ECONADAPT:
The Economics of Adaptation

Funded by
the European Union

Policy Synthesis

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Key Messages

This policy synthesis paper summarises the results of the ECONADAPT project on the economics of adaptation, funded by the European Union's Seventh Framework Programme. The key messages are summarised below.

The ECONADAPT project has developed a policy-led approach to frame the research and policy analysis. This focuses on the practical application of adaptation economics to near-term adaptation decisions for both the short- and the longer-term, using iterative risk management and prioritising low-regret options.

The project has collated the knowledge base on the costs and benefits of adaptation. This evidence has evolved significantly in recent years, with a greater coverage of risks, sectors and countries, though important gaps remain in many areas. More recent studies show the importance of considering uncertainty, as well as policy implementation costs.

The project has made methodological advances in a range of areas. It has developed adaptation economic methods for assessing adaptive capacity, undertaken primary survey work to understand public preferences for adaptation, and developed methods for the scaling, transfer and aggregation of cost and benefit values. The project has also applied decision making under uncertainty to adaptation economics, reviewing and producing summary information on methods, and undertaking example applications.

The ECONADAPT project has applied these methodological advances to a series of policy domains, considering the major priorities for adaptation economics over the next decade.

It has considered the bottom-up costs and benefits of addressing the increased frequency of weather related disasters from climate change, and complemented this with analysis of the fiscal consequences of climate change exacerbating current national level disasters.

It has developed guidance for economic project appraisal and undertaking practical case studies that consider river flooding and sea-level rise. It has also developed guidance for policy appraisal (impact assessment), looking at the development of mainstreaming with a case study in the agriculture sector. A key priority in both the project and policy appraisal studies has been to include decision making under uncertainty.

The project has looked at the wider economic effects of both market-driven and planned adaptation, undertaking macro-economic modelling to assess the economic consequences of adaptation from a top-down perspective.

It has also developed the project and policy appraisal frameworks for application in the developing country context, particularly in relation to international climate finance, and undertaken a series of practical case studies to demonstrate the application.

Finally, the project has compiled the project information, methods, insights and guidance into a web-based library and policy toolbox (www.econadapt.eu).

Introduction

The ECONADAPT project, on the Economics of Adaptation, is a research project funded by the European Union Seventh Framework Programme (FP7) for research, technological development and demonstration under grant agreement no 603906.

The objectives are to build the knowledge base on the economics of adaptation to climate change and to convert this into practical information for decision makers, to help support adaptation planning. The project has had a strong element of stakeholder engagement and co-production and has organised the research around two questions / work streams:

- What are the key methodological advances needed to improve the economic assessment of adaptation?
- What are the big adaptation decisions facing Europe in the next decade where these improved economic methods could be applied?

This policy synthesis summarises the results from the project. Further information is available at http://econadapt.eu/

Methodological Advances

The project has investigated some of the key challenges on the economics of adaptation, addressing:

- Framing the economics of adaptation;
- Methods for economic appraisal and estimates of costs and benefits;
- Scaling, transfer, aggregation;
- Treatment of uncertainty.

