMATE CHANGE:

DEEP EMISSIONS REDUCTIONS AND MAINSTREAMING OF MITIGATION AND ADAPTATION

Key Findings of the FP7 RESPONSES project

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European RESPONSES to climate change

SEVENTH FRAMEWORK PROGRAMME

European Commission

THE RESPONSES PROJECT

EU action on climate change will focus on accelerating emission reductions, while seeking to put adaptation at the heart of all sectoral policies. As policy attention to climate change intensifies, mitigation and adaptation increasingly need to be pursued in parallel, and where feasible integrated. Climate change risks need to be taken into account, or mainstreamed, throughout the private and public sectors. European action also needs to take into account the broader international context, in order to ensure that EU efforts are effective, efficient, proportionate and affordable, and coordinated with action in other countries and regions.

The RESPONSES project addressed these policy challenges. Its overall objective was **to assess integrated EU climate-change policy responses to achieve ambitious mitigation and environmental targets while at the same time reducing the Union's vulnerability to inevitable climate-change impacts**. The empirical focus of the project was on five EU policy sectors: water and agriculture, biodiversity, regional and cohesion policy, health, and energy. Specifically, the project sought:

- To develop a set of low emission scenarios;
- To develop and assess strategies for integrating mitigation and adaptation to climate impacts into existing EU policies; and
- To identify synergies, trade-offs and conflicts between mitigation and adaptation, and identify opportunities for future EU strategies and policy measures.

Synergies can be achieved between greenhouse gas emissions reductions (mitigation) and increasing climate resilience (adaptation) in some areas of EU policy, such as land use management in agriculture and more efficient use of water resources. But for much EU policy **mitigation and adaptation are likely to remain separate endeavours.**

1. GETTING CLIMATE INTO THE **MAINSTREAM** OF EU POLICIES

Climate policy 'mainstreaming', 'proofing' and 'integration' are concepts that are increasingly appearing in a range of EU policy discussions, including those concerning the 2014-2020 Multi-Annual Financial Framework (MFF). They reflect the view that all policy sectors need to play a part in both reducing emissions and increasing resilience to unavoidable climate impacts. Broadly defined, mainstreaming involves including climate considerations in policy processes, improving the consistency among policy objectives, and where necessary, giving priority to climate-related goals above others (Rayner and Berkhout, submitted). Although often couched in technical language, profound political challenges, at multiple levels of governance, lie at the heart of the mainstreaming agenda. The RESPONSES project analysed how far adaptation and mitigation was being mainstreamed in EU policies, and assessed the potential opportunities and limits for the future.

Mainstreaming is sector-specific

There is no one-size-fits-all approach for mainstreaming climate into EU policies. This is partly because policy fields differ in nature and scope. EU agricultural and cohesion policies are primarily *distributive* in that they allocate funds to farmers and regions, while biodiversity and water policies are *regulative* in that they set rules and standards. Beyond this, EU policies operate over different temporal and spatial scales (the farm is the relevant spatial unit for agriculture policy, while the river basin is at the core of water policy), and employ different sets of policy instruments and measures. Increasingly, cross-sectoral integration across policy domains has become important for achieving environmental and climate goals. Finally, the potential for reducing greenhouse gas emissions or vulnerability to climate change impacts varies greatly between sectors. For instance, while flood and drought are critical risks for water policy, extreme heat and vector-borne disease are key risks for health.

Successful mainstreaming needs high-level political commitment

Drawing on previous experience with 'environmental policy integration' (EPI) in the EU, scholars have suggested a number of factors explaining success and failure in climate policy integration, or mainstreaming. Important insights are summarised in Table 1. Broadly, where there is a shared sense of climate risks, high-level political commitment, cross-sectoral co-ordinating institutions, 'hard' instruments (like mandates) are in place and 'win win' opportunities are available between climate-related and other policy goals, mainstreaming is more likely to be successful. While many of these conditions exist in the EU, the seriousness with which mainstreaming is pursued is currently highly variable, both spatially and sectorally.

Types of explanation	Factors explaining success of mainstreaming
Knowledge-related	Experience and perceived seriousness of climate impacts Expert consensus about future climate impacts
Institution-related	Degree of high-level political commitment to climate goals Existence of venues allowing co-ordination between sectors A capacity to regulate A balance of power and resources between environmental/ climate regulators and other policy sectors
Instrument-related	'Hard' incentives (rather than 'soft' incentives) to stimulate mainstreaming.
External factors/ synergies	Timing/ sequencing of relevant policy processes Potential for technological win-win solutions Policy developments in the target sector coincide with a climate agenda

TABLE 1: AN OVERVIEW OF FACTORS INFLUENCING CLIMATE POLICY MAINSTREAMING (BASED ON HEY 2002; LARSEN AND KØRNØV 2009; POLLACK AND HAFNER-BURTON 2010; PERSSON 2004, PITTOCK 2011).

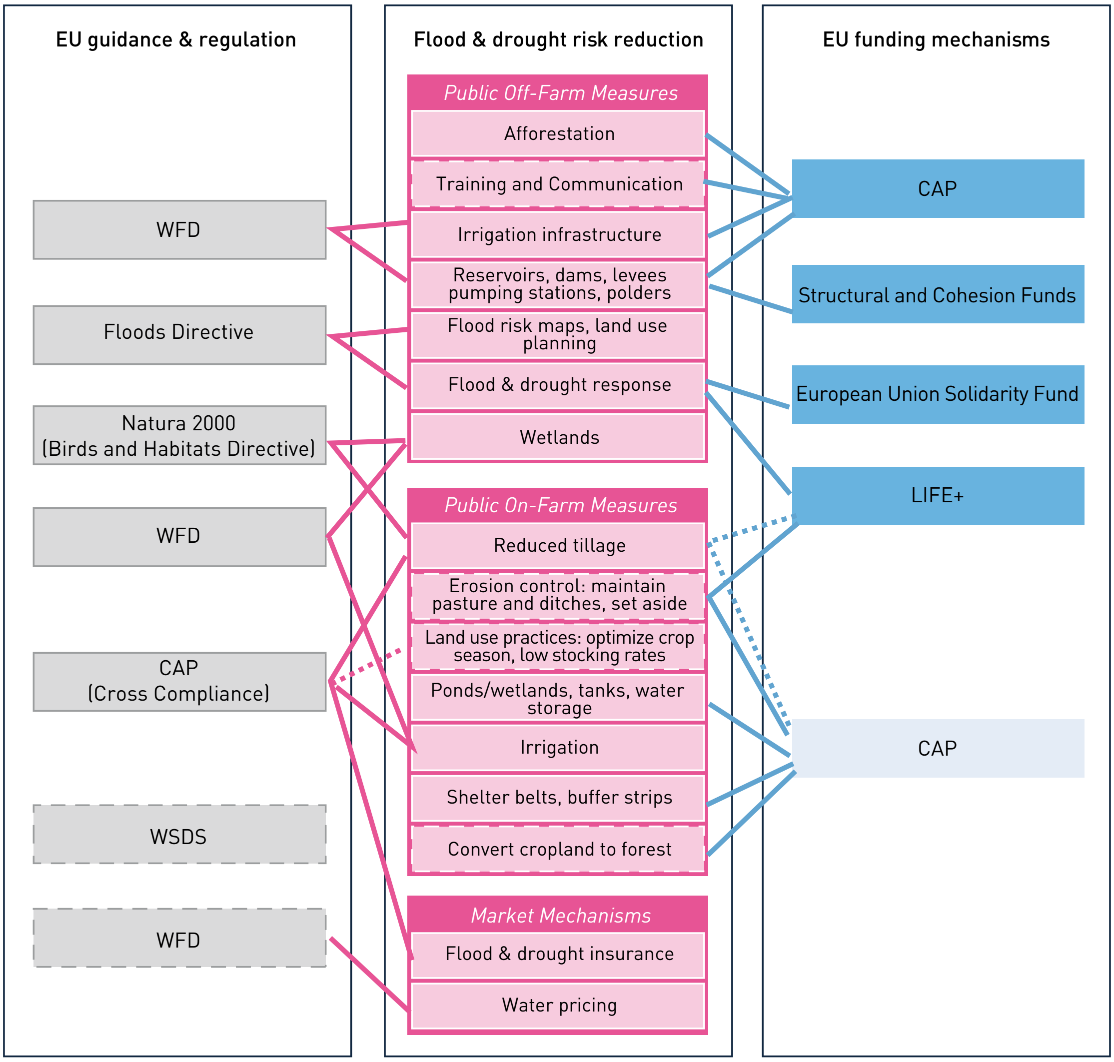


FIGURE 1. EU POLICIES FOR REDUCING FLOOD AND DROUGHT RISKS: A COMPLEX INTERACTION

Policy mainstreaming is complex and often requires cross-sectoral action

A sense of the complexity of the relationship between EU policy, and vulnerability and adaptation measures is given in Figure 1. This shows on- and off-farm measures relevant to flood and drought risk reduction – important adaptation measures in the water and agriculture sectors - and how these are supported through EU water, agriculture and biodiversity policies. Through this web of relationships, EU policies combine to build climate resilience in the face of the linked threats of flooding and drought. Note that EU policy measures also work in combination with market measures. This complexity is both a source of strength, since it offers resilience in responses, but also a potential weakness, as it makes climate adaptation hard to 'see' and to measure. Cross-sectoral linkages appear to be fundamental to achieving effective adaptation at a European scale.

Policy implications

The need to mainstream climate concerns into sectoral policies has been presented by the Commission as a technical problem. This belies profound, long-term scientific and political challenges. First, mitigation and adaptation priorities potentially require incompatible actions from policy makers, sometimes at the expense of conventional environmental policy goals. Many experts believe that climate change – particularly 'beyond-2°C' warming - will demand a more radical, on-going and 'transformational' consideration of existing policy objectives. These factors make climate mainstreaming more complex and uncertain than environmental policy integration. Second, as well as its cross-sectoral dimension, mainstreaming requires a multi-level effort. While many substantive decisions about prioritising objectives need to be taken at national and local levels, EU-level decision makers can ensure that *sufficient resources* are allocated to climate-related purposes, appropriate *procedures* for impact assessment and improved cross-sectoral coordination are implemented, organisational and institutional *capacities* are developed, relevant *knowledge* is brokered, and potential change agents are *empowered*.