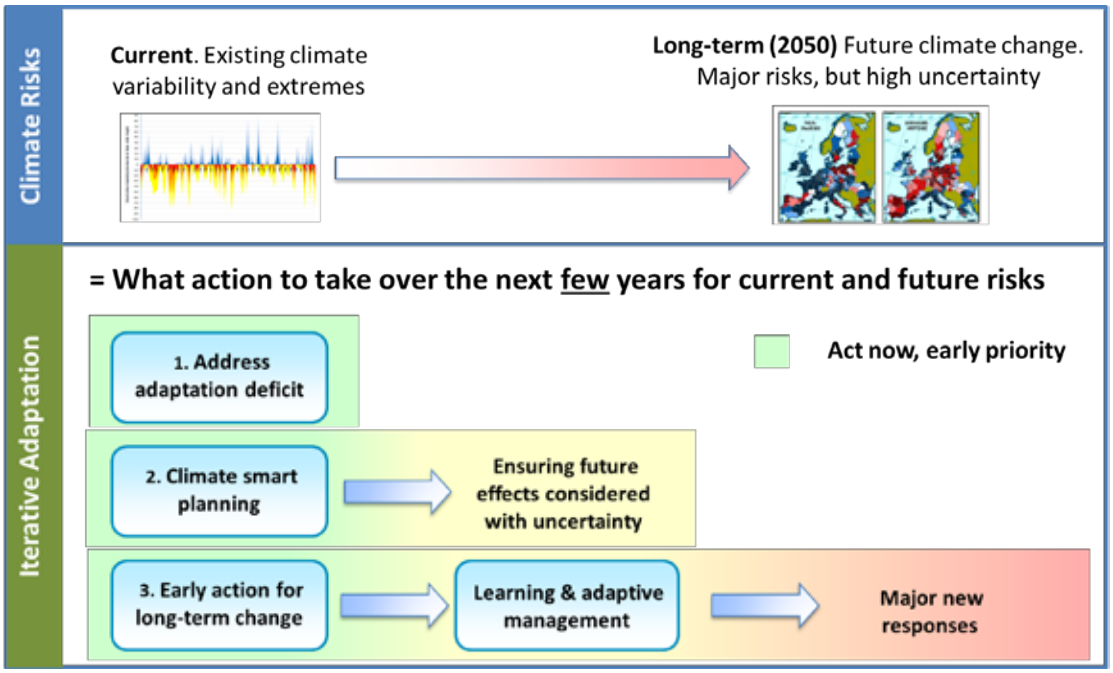
Framing early adaptation

Historically, the main framework for assessing adaptation options has been centred on an impact-assessment methodology which takes a stylised "predict-then-optimise" approach. This raises some problems: studies tend to focus on the longer term and ignore uncertainty, and on their own do not provide relevant policy information for early practical implementation.

The ECONADAPT project addressed these limitations by developing a policy-led framework. This ensures that the policy context for adaptation – in the context of broader objectives and non-climatic factors – is understood first. It has prioritised near-term adaptation implementation, i.e. for decisions that need to be made in the next five years or so, using economic principles to identify options that are early priorities. The framework uses an iterative risk management approach and identifies three types of early adaptation investments that are priorities for early adaptation:

1. Immediate actions that address the current risks of weather and climate extremes (the adaptation deficit) and build resilience to future climate change. This includes early capacity-building (non-technical adaptation) and the introduction of low- and no-regret actions, which provide immediate economic benefits as well as future benefits under a changing climate.
2. The integration of adaptation into immediate decisions or activities with long life-times, such as infrastructure or planning (climate smart development). This involves different options (to above) because of future climate change uncertainty. It involves a greater emphasis on climate risk screening and the identification of flexible or robust options that perform well under uncertainty.
3. Early monitoring, research and learning to start planning for the future impacts of climate change. This includes the use of adaptive management, the value of information and future option values and learning so that appropriate decisions can be brought forward or delayed as the evidence and knowledges emerges.

The three categories can be considered together in an integrated adaptation strategy, often termed a portfolio or adaptation pathway. At the national or programme level, a portfolio of all three will be relevant, and they are particularly useful with respect to mainstreaming, i.e. the integration of adaptation into existing policies and plans. An important aspect is that the different types above require different methods, and thus different economic appraisal techniques.



The costs and benefits of adaptation

The ECONADAPT project has compiled the available literature and found around 700 studies of potential relevance to the economics of adaptation. This literature has been compiled in an inventory of studies, which is freely available in the ECONADAPT library. This inventory provides access to a comprehensive evidence base on the costs & benefits of adaptation, with a search function, and is available at: http://econadapt-library.eu/.

An analysis of this literature reveals that the information base on the costs and benefits of adaptation has significantly grown in recent years. This is show in the table below.

There are some major gaps that remain in the coverage, notably on biodiversity and ecosystem services, business/industry, and cross-cutting adaptation. Nonetheless, this new evidence base provides an increased opportunity for sharing information and good practice. An analysis of this literature also reveals important insights:

- The methods for identifying options and assessing costs and benefits of adaptation are changing. A focus of more recent studies has been on early low-regret options, with a greater range of options including capacity building and non-technical options. Some recent studies are also using decision making under uncertainty, using new economic appraisal approaches.

Coverage of Cost and Benefit Estimates by Sector in the Adaptation Literature

Risk / Sector	Cost estimates	Benefit estimates
Coastal zones and coastal storms	✓✓✓	✓✓✓
Floods including infrastructure	✓✓✓	✓✓
Agriculture (multi-functionality)	✓✓	✓✓
Water sector management including cross-sectoral	✓✓	✓
Over-heating (built environment, energy and health)	✓✓	✓
Other infrastructure risks	✓	✓
Other health risks	✓	✓
Biodiversity / ecosystem services	✓	
Business, services and industry	✓	✓

✓ = limited evidence; ✓✓ = moderate body of evidence; ✓✓✓ = good body of evidence

- More recent policy-orientated studies indicate higher costs of adaptation than the previous literature (for like for like measures). This is because they include existing policy objectives and standards, consider multiple risks, recognise and plan for uncertainty and include the additional opportunity and transaction costs associated with policy implementation. The new literature does, however, identify many early low-cost options and alternatives to engineered adaptation.

The ECONADAPT project has also considered whether cost or benefit estimates from one study – such as the values from the studies in the inventory above – can be transferred to a new study. This would save considerable time and resources and is especially important for benefits as it is time and resource intensive to undertake primary benefit valuation studies.

The project has found that such benefits transfer is difficult for adaptation, as there are numerous limitations including: data and methodological heterogeneity, temporal issues from primary studies, and thus there are likely to be errors associated with such transfer. The costs and benefits of adaptation depend on the method used, the objectives set, the types of adaptation considered, whether uncertainty is addressed, and whether policy implementation costs are included, as well as with the scenario, climate model and time-scale chosen.

This cautions against the production of simple inventories or look-up tables on the costs and/or benefits of adaptation. What is possible, however, is to use existing studies to help inform analysis.

Preferences for adaptation

The ECONADAPT project has looked at a range of methodological issues around the preferences for adaptation. This has included an analysis of the willingness to pay (WTP) for adaptation using direct surveys, and whether this varies with the type of adaptation option. The results are outlined in the box below.

Box 1: What are public preferences and WTP for adaptation?

How much are people willing to pay for adaptation and do they prefer certain types of adaptation? These questions were explored in ECONADAPT by eliciting preferences with economic techniques.

The project undertook a survey of Willingness-To-Pay for planned public adaptation in three EU countries, the Czech Republic, Italy and the United Kingdom. The survey used discrete choice experiments to elicit individual preferences for adaptation options. One survey looked at the trade-off between severity and size of droughts and flood risks, while a second considered different adaptation measures. The findings were:

- Willingness to pay for additional flood and drought adaptation measures – as an increased monthly household bill for water consumption – were in the range of €15 to €19 in the Czech Republic, €35 to €45 in Italy, and €33 to €44 in the UK (market exchange rates).
- In all three countries, citizens preferred to reduce the severity of climate change impacts across a given population, as opposed to reducing the number of affected people in the population.
- Rainwater harvesting was the most popular measure in all three countries. In the UK, large reservoirs and dams came second, but large dams were the least popular measure among Czech citizens.
- Citizens in all three countries express relatively high preferences for nature-based adaptation measures: creating wetlands and changing the use of agriculture land.

The results show differences in WTP between floods and droughts, and between structural (natural and technical) and non-structural soft measures. There were also differences in WTP between the three countries. The results also provide useful information for policy makers, highlighting that the choice of adaptation can increase public support for plans and measures.

The project has looked at how preferences might change over time. This has included consideration of discount rates. In general, the finding is that these are less contentious for adaptation than for mitigation, especially when considered for short-term adaptation at the national to local scale.

The project has also considered how preferences for environmental goods and services might change in the future, reflecting income growth, the depletion of environmental assets, the elasticity of substitution (between man-made and environmental goods and services) and the change in preferences of future generations. Modelling reveals these could have important effects on the overall benefit estimates of adaptation measures.