2. MANAGING **FLOOD AND DROUGHT RISKS** UNDER CLIMATE CHANGE

The costs of floods and droughts continue to rise in the European Union, despite more than a century of investments in levees, reservoirs and other infrastructure (OECD 2010). Only to a very limited extent can these growing costs be attributed to climate change. Yet climate projections suggest significant changes in future risk across the EU (IPCC 2012). This prospect adds to the need for investing in drought and flood risk management today as a way of preparing for future climates. If possible, such investments should also aim to reduce greenhouse gas emissions. We examined the potential and challenges for mainstreaming climate into EU water and agriculture policies influencing flood and drought risks, focusing on a case study in the Warta river basin of Poland.

Many EU policies contribute to flood and drought risk management

The EU has a comprehensive portfolio of policies addressing flood and drought risk. The most important are the (see also Figure 1):

- EU Common Agricultural Policy (CAP),
- EU Water Framework Directive (WFD),
- EU Floods Directive (FD),
- EU Water Scarcity and Droughts Strategy (WSDS), and
- Structural and Cohesion Funds.

There are many examples of flood and drought risk adaptation measures, with links to mitigation, mainstreamed into EU policies. For instance, the WFD and FD require flood and drought risk management plans and flood risk assessments that take climate change into account, although without specific targets. While CAP does not directly address flood and drought risks, recent reforms present mainstreaming opportunities. For instance, the CAP cross-compliance regulations can require on-farm measures, such as constructing small retention ponds, planting shelter belts that reduce runoff and changing tillage practices to hold moisture in the soil, which not only reduce flooding downstream and provide water in time of drought, but also contribute to mitigation by enhancing carbon sequestration. CAP's Agri-Environment Programme (AEP) compensates farmers for making on-farm water-retention and other investments. Off-farm measures, such as large reservoirs, are eligible for co-funding from the European Agriculture Fund for Rural Development (EAFRD) and Structural and Cohesion Funds. As yet, however, these programs have not been linked in a unified EU policy for flood and drought risk management. EU policies therefore provide a broad but poorly-linked framework for mainstreaming flood and drought risk management in agriculture and water policies. Yet there remain many challenges for explicitly addressing climate change in these measures, as well as for their implementation at the national and local scale.

Cost-effectiveness of adaptation measures hard to establish

In the Warta, and throughout Europe, authorities have historically responded to flood and drought risk with large water infrastructure projects. These are increasingly facing budgetary constraints, environmental concerns and public opposition. Many stakeholders recognize the need for new reservoirs in the Warta region, but suggest these should be supplemented by on-farm water retention strategies, especially those that promote climate change mitigation. Current CAP reform presents an opportunity to support climate-friendly on-farm measures. But this raises questions about cost effectiveness. The prioritization between large public infrastructure projects versus on-farm activities is critical for the Commission and national authorities implementing CAP and WFD programs.

We conducted a cost effectiveness study comparing the Wielowies-Klasztorna reservoir for retaining water with three on-farm measures: ponds, shelter belts and conservation tillage. Preliminary estimates show that the reservoir is more cost effective (€1.7/m3 water retained). But this advantage may be reduced or eliminated if climate change mitigation, as well as other un-quantified costs (like restricting fish migration) and co-benefits (like contributions to biodiversity and erosion control) are taken into account.

Setting priorities for climate-robust flood and risk management

While there are major uncertainties about the scale and dynamics through time of flood and drought risk, the RESPONSES assessment of adaptation measures and their costs suggests a number of near-term priorities:

WATER RETENTION MEASURES	COST/M3 WATER STORAGE* EURO	CLIMATE CHANGE MITIGATION AND OTHER SIGNIFICANT NON-QUANTIFIED COSTS	CLIMATE CHANGE MITIGATION AND OTHER SIGNIFICANT CO-BENEFITS
Off-farm Large reservoir (Wielowies Klasztorna)	⩽ 1	**Increased CO2 emissions (deforestation for construction)** Restriction of fish migration Reduction of groundwater levels downstream Social and psychological costs of displaced persons	**Electricity production decreasing CO2 emissions** Tourism Contribution to biodiversity Fisheries
On-farm pond*	⩽ 4	**Increased CO2 emissions (deforestation for construction)**	Contribution to biodiversity (including migration corridors) Landscape enhancement & recreation
On-farm Shelter belt	⩽ 7		**Sequestration of CO2** Erosion reduction Contribution to biodiversity (including pollination) Increased yield from remaining crops Landscape enhancement
On-farm Switch to no-tillage	wide range	Increased pesticide use	**Sequestration of CO2** Contribution to biodiversity Increased agricultural productivity

TABLE 2: COST EFFECTIVENESS OF SELECTED ADAPTATION MEASURES WITH NON-QUANTIFIED COSTS AND CO-BENEFITS (CLIMATE CHANGE COSTS AND BENEFITS MARKED IN BOLD)

*PRELIMINARY ESTIMATES

NOTE THAT, AMONG CALCULATIONS ARE BASED ON ASSUMED LIFE OF PROJECTS OF 30 YEARS AND DISCOUNT RATE OF 5%

Smaller-scale, more flexible responses to flood and drought risk appear to be more costly than classical responses such as large reservoirs. But this depends on which costs and benefits are factored in and how. Improved methods for cost-benefit analysis are needed that take account of risk and emissions reduction benefits of these smaller-scale responses over the longer term.

Valuing co-benefits of adaptation. The un-quantified costs and co-benefits shown in Table 1 illustrate the need for valuing the full range of environmental costs and benefits, including carbon sequestration. Methods exist for pricing non-market costs and benefits and eco-system services, but they are difficult to implement.

Taking account of uncertainties in risks assessment. The FD and WFD state that uncertainty related to climate change should be presented transparently in flood maps, with climate change scenarios included in planning processes. According to the EU's Guidance document *'River Basin Management in a Changing Climate',* climate change is expected to be fully-integrated into river basin management in future planning cycles. However, there continue to be great uncertainties in projecting climate change impacts on flood hazards over investment horizons relevant to water managers. This explains why climate change was not considered in assessing the flood risk in the cost-benefit analysis carried out for the Wielowies-Klasztorna reservoir.

Making robust investments for adaptation and mitigation in light of climate change. Estimates by the RESPONSES project show that climate change increases flood hazards for the Warta region after 2070 (nearly doubling) and drought losses after 2030 (30-40% increase). However, the uncertainty surrounding these estimates, and other model results, is significant, with even the sign of the uncertainty being in doubt (-17% to +85% for floods). This supports the case for robust policies that work well given a range of future scenarios. For instance, water retention measures are robust for both growing flood hazard (increased precipitation) and for increased drought hazard (decreased precipitation).

Addressing risks of mal-adaptation arising from EU policies. The CAP requirement for crop insurance has been implemented by Polish authorities with large public subsidies, which can result in mal-adaptation by encouraging cultivation in high-risk areas. The potential for mal-adaptation also arises with regard to the European Union Solidarity Fund, which provides post-disaster assistance to governments.

Pricing water. Water pricing, as required by the WFD, has proven to be contentious in water scarce regions. The Polish policy of exempting surface waters used for irrigation from water pricing discourages farmers from changing crop practices, investing in water retention measures and other adaptation activities.

Policy implications

A pressing issue facing the Commission with regard to mainstreaming adaptation to flood and drought risk, linked to mitigation, is better integration of the patchwork of CAP, WFD, Structural and Cohesion funds and other policy instruments currently available. The aim should be to prioritize investments and activities for managing flood and drought risk, taking account of future climate risk and the full range of costs and benefits. More specifically, the Commission should consider providing guidance on valuing co-benefits of adaptation and mitigation measures in the agriculture and water sectors. There is also a need for risk assessors to be given concrete guidance on how to assess and value distant future climate change impacts in present-day infrastructure decisions. Irreducible uncertainties in climate and hazard projections mean that policy makers should consider the benefits of flexible, no-regret strategies, which in the Warta may mean more attention to more on-farm measures like ponds, shelter belts and no tillage, despite higher costs over the short-run. Beyond this, the Commission should consider a guidance document for catastrophe insurance that is sensitive to the risks of mal-adaptation.

3. **PROTECTING** EU BIODIVERSITY UNDER A CHANGING CLIMATE

While reaching the EU goal of halting the loss of biodiversity by 2020 is already challenging, climate change adds to this challenge. As climate changes, localities change in suitability and may become unsuitable to species occurring there today. This can lead to reductions and shifts in species distributions, but also breaks in important ecological interactions – increasing extinction risk of species and jeopardizing vital ecosystem services, such as pollination.

The RESPONSES project explored the impacts of climate change on biodiversity in two alternative climate scenarios: a baseline scenario, where the annual mean global temperature increases by 4°C by the end of the century, and a mitigation scenario where the temperature increase is limited to below 2°C. We addressed the role of EU policy in adaptation and mitigation and highlighted major challenges and uncertainties. We also identified key links between conservation and mitigation action and/or adaptation in other policy sectors.

Climate change threatens effective conservation in the EU

Climate change can undermine past conservation successes if protected areas become climatically unsuitable for the species they were supposed to protect. A recent RESPONSES study provides a comprehensive assessment of the likely impacts of climate change on terrestrial vertebrates and plants in European protected areas. With respect to the current Natura 2000 network, about 63% of species included in the annexes of the EU's Birds and Habitats Directives are expected to lose climatic suitability by the year 2080. Previous studies had alerted us about significant expected climate impacts on biodiversity. This study evaluates for the first time the extent to which conservation instruments, namely protected areas, are able to protect biodiversity against the effects of climate change. The results show that with major climatic changes, many current EU conservation goals will not be achieved over the longer term.

EU biodiversity policy under climate change: Matches and gaps

An important question for policymakers is: to what degree can current EU biodiversity policy already address climate change related challenges and where are the important gaps? Figure 2 shows how EU policies key into adaptation strategies available to secure nature conservation (Van Teeffelen et al. in review). Again, the interaction of major EU policies is evident. Key findings are:

Focus on patterns and voluntary action. While EU biodiversity legislation leaves room for proactively adapting to climate change, the interpretation by the Member States focuses on patterns rather than processes: Natura 2000 sites are designated for the occurrence of annex species and habitats, but nature is dynamic, even more so under climate change. Furthermore, several tools, like habitat restoration and ensuring coherence of reserve networks, are left at the discretion of the Member States.