Alongside these time preferences, the project has considered the distributional effects of adaptation, to consider who bears the costs and benefits from adaptation. The project has considered the use of distributional weights to adjust, where weighting factors are applied to reflect the relative income levels of those affected by the costs or benefits of an investment. It has also looked at risk aversion and case study work has demonstrated these factors can have an important role in the consideration of adaptation options.

Adaptation decision making

The project has explored several key areas that have been considered challenging for economics.

One priority for early adaptation is on building adaptive capacity (sometimes termed system-wide actions). This does not involve technical or hard adaptation options and is more difficult to quantify and value. The ECONADAPT project has advanced the valuation of these actions, looking at their direct and indirect benefits. The approach has been tested with examples looking at the benefits of the provision of climate information.

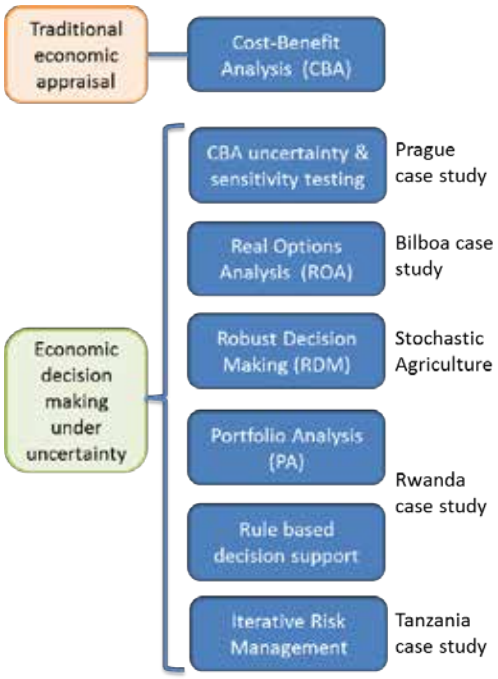
The project has also explored the use of non-monetary metrics and methods. The project has considered the application of non-monetary metrics through multi-criteria analysis, which is useful when there are attributes or criteria that cannot easily be monetised, or in earlier scoping of options for example to include issues such as uncertainty, urgency, synergies and conflicts.

A further quantitative non-monetary benefits approach is cost-effectiveness analysis. This can be useful for capturing effects that are difficult or contentious to value and can be particularly useful when looking at adaptation to clearly defined targets, such as flood protection levels. The project has summarised the approaches and the literature on these methods, noting their potential benefits but also limitations.

The ECONADAPT project has concentrated on quantitative methods, given their role in the economic appraisal of adaptation. The project has reviewed and tested different decision support methods, and has produced guidance on their applicability and use (http://econadapt-toolbox.eu/methods). This has included decision making under uncertainty methods, recognising this is a key issue for adaptation. The figure shows the range of case studies that have been used in the project to test these different decision-support tools.

The project has produced guidance on which methods of economic appraisal might be applicable for different adaptation problems, and undertaken case study applications on real options analysis, portfolio analysis and iterative risk management in a range of sectors and countries.

A key finding of the project is the need for 'light-touch' approaches of these methods, in recognition that they are technically complex to apply and require considerable time and resources: these would capture the conceptual aspects of these uncertainty approaches, while maintaining a degree of economic rigour.



Policy Results

The ECONADAPT project has applied these methodological advances to a series of policy domains, focusing on the major priorities for adaptation economics over the next decade in Europe. The key results are summarised below.

Disaster risk and climate adaptation

Natural disasters (from current climate variability) already lead to high economic costs in Europe, including from major floods. Climate change is likely to increase the frequency of these extreme events, even in the short-medium term. As these will be amongst the highest near-term economic costs of climate change, managing these risks is an early priority for adaptation.

The ECONADAPT project first compiled an inventory on the economic benefits of flood protection investments in Europe. The inventory found 110 observations from 32 studies in 17 countries. An analysis of the studies demonstrates that current adaptation to disasters has high benefit to cost ratios (BCRs), with a median value of 3:1. Analysis of different types of measures found the highest BCRs were for investing in preparedness, rather than prevention or amelioration.