Adaptation options are generic. The effectiveness of adaptation strategies will vary with respect to ecosystem type, species and spatial context. While habitat restoration is important for some species, greater connectivity between reserves will be of greater value for others. A range of strategies are potentially available under EU policies, but little attention has been given to tailoring these measures to different (groups of) species.

Not all impacts covered. Most adaptation strategies available focus on shifts and contractions in the distributions of species. The dependencies and interactions between species, many of which are disrupted by climate change, have not been addressed yet and nor are the consequences for ecosystem functioning. This added complexity will require substantial new research.

Climate change mitigation should be a key conservation strategy

Previous European research projects, such as the MACIS project, have identified potential conflicts between climate change mitigation and biodiversity conservation. Bio-energy is among the important options for greenhouse gas emission reduction, but it is believed to have negative ecological impacts. Using European birds as an indicator, an integrative RESPONSES study by Meller et al. (2012) explored the balance between reduced climate impacts and increased land use pressure in a scenario where bio-energy plays a significant role in achieving emissions

EU nature and biodiversity policy is implemented by providing protected areas for valuable and endangered species and ecosystem types. With changing climates, the suitability of localities for species and ecosystems will shift over time. **The current policy of protecting particular species and habitats at particular places is untenable given climate change. Furthermore, key adaptive responses, such as habitat restoration and ensuring coherence of reserve networks, are left to the discretion of EU Member States.** A reassessment of goals is needed, as well as better coordination at the EU-level.

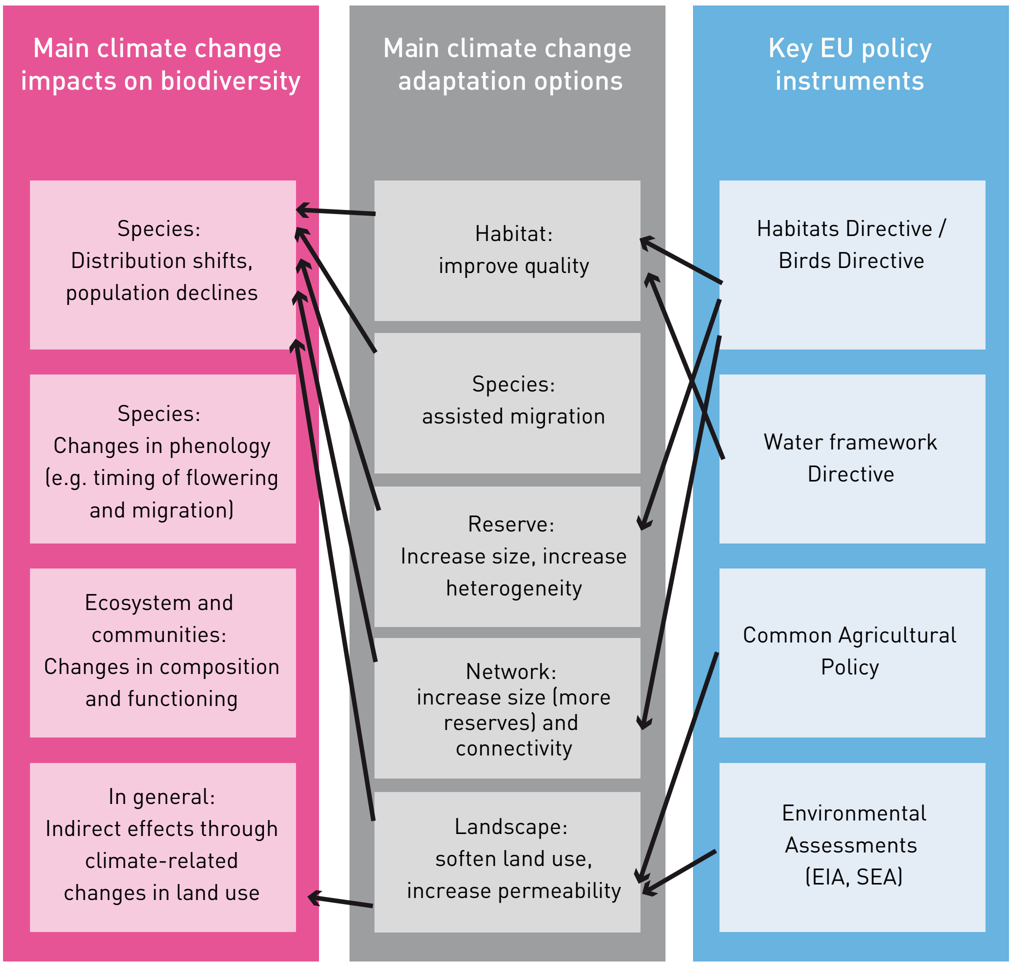
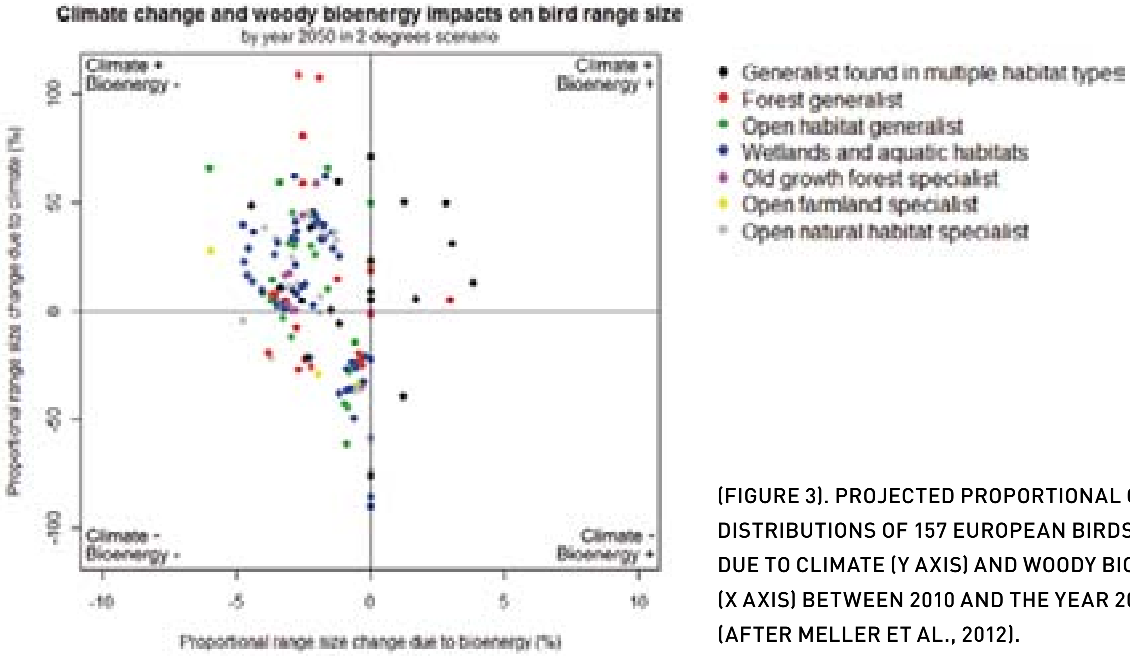


FIGURE 2. INTERACTIONS BETWEEN IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY, STRATEGIES TO ALLEVIATE THESE IMPACTS, AND EU POLICY INSTRUMENTS AVAILABLE TODAY, TO IMPLEMENT THESE STRATEGIES IN PRACTICE



(FIGURE 3). PROJECTED PROPORTIONAL CHANGE IN DISTRIBUTIONS OF 157 EUROPEAN BIRDS DIRECTIVE SPECIES DUE TO CLIMATE (Y AXIS) AND WOODY BIOENERGY PLANTATIONS (X AXIS) BETWEEN 2010 AND THE YEAR 2050 IN A 2°C SCENARIO (AFTER MELLER ET AL., 2012).

reductions, sufficient to limit warming to below 2°C. This analysis shows that the pressure from climate change would be far greater than that from the woody plantations for producing bio-energy within Europe. Nevertheless, the authors identified potentials for local conflict between conservation and bio-energy production. This potential needs to be resolved by clarifying the sustainability criteria for renewable energy production.

Need for improved analysis of uncertainties

Adaptation to climate change is hampered by uncertainty about future climate and ecosystem changes and our abilities to anticipate them. Projected changes in climate depend strongly on the selection of emission scenarios and the climate model used to produce them. When projecting species distribution shifts further uncertainties arise from the choice of bioclimatic envelop model. A RESPONSES paper (Garcia et al. 2012) showed how uncertainty in projections of impacts on biodiversity is substantial and derived primarily from the bioclimatic envelop models, rather than from the climatic models. This result supports the use of model ensembles to account for some of these uncertainties.

While awareness and concern about uncertainty is increasing, a RESPONSES review paper found that only some 5% of the scientific literature discussing climate change mentions uncertainty. In addition, uncertainty research is dominated by studies that identify, map and reduce epistemic uncertainties (i.e. uncertainty about facts), especially within natural sciences. Other sources of uncertainty which stem from communication (linguistic uncertainty) or human behaviour and values (human decision uncertainty) are less addressed (Kujala et al. 2012).

Given these uncertainties, it is challenging to promote proactive adaptation. The field of biodiversity conservation is faced with a dilemma: Climate change is a major threat to biodiversity and taking no action can lead to catastrophic outcomes. But investing in uncertain conservation actions, while taking away scarce resources for conservation actions that would successfully protect biodiversity against present day threats, appears risky. However, two RESPONSES studies illustrate the use of robust decision making approaches for conservation planning in the context of climate change (Kujala et al. 2013; Wintle et al 2011).

Policy implications

Climate change has profound impacts on biodiversity. While research is giving rise to tools and methods to account for uncertainty and plan conservation in a robust manner, climate change is threatening to undermine conservation efforts. Ambitious climate change mitigation action is therefore a crucial conservation strategy. Nevertheless, climate change impacts have already been observed throughout ecosystems, and biodiversity conservation needs to be adapted to meet these impacts. Many of the adaptation options that are needed to support biodiversity under climate change seem to be supported by Birds Directive and Habitats Directive. However, the current implementation of the law is very focused on particular species and habitat types at particular locations, which is untenable given climate change. Re-interpretation of the aims and measures of the legislative framework in the context of climate change is therefore urgently needed. Furthermore, a number of climate impacts are currently not addressed, such as the disruption of ecological communities and associated ecosystem services.

4. **MAINSTREAMING** CLIMATE CHANGE OBJECTIVES IN EU REGIONAL POLICY

Regional and cohesion policy is an important European policy field, accounting for total expenditures of about Euro 50bn per year in 2007-13 (about 36% of total EU budget). It also holds important potential for supporting climate change mitigation goals through investments in greenhouse gas emissions reductions, as well as funding climate resilience and reducing vulnerability. Given the redistributive nature of regional policy – supporting mostly the least developed European regions – the EU could address the unequal burden of required efforts and differences in capacities in facing climate change that exist across Europe.

RESPONSES research on regional policy first assessed EU-level policy-making and commitments towards climate change mitigation and adaptation in expenditures for regional policy. Second, a climate change impact assessment was done for key hazard types in the EU, to assess how EU regional expenditures match the distribution of projected climate change impacts. Third, more in depth analyses were made of regional policy; through a top-down analysis of climate-relevant allocations under European regional policy in the Structural and Cohesion Funds (SCF); and through a bottom-up analysis of procedures and capacities to address climate resilience at the national and local level, through interviews in a number of Member States.

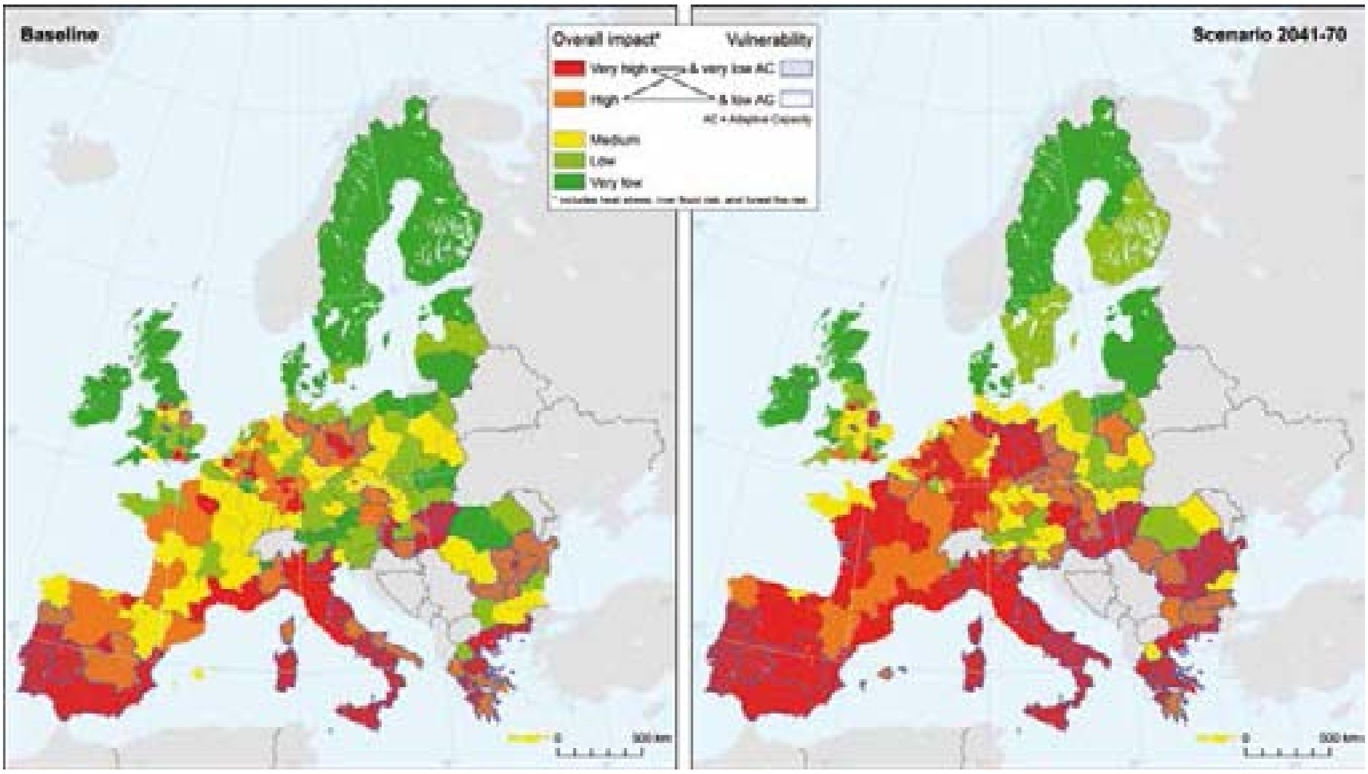


FIGURE 4: OVERALL CHANGE IN CLIMATE IMPACTS AND ADAPTIVE CAPACITY ACROSS THE EU (PRESENT DAY (LEFT) AND 2041-2070 (RIGHT) (LUNG ET AL., IN PRESS)

Climate vulnerability varies greatly across the EU, as does adaptive capacity

The climate change impact assessment is based on indicators for heat stress (in relation to human health), river flood and forest fire at a pan-European (NUTS 2) level (Lung et al., in press). Compared with the baseline situation, we find for the period 2041-2070 a strong projected increase of overall impacts for almost all regions in southern Europe and France, as well as large parts of Germany, Czech Republic, Belgium and the Netherlands. In contrast, for Ireland, Scandinavia, much of Poland and the Baltic countries, and most regions of the UK, overall impacts remain relatively low.

We identified hotspots of vulnerability to heat stress, river flood risk and forest fire risk and compared these to patterns of adaptive capacities based on current human, financial and technical capital. For the future scenario for 2041-2070, we project an increase in the number of potentially most vulnerable regions, assuming adaptive capacity remains unchanged at current levels. New hotspot regions would be in Bulgaria, Romania, Czech Republic, Poland, and France, while other regions are projected to turn into 'more severe' hotspots, such as southern Romania and northern Bulgaria or (north)-eastern Germany (see Figure 4).

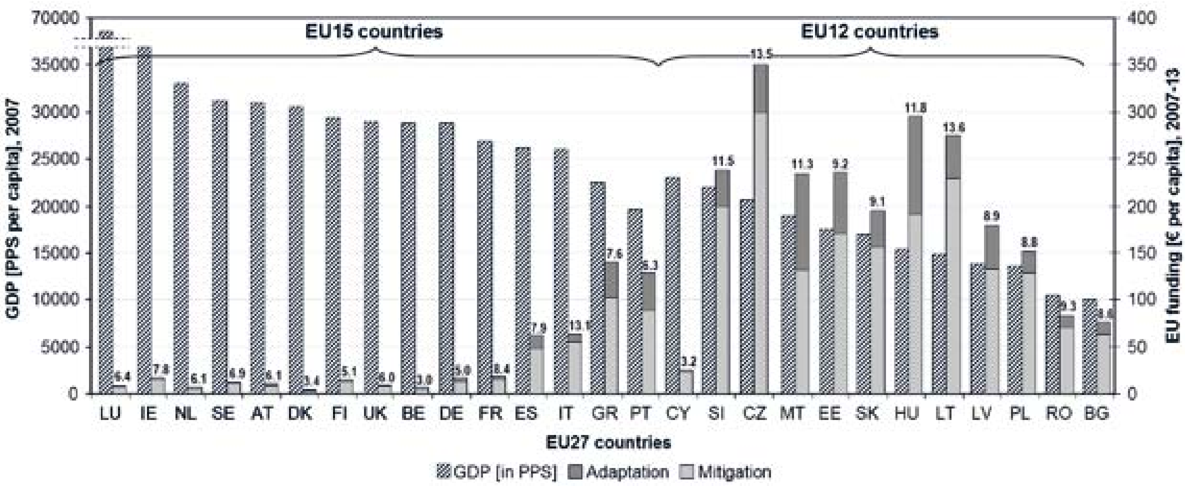


FIGURE 5. ALLOCATIONS FOR THEMATIC PRIORITIES RELEVANT FOR MITIGATION AND ADAPTATION (RIGHT BARS) IN THE EU STRUCTURAL AND COHESION FUNDS, AND INCOME LEVELS (GDP) (LEFT BARS) IN THE EU-27 (HANGER ET AL. SUBMITTED).

Greater need to match EU regional and cohesion funding to climate vulnerabilities

More effort has been made to mainstream mitigation concerns than adaptation goals. Our systematic review of Member States' strategic planning documents shows that references to the need for mitigation to be pursued in the 2007-2013 funding period are quite common. Much less attention is paid to issues related to vulnerability and adaptation. The focus on mitigation is also reflected in the financial allocations, owing to the earmarking provisions for items under the Lisbon Agenda, which include renewable energy and energy efficiency. Overall, climate change seems to be inconsistently integrated in funding allocations, in that it does not necessarily occur in regions where it might be expected, i.e. those with high emission reduction targets and/or high impacts and low adaptive capacity. Regarding adaptation, Hungary and Malta are exceptional, with considerable allocations made for relevant investments. On the whole however we find that the rhetoric displayed in various high-level policy documents exceeds action as evident from actual financial allocations.

Climate mainstreaming has not broken through to the national level

Interviews with Managing Authorities, responsible for the administration of the Structural and Cohesion Funds, in Romania, Greece and Hungary reveal that climate change adaptation is of little or no concern at the national level. Awareness raising and mainstreaming efforts have not yet been effective. In general, we found that policy makers have other priorities and limited institutional capacity to deal with climate vulnerability and adaptation priorities, even if there is some awareness of risks.

Policy implications

There is ample potential to improve climate-relevant Structural and Cohesion Fund support, particularly in the area of adaptation. Most strategic plans already include priority themes relevant to adaptation, including risk prevention, water management and biodiversity conservation. Linking these themes to expected climate impacts and increasing their priority represents a way forward. Regional and cohesion policy operates at multiple scales, giving room for locally-appropriate adaptation investments and for building adaptive capacity.

Climate impacts and adaptive capacities are unequally distributed across EU countries and regions. Structural and Cohesion Funds are a way of strengthening European solidarity by helping more vulnerable or weaker regions adapt. This solidarity could be provided by increasing the European support for climate mitigation and adaptation priorities, not through new instruments, but through a slightly reforming of EU regional policy. Anchoring adaptation concerns more deeply into regional policy could expand this burden-sharing function to consider climate-related inequalities. In order to adapt cohesion policy, incentives at the EU level such as earmarking, and setting of clear policy priorities, as well as awareness raising and provision of guidance at the national and local levels are essential.

A key governance dilemma for climate adaptation mainstreaming exists between the need for central direction and the benefits of local discretion. The European Commission can play an important role in providing guidance, information and supporting capabilities on the ground. But, given the spatial and social variability of climate vulnerabilities, as well as uncertainties about where and how quickly climate risks will emerge, local-level discretion in adaptation will be important. **Especially for long-term investments, there will be growing benefits in opting for robust solutions that are resilient under different scenarios.**

The distribution of climate vulnerabilities across the EU varies greatly by impact category (RESPONSES looked at fire, heat stress and river flooding). A new analysis, combining climate impacts with adaptive capacity, shows that **climate risks, which currently exist mainly in southern Europe, will grow significantly in many parts of continental Europe by the 2040s.** In contrast, for Ireland, Scandinavia, much of Poland, the Baltic countries, and most UK regions, overall impacts will remain relatively low.

5. MANAGING NEW CLIMATE-SENSITIVE **HEALTH THREATS** IN THE EU

The role of the EU in improving public health is to complement national actions, especially where national authorities need to cooperate. In the RESPONSES project, we reviewed the adverse impact of climate change on human health in European countries, focusing on heat-stress and vector-borne diseases. Management of new disease threats requires international cooperation, with other agencies, such as the World Health Organisation (WHO) already playing a prominent role of health protection and promotion. Vector-borne diseases, such as dengue fever, are not currently autochthonous in Europe. RESPONSES modelled the disease risk and potential spread of vector-borne diseases in Europe under climate change scenarios. We found an urgent research need to establish the effectiveness of public health interventions (viewed here as adaptation strategies) to reduce the burden of climate-related morbidity and mortality and inform future adaptation policies. Finally, we conducted a policy baseline assessment in the EU health sector, focusing on mainstreaming of climate change adaptation and mitigation.

Disease burden in Europe increases under climate change

Adverse health impacts of climate change may follow extreme weather events, especially drought, flooding and heat waves, or could be associated with gradual changes in the ecology of natural environments or biota. Based on a literature review, we identified a list of high-priority diseases likely to pose a threat in Europe under a changing climate. For vector-borne diseases, these include West Nile fever, dengue fever, chikungunya fever, malaria, leishmaniasis, tick-borne encephalitis (TBE), lyme borreliosis, Crimean-Congo haemorrhagic fever (CCHF), spotted fever rickettsioses, yellow fever and Rift Valley fever. Waterborne diseases are also likely to be influenced by climate change. The risk to human health is associated with the contamination of drinking and recreational waters with waterborne bacteria, parasites and viruses. Finally, another major health impact is associated with heat stress-related morbidity and mortality, which is considered an area of major direct impact because of the severity of the outcome (death) and increased political sensitivity. In summary, climate change is likely to allow expansion of the geographical distribution of vector-borne diseases or even emergence of new ones, increase prevalence of waterborne diseases and result in more extreme weather events, thus contributing to an increased burden.

Effective public health interventions exist for some climate-sensitive diseases

We sought to evaluate the effectiveness of public health interventions directed at the climate-sensitive diseases outlined above through a systematic review of systematic reviews. No such reviews for 53% (9/17) of the high priority climate-sensitive diseases were found. Chemoprophylaxis (medication preventing disease) and immunization interventions were generally backed by good quality evidence and showed high effectiveness. In addition, this study (Bouzid et al., 2013) highlighted for each intervention type if more high quality systematic reviews or further primary studies are needed to improve the quality of evidence and inform practice. We consider that environmental and/or community based interventions - such as removing mosquito breeding sites, or checking on vulnerable groups during heat waves - could have the most value in a warmer world, despite a lack of good quality evidence to date. These interventions should be prioritised as climate adaptation options.

Adaptation options depend on health services, including appropriate infrastructure and an efficient health care system. In addition, to ensure adequate responses to the health challenges caused by climate change, it is crucial that health care professionals receive appropriate and focused training. It is important that the training material is regularly evaluated and updated according to the most recent findings. In this context, scientific research should assist efficient adaptation and mitigation measures and future research should address gaps identified here and elsewhere, including lack of primary studies for public health interventions for extreme weather events and need for good quality systematic reviews for effectiveness of interventions for vector-borne diseases, which are likely to be the most imminent threat to Europe.

Other adaptation options include early detection, and disease management and prevention. The implementation of entomological and sentinel clinical surveillance networks

Many **new and emerging vector-borne diseases could potentially become endemic in Europe over the coming decades under climate change.** However, based on modelling dengue fever risk in Europe, **the scale of disease burden appears to be modest**, even when looking at projections to the end of the century. Nevertheless, when combined with permissive weather for vectors and local transmission, the disease burden is likely to be higher than anticipated. **Effective public health interventions exist for some diseases,** as well as for reducing heat stress risk among vulnerable groups. Implementation and evaluation of such programmes remain patchy and research gaps exist mainly for extreme weather events.

(early detection of the mosquito vector and index of human cases) has proven to be very valuable in identifying disease hotspots and in limiting disease spread when appropriate health responses (case isolation and treatment) are promptly implemented. For extreme weather events, appropriate infrastructure, accurate forecast and timely alerts for at-risk populations are likely to be the best adaptation and preparedness options. An example of this is Heat Health Warning systems (HHWS) currently implemented in several European countries to limit the impact of heat waves.

A range of potential entry points exist for mainstreaming climate into EU health policies

Health in general and health protection in particular is one of the pillars of the EC Treaty, which was subsequently emphasised in the EU health programme (Decision 1350/2007/EC). These policy documents represent the legal basis for EU action in the field of public health (see Figure 6). In order to give a legal basis to disease control and prevention, a Network focusing on communicable diseases was established in 1999 (Decision 2119/98/EC). Focus on climate change adaptation was the main aim of the 2009 White Paper: Adapting to Climate Change (COM(2009) 147).

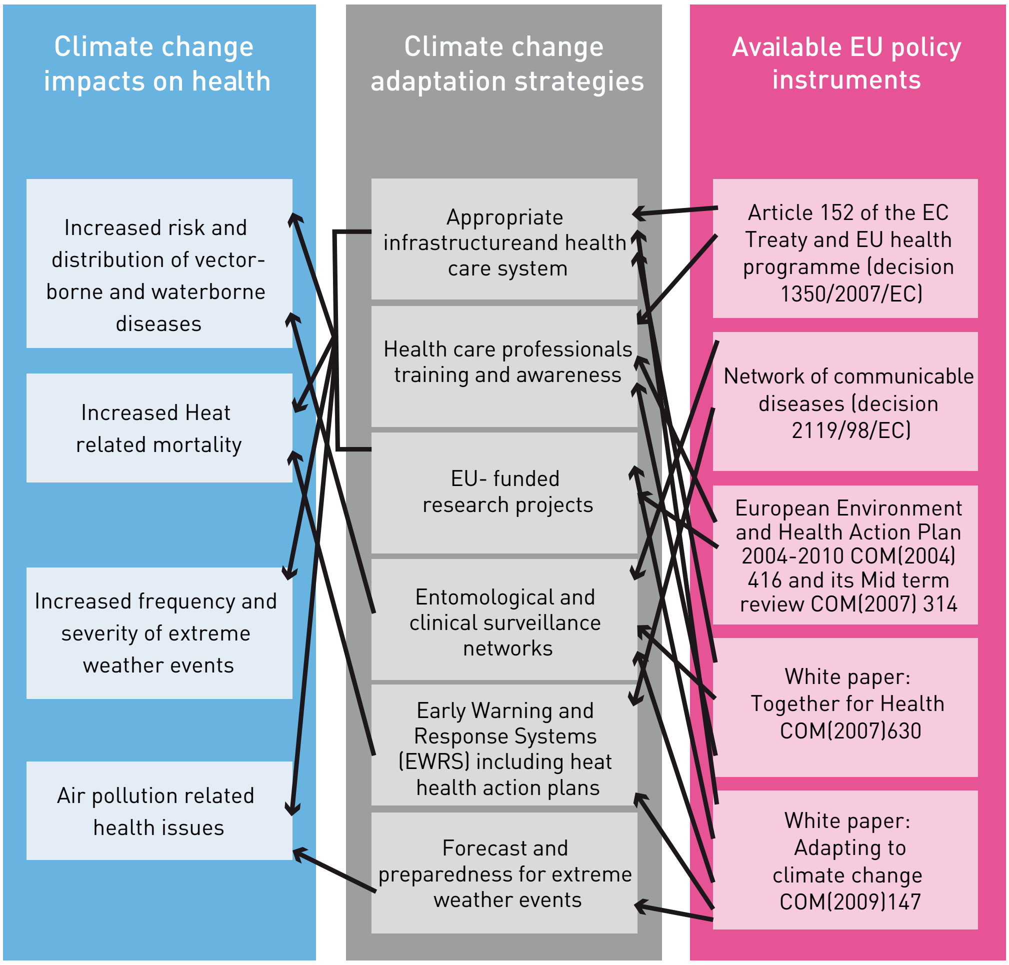


FIGURE 6. INTERACTIONS BETWEEN THE IMPACT OF CLIMATE CHANGE ON HEALTH, THE ADAPTATION STRATEGIES TO REDUCE THE DISEASE BURDEN OF CLIMATE CHANGE AND THE AVAILABLE EU POLICY INSTRUMENTS DESIGNED TO ENSURE APPROPRIATE EUROPEAN RESPONSES TO CLIMATE CHANGE.

Policy implications

For the health sector, policies are likely to be more efficient when planned and implemented on a regional and/or national scale, rather than European wide. This is mainly due to the geographic and climatic heterogeneity that characterises disease risks, but also to variations in health services and infrastructures. Although progress is being made, there is a widespread need for more focus on educating public and local health practitioners on how to cope with impacts of climate change. In general, we find that the absolute scale of climate change (whether a 2°C rather than a 4°C world) is unlikely to radically alter health impacts of climate change, although it will give rise to greater geographical spread of climate sensitive diseases. In general, we also find that mitigation objectives rank low on priorities of health providers. A goal that will become far more important will be the management and prevention of disease burden due to climate variability. In addressing new risks, there will be a need to target particularly vulnerable subgroups (elderly, very young and socially isolated). When considering adaptation options, there is a need to consider conflicts with other sectors, such as biodiversity conservation and need for environmental modifications to control vector-borne diseases. Finally, there is a need to ensure that flexible and rapid funding is mobilised and granted to researchers shortly after extreme weather events to allow generation of good quality primary data for these rare events associated with significant health burden.

Mainstreaming adaptation often involves linkages between different sectoral policies (for instance, between water and agriculture, or between cohesion and health policies). The RESPONSES project developed a way of mapping these interactions and linking them to climate vulnerabilities and adaptation strategies. **There are many opportunities for cross-sectoral support for adaptation.** But these are not being fully exploited because cross-compliance between policies has not been aligned to the goal of increasing climate resilience.

6. CUTTING **EMISSIONS** RADICALLY: THE ROLE OF CHINA, INDIA AND ELECTRICITY

It is now widely acknowledged that for a medium to likely probability of achieving the 2°C target, global atmospheric concentrations of greenhouse gases should be stabilized at 400-450 ppm. Recently, fully elaborated emission scenarios for achieving such targets found them to be technically achievable at costs of a few percent of GDP, assuming full participation of all countries. However, large changes are required: global emissions would need to peak within the next 20 years, cumulative emissions reduction over the century would need to be about 70% with total emissions in 2100 falling by more than 95% compared to baseline (van Vuuren et al., 2011). This requires an improvement of greenhouse gas intensity of around 5–6% per year, considerably above the historical rates of around 1–2% per year. Moreover, negative emissions from energy use in the second half of the 21st century are probably required. This could be achieved by combining a considerable improvement of energy efficiency, replacement of unabated use of fossil fuels by a combination of fossil-fuel use with carbon capture and storage (CCS), reforestation, renewable energy, nuclear power, and the use of bio-energy with CCS. In doing so, major consequences for global land use associated with some of these measures (specifically the use of bio-energy and reforestation measures) must be borne in mind.

A global context for EU emissions

As the EU cannot achieve such emissions reductions alone, there will need to be major contributions from major economies, including the United States, China and India. Moreover, up to now these scenario studies have assumed a cost-optimal path of reducing emissions, paying little attention to specific policy measures and their feasibility.

An electricity system based on intermittent renewable energies is feasible, but must be well-balanced in terms of technologies, sites and complementary infrastructures. **Depending on a single policy measure - the price of allowances in the EU ETS - does not account for the complexity of the future electricity system** and the need for a stable and consistent policy framework. Current policies in the EU are not supporting effectively possible game-changing technologies like CCS, and promising renewable technologies, such as concentrated solar power and marine energy technology.

Mainstreaming climate adaptation into EU policy is more likely where there is a shared concern about climate risks, high-level political commitment about the need to respond to these risks, 'hard' instruments (like mandates) and 'win-win' opportunities for linking climate- and other policy goals. **While many of these conditions exist in the EU, the seriousness with which mainstreaming is pursued is currently highly variable.**

In this context, RESPONSES aimed to provide more insight into i) emission reductions scenarios of China and India, who will play an increasing important role in international climate strategies, and ii) the real effort involved in achieving deep emission reduction scenarios, both on a global level and for Europe specifically.

To gain more insight into mitigation scenarios for China and India, we compared domestic and international scenario studies with each other, focusing on differences in assumptions about emissions and the underlying reasons for these differences. The international studies consisted of scenarios published in the context of the AME and EMF-22 modelling comparison exercises. In analysing the real effort involved in achieving deep emissions reductions, we identified promising policy measures – based on current planned or implemented policies and others mentioned in literature – and assessed their emissions reduction potential and trade-offs between measures, by using two energy system models (TIMER and Power ACE).

Chinese and Indian domestic scenarios higher than international studies

Important drivers of future trends in CO2 emissions are population and income. The Chinese and Indian comparison study (Hof et al., under review) revealed that both domestic and international scenario studies assume the population of China to be about 1.5 billion by 2030, remaining more or less constant at this level until 2050. The population projections for India for 2030 are about the same, but increasing to about 1.6 billion by 2050. Income assumptions do differ between domestic and international studies, with the former assuming higher income growth rates for both China and India. As Chinese domestic studies also assume a much higher improvement in carbon intensity (CO2 emissions per unit of income), the projections of CO2 emissions by 2030 without specific climate policies do not differ between domestic and international studies. These amount to about 12 GtCO2 by 2030, compared to about 7 GtCO2 in 2010. For India, however, large differences are found between domestic and international studies in projected emissions levels without implementation of climate policies. International studies, on average, project CO2 emissions of 3.7 GtCO2 by 2030, compared to 5.4 GtCO2 projected by domestic studies. This difference can largely be explained by higher income growth assumptions in domestic studies.

For scenarios including climate policies there is a wide gap in emission levels between domestic and international studies – with the latter suggesting lower emission levels (see Figure 7). This gap cannot be explained by higher projected emission levels without climate policies. This difference in ambition should be carefully interpreted, as it may be caused by different insights regarding emission reduction potential, but also by differences in assumed policies.

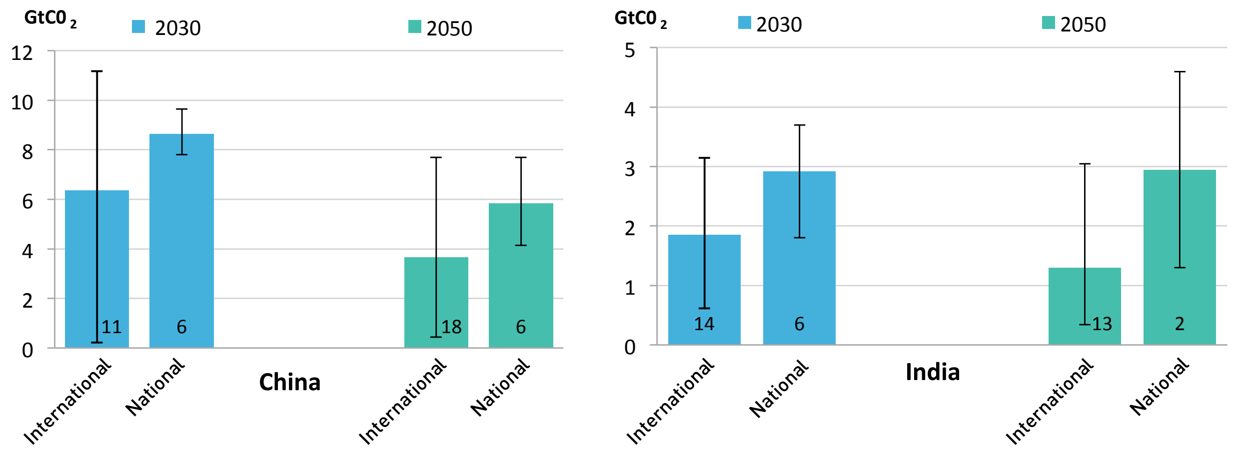


FIGURE 7. AVERAGE CO2 EMISSION LEVELS IN 2 °C SCENARIOS FOR INDIA AND CHINA, DOMESTIC VS INTERNATIONAL STUDIES. THE ERROR BARS INDICATE THE TOTAL RANGE; THE NUMBERS IN THE BARS THE NUMBER OF STUDIES ON WHICH THE AVERAGE AND RANGES ARE BASED (AFTER HOF ET AL., UNDER REVIEW).

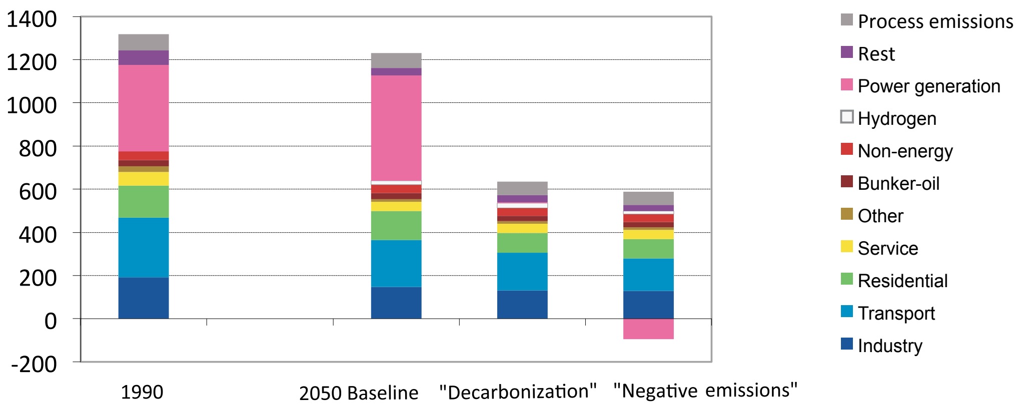


FIGURE 8. ENERGY-RELATED CO2 EMISSIONS IN EUROPE BY 2050 RESULTING FROM ALL IDENTIFIED REDUCTION MEASURES IS (AFTER DEETMAN ET AL., 2013). Note that the "decarbonization" column shows results without Biomass-Enhanced CCS (BECCS); the "negative emissions" column shows results with BECCS. Emissions are allocated to the sector in which they occur (e.g. emissions from electricity use in the residential sector are allocated to the power generation sector).

Sector	Measure	Percentage reduction of total European emissions in 2050 (%)
Transport	50% tax increase on fossil fuel combined with a 35% subsidy on electric cars	3.0
	25% subsidy on high speed rail combined with a departure tax for air travel	1.4
Residential	Enforcing advanced heating technologies and highest building insulation standards	7.6
	Banning traditional light bulbs	0.2
	Enforcing only "A" Label appliances	0.6
Industry	lower clinker ratios in cement production	0.3
	Enforcing advanced type steel furnaces	0.7
	enforcing good housekeeping	3.4
Power generation	"decarbonization" scenario	33.7
	"negative emissions" scenario (incl. BECCS)	42.8
Agriculture[a,b]	Crop yield increase	0.9
	Feed conversion and supply chain efficiency	1.8
	Changing Dietary preferences	1.4
	Improving forest and nature management	0.6
Non-CO_2[a]	Methane control measures on fossil fuel production, animal waste, landfills and wastewater	6.7
	BC control measures (mostly transport)	0.1

TABLE 2. PROJECTED CO2 REDUCTIONS FROM MODELLED MITIGATION OPTIONS BY SECTOR.
Note that reduction percentages cannot be added, as some options overlap and combinations of options may lead to price effects.

Electricity sector critical to deep carbon emissions reductions in the EU

The analysis of specific EU emissions reduction measures provides some important insights into the effectiveness of measures (Deetman et al., 2013). In total, 15 policy measures for Europe were evaluated, with a combined effect of a 60% reduction in greenhouse gas emissions by 2050, compared to 1990 levels (see Figure 8). For the global analysis, 16 energy-related policy measures were evaluated, together leading to a reduction of 73% in CO2 emissions compared to a reference scenario without climate policies. The analysis confirms the finding of other modelling studies that the electricity sector is crucial in reaching deep emission reductions (see Table 1). The reasons are that i) the electricity sector influences the potential emission reductions for all sectors using electricity, ii) emissions from the sector are projected to account for the largest share in total emissions by 2050, and iii) power generation has the potential to achieve negative emissions by using carbon capture and sequestration technologies in combination with bio-fuel use (BECCS). The development of CCS technology and acceptance therefore remain crucial for reaching ambitious climate targets. Furthermore, measures that are not fully deployed under cost-optimal 2°C scenarios, like advanced insulation, stimulating electric passenger vehicles, good housekeeping in industry and general methane control measures, do seem to have significant potential. Finally, important trade-offs between measures were identified, both within and between sectors. For instance, a fuel efficiency standard for passenger cars could prove to be counterproductive in the long term. The explanation for this is that an efficiency standard leads to lower fuel costs of fossil-fuelled cars, keeping them competitive with hybrid electric alternatives, with a negative effect on greenhouse gas emissions. (Deetman et al., under review).

Getting climate mitigation and adaptation embedded within all EU policies is called 'climate mainstreaming': a key goal of EU climate adaptation strategy. **Mainstreaming of emissions reduction in EU policy, at least to the point of 2020 objectives, is relatively well-advanced,** both in declared objectives (normative mainstreaming) and in implementation. Less well advanced is mainstreaming of the deep emissions cuts required thereafter.

Policy implications

The electricity system plays a central role in EU ambitions to achieve radical greenhouse gas emissions reductions by the 2050s. Decarbonisation of the European power system must therefore be an objective for EU and national energy and climate policy. This needs to include serious attention to the potential for 'negative emissions' from the power sector by the fourth-quarter of this century. Few other options exist to transform the European carbon footprint. The comparison of domestic and international scenario studies shows that the former cannot be used to show how the projections of the latter could be implemented. More extensive collaboration between national and international research groups would lead to better understanding of the differences in projections. This process could also improve historic data assumptions - a key issue for calibrating Integrated Assessment Models, which provide global projections. The rapid development of both China and India currently leads to errors in short-term estimates of greenhouse gas emissions and renewable power potentials. The European and global model analysis of specific mitigation options could lead to prioritisations on global and regional policies. In some cases, global agreements on specific measures could accelerate action in currently slow international climate negotiations. Furthermore, our analysis shows that policies always need to be evaluated in an integral way – as some policies may be mutually reinforcing, but others may counteract each other.

7. TRANSFORMING **ELECTRICITY** PRODUCTION IN THE EU

The electricity sector is fundamental to CO2 emissions reductions in the EU. But it also plays a role in adaptation. RESPONSES research on the electricity sector reflects this duality. First, the need for climate change adaptation in the electricity sector was investigated through a literature-based vulnerability analysis identifying the impacts of climate change on electricity supply and demand in the EU (Held et al. 2010). Second, the mitigation potential of the sector was explored, with a focus on whether incentives provided by existing policies are sufficient for meeting long-term EU climate targets for the sector. In particular, the political and technological drivers of the EU electricity sector and how they influence greenhouse gas emissions trends up to 2050 were analysed. To do this, detailed electricity system modelling, focusing on the interactions between renewable energies and other infrastructures, was performed. Third, qualitative case studies, drawing on interviews with firm representatives, were done to explore the effects of a technology-specific climate and energy policy mix on the innovation and diffusion of key climate mitigation technologies in the EU (Reichardt et al. 2011).

The climate vulnerability of the EU electricity system is limited

In general, the impacts of climate change on the demand and supply side differ by region (and over time), but are – in the main – limited in scope. Major findings on electricity supply are that hydropower, thermal and nuclear power technologies are most vulnerable. Hydropower, which depends on river flow regimes, is threatened by changed precipitation patterns. For thermal and nuclear plants, reduced availability of cooling water (from rivers) will increase the number of shut-downs and the costs for alternative cooling systems. In contrast, wind and solar power are less vulnerable. Especially in Southern Europe, electricity demand for cooling purposes is affected by climate change.

Renewable energies are essential, but the future of CCS and nuclear energy is uncertain

The modelling of different energy scenarios for the EU revealed that existing policies at current ambition levels decrease emissions from the power sector substantially. However, this is not sufficient for meeting long-term EU climate targets. A high share of renewable energies is cost efficient in all scenarios analysed (Pfluger and Schleich 2013). Realising this requires an extensive expansion of the electricity grid. Few new large-scale electricity storage facilities will be needed. However, if the growth in electricity demand cannot be slowed down through effective energy efficiency measures, at least one additional low-carbon technology is necessary. If all the obstacles to Carbon Capture and Storage (CCS) can be removed, it will become an important pillar of the decarbonisation strategy. In this case, it will displace nuclear power almost completely. Without CCS a more rapid growth in renewable would be required and nuclear energy could become competitive again. Nevertheless, path dependencies require speedy decisions on the future technological mix regarding renewables, nuclear energy and CCS.

Prospects for game-changing technologies

RESPONSES investigated the role of policy support for a number of technologies with significant mitigation potential: concentrated solar power (CSP), offshore wind, marine energy production (tidal and wave power) and CCS. The main findings from the case studies suggest that although feed-in tariffs and renewable obligation certificates are major drivers in all innovation phases of the three renewable technologies, they are not sufficient for these technologies to develop successfully. Rather, further policy mix elements need to be in place, such as research, development and deployment funding, which are easily

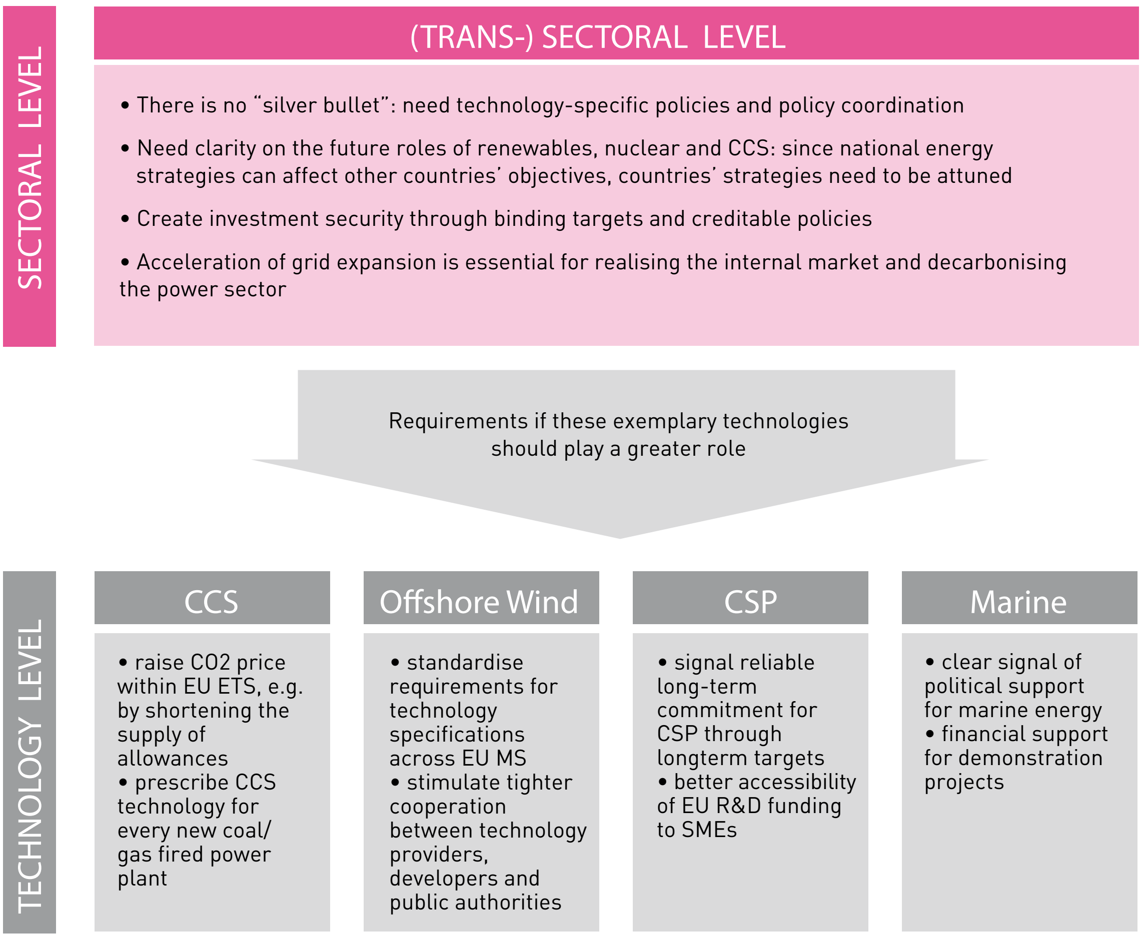


FIGURE 9: POLICY RECOMMENDATIONS FOR DECARBONISING THE EU ELECTRICITY SECTOR

accessible and tailored towards specific technologies. We found that these elements are only partially in place. In addition, their design and implementation should be improved. Concerning innovation in CCS, first, the CO2 price – supposedly the strongest driver for CCS development – has been too low to act as a driver for CCS innovation. Second, in Germany there is no effective legal basis for storing CO2, and thus for implementing CCS in fossil power plants. CCS faces significant legal and public acceptance challenges across the EU.

Policy implications

Our modelling study revealed that an electricity system based to a large extent on fluctuating renewable energies is possible, but needs to be well-balanced in terms of technologies, sites and complementary infrastructures. This balance is a question of both technical reliability and cost efficiency. However, leaving such a transformation process to a single policy measure, such as the price for EU allowances within the EU ETS, does not account for the complexity of the future electricity system and the need for a stable and consistent policy framework. Some of the necessary technologies are cost-efficient only in the long term and generate systemic benefits which are not directly remunerated by ETS prices. Accelerating the transformation of the EU power sector requires coordination, well-placed incentives and targeted regulation. This concerns the design of markets, as well as of the support mechanisms for developing and realising particular technologies (see Figure 9).

In addition to these general implications, more specific guidance for policy making can be derived from the case studies. First, concerning concentrated solar power in Spain, administrative requirements for accessing EU research and development funding should be simplified for small and medium enterprises (SMEs). Second, regarding marine energy in the UK, more EU and national support for demonstration projects that is accessible to SMEs should be launched. Third, for offshore wind, technical specifications for turbines should be standardised across EU Member States. And fourth, concerning CCS in Germany, the CO2 price is too low to incentivize technology development. Prices need to be raised, for instance by shortening the supply of CO2 allowances or by introducing CCS standards.

The **electricity sector is critical to achieving deep emissions reductions in the EU**. Under a new RESPONSES low emissions scenario for the EU, which looked at specific policy measures across different sectors (that is, not assuming cost-optimal solutions with a carbon tax alone), we find that **a reduction of 34-43% in total EU emissions by 2050 could be achieved in the power generation sector alone,** with wind generation playing a major role.

8. GETTING CLIMATE APPRAISAL RIGHT

Researchers in the RESPONSES project have produced practical advice on how to implement key conclusions of the project in the context of formal appraisals of EU policies, programmes and projects. This advice contains a number of key findings, beginning with procedural considerations, and then moving on to a number of difficult substantive issues.

Procedural considerations

Since the late 1960s, industrialized countries have included mandates for information-gathering and transparency as a core policy approach to protecting the environment. Today in the European Union, formal appraisals include Impact Assessment (IA), Strategic Environmental Assessment (SEA), and Environmental Impact Assessment (EIA), which are mandated for actions, ranging from long-term policy proposals in the European Commission and Member States, to individual infrastructure developments. Key findings of the RESPONSES project are:

EU guidance documents mention climate change implications as a category to be assessed, but have provided little specific guidance. Past appraisals have reflected this, assessing impacts on energy use where such impacts are obvious and direct (such as within the transportation or energy sectors), but not elsewhere. There has been little attention given to climate vulnerability or adaptation.

Stakeholders have expressed a desire for continuing evolution of such guidance, but there is some reluctance from policy makers concerning new mandates. Progress of mainstreaming climate goals has not necessarily been hindered by this gap. New mandates could impose a substantial economic burden with little justification. There is value, however, in more detailed guidance on a number of key points.

Appraising consistency with deep emission reductions

Appraisals have increasingly examined effects on energy consumption, and often translated this into savings in CO2 emissions given today's proportion of energy derived from fossil fuels. All proposals for deep emissions cuts, however,

Appraising the eventual effect of policy interventions made today on mitigation and adaptation goals is fraught with problems. For mitigation, the consistency of an intervention with one particular technology pathway for decoupling CO2 and energy cannot yet be appraised, as relevant decisions determining the pathway to be taken have yet to be made. **For adaptation, it often makes sense to focus efforts on correcting existing mal-adaptations, rather than trying to prepare for highly uncertain conditions in the future.**

Much **less well-developed in EU policy is mainstreaming the goal of reducing climate vulnerability** and stimulating adaptation. This is especially the case at the level of national, regional and local implementation of EU policies in biodiversity, water, and structural and cohesion funding.

would decouple CO2 emissions from energy use. Given this, the relevant impact to appraise would be not total energy use, but rather effects on the feasibility and ease of absolute decoupling over policy-relevant timescales (to 2020 and 2050). Key findings of the RESPONSES project are:

It is premature to appraise consistency with one particular technology pathway for decoupling CO2 and energy. Decisions not yet made, but likely to be reached over the coming decade, will determine the extent to which Europe expands renewable energy, develops nuclear energy, or implements carbon capture and storage. These choices will have profoundly different implications on the structure of the energy system, energy markets, and the need for international cooperation.

Across all pathways, improvements in energy efficiency play an important role, as does the shift towards electricity as the primary energy carrier. The former is important, as it lessens the need for new investment in energy infrastructure, which will likely prove an important barrier. Because of the "rebound" effect, efficiency gains may be longer-lived when they are driven by increases in energy prices at the point of demand, rather than by implementation of cost-saving technologies and processes. It is important to take this into account. Effects on a shift towards electrification matter because the use of other energy carriers — such as liquid fuels — make complete decarbonization very challenging.

Goals and indicators for adaptation and vulnerability reduction

The primary goal of adaptation has so far been to secure existing policy and social objectives under conditions of climate change. Current climate and impact projections suggest, however, that in some regions or sectors the impacts may be severe enough that it is either impossible, or impracticable, to achieve this primary goal. This would necessitate a re-evaluation of core policy and social objectives themselves. Key findings of the RESPONSES project are:

Core decisions concerning the goals for adaptation implicate basic societal values, and need to be devolved to the lowest possible level of governance. Stakeholders have suggested that achieving widespread acceptance and buy-in of adaptation priorities requires effective mechanisms for public participation. The local level is often best suited for this, because of both practical considerations, and heterogeneity across Europe with respect to societal values and anticipated climate impacts. Mandates coming from Brussels, if not based on such input, may face opposition.

To reduce vulnerability to climate change, the European approach needs to be one of lessening exposure through sound decisions based on up-to-date information, though there are some places where improvements in adaptive capacity are critical. Globally, the most significant barrier to successful adaptation is often a lack of capacity to appraise and implement available options. Policies to stimulate adaptation can be most effective when they focus on these capacity deficits, rather than the information and finance needed for the options themselves. In many newer Member States and at lower levels of governance throughout the EU there is a continued need for programs to raise capacities to appraise climate risks and make effective adaptation decisions.

Dealing with uncertainty in climate, ecological, and social systems

Even as Europe has adopted a target to mitigate emissions to an extent necessary to limit climate change to 2°C average warming, it is quite likely that a failure to achieve longer-term EU targets, combined with a lack of necessary action beyond Europe's borders, will result in substantially more warming. This and other uncertainties create a key challenge for appraising consistencies with adaptation needs. Key findings of the RESPONSES project are:

It is rarely possible to apply quantitative state-of-the-art uncertainty analysis methods in the context of policy appraisal, and an emphasis should instead be on qualitative insights. Methods such as real options analysis, robust decision-making, or the propagation of uncertainties all promise important findings, and their use usually requires more data and time than are typically available for policy appraisal. Simpler methods such as back-casting and sensitivity analysis can usually give more useful results given real constraints.

It often makes sense to focus adaptation efforts on correcting existing mal-adaptations, rather than trying to prepare for highly uncertain conditions in the future. Uncertainties in future climate and climate impacts are large, but uncertainties in both socio-economic conditions and public attitudes concerning difficult tradeoffs are often even larger. Combined, they can preclude meaningful quantitative appraisal of long-term adaptation costs and benefits, and efforts to do so may be more misleading than reliable. In almost every sector and region of Europe, however, there are major existing mal-adaptations that can be corrected, and it is should be a priority to focus on these.

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Policy Updates

RESPONSES Policy Update 1: EU Biodiversity policy in times of climate change

RESPONSES Policy Update 2: Climate change adaptation in the health sector

RESPONSES Policy Update 3: With or Without CCS? Decarbonising the EU Power Sector

RESPONSES Policy Update 4: Low emission scenarios and 2020 reduction pledges

RESPONSES Policy Update 5: Climate Policy Mainstreaming in the EU.

RESPONSES Policy Update 6: Climate change impacts across Europe and the role of EU regional policy in adaptation

Project Reports (at time of going to press)

D2.1 Draft Methods Paper

D2.2 Research protocol

D3.1a Country report on mitigation and adaptation in India

D3.1b Country report on mitigation and adaptation in China

D3.2 Deep greenhouse gas emission reductions: a global bottom-up model approach

D3.3 Low emission scenarios and 2020 reduction pledges

D3.5 Scenario report 2: Workshop report 'The feasibility of transitions in 2 degree scenarios'

D4.1 Scoping study of current policies and institutions (EU/national/regional) for water management

D4.2 Impact analysis of climate change on drought/flood risk, and relevant non-climate policies and their implementation, and consequences for agriculture and ecosystems

D4.3 Report on integrated options for reducing risk/vulnerability (adaptation) that take account of mitigation

D.5.1 Review report on present EU biodiversity policy

D5.2 A matrix of biodiversity indicators

D5.3A Integrated Activity Report: Joint impacts of climate change and bioenergy production on the state and conservation of European birds

D5.4 EU Biodiversity in times of climate change

D6.1 Catalogue of programmes and policies related to regional development and infrastructure ('Baseline assessment')

D6.2 Digital map of investments in the EU

D6.3 Report on potential impacts of climate change on regional development and infrastructure

D7.1 Scoping document on Health

D7.3 Adaptation strategies report on health

D7.4 Climate change adaptation in the health sector

D8.1 Report including literature review on impact of global warming on supply and demand of energy in the EU

D8.2 Results of modelling for existing policies (frozen intensity)

D8.3 Effects of the policy mix on the development, demonstration and diffusion of low-carbon power generation technologies. Results of qualitative research - in depth interviews

D8.4 With or Without CCS? Decarbonising the EU Power Sector

D9.1 Assessment of alternative deep emissions reductions in Europe

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