The study also undertook case studies on the use of decision-making tools in flood risk management in four countries (UK, the Netherlands, the Czech Republic and Austria): interestingly, this found that the countries use different methods for appraisal of flood investments, highlighting the need to consider these aspects in appraising adaptation at the national-local level.

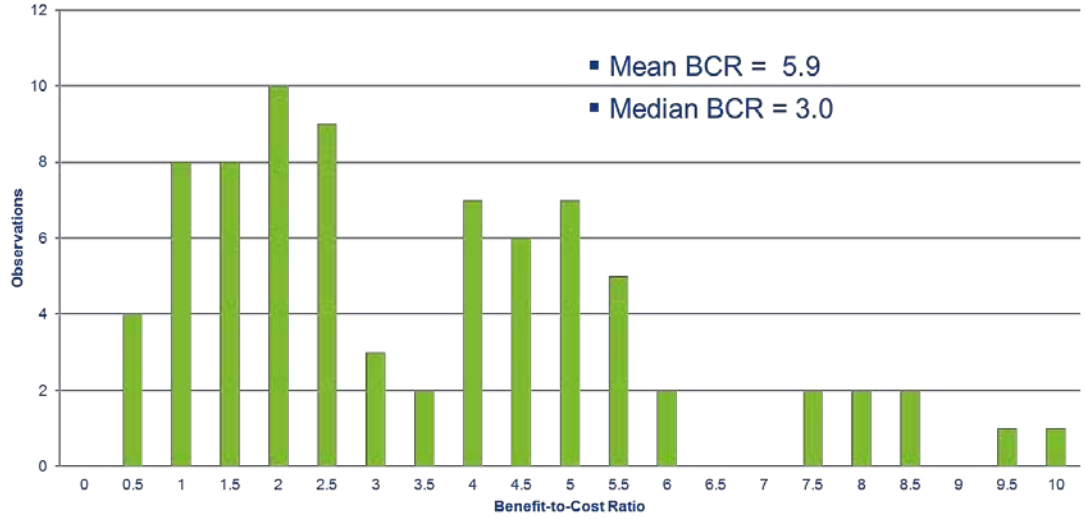
The ECONADAPT project also complemented this more bottom-up analysis with a top-down analysis, looking at the fiscal consequences of climate change exacerbating current national level disasters in relation to national budgets. A case study was undertaken using economic and fiscal modelling to look at contingent disaster liabilities.

The case study modelled the potential liabilities using a stochastic assessment of debt at the national level with a case study in Austria. This included the analysis of explicit liabilities, for example, the rebuilding of damaged public infrastructure, but also implicit liabilities, such as support to the private sector and households to cover estimated losses. The results show that the fiscal costs of increasing climate extreme events could be a very significant public finance issue.

Based on this work, a fiscal scorecard has been produced for all EU member states. This gives an overview of inter-related issues in relation to longer-term fiscal drivers and sustainability, covering climate and non-climate drivers.

The analysis shows there are large economic risks from climate extremes – relative to the size of economic and public finance resources – in Hungary, Slovenia Latvia, Lithuania and Slovakia. This analysis highlights that these countries may need fiscal consolidation in the medium to long-term and that proactive fiscal risk management is likely to be important.

Benefit to Cost ratios for Flood Protection Investments in Europe



EU Fiscal Scorecards

	Underlying Fiscal Pressure				Variability		Climate Change Extreme				
Country	Debt/GDP	S1 Indicator	Ageing Cost	Climate change mitigation	Growth adjusted interest rate	Semi-elasticity parameter	AAL 2015	AAL 2030	AAL 2050	Reserve fund/budget item	Average insured losses
Belgium	🔴	🔴	🔴	🟠	🟠	🔴	🟠	🟠	🟠	🟠	🟢
Bulgaria	🟢	🟠	🟡	🟢	🟠	🟢	🟠	🟠	🟠	🟠	🔴
Czech Republic	🟢	🟡	🟠	🔴	🔴	🟢	🔴	🔴	🔴	🔴	🟢
Denmark	🟡	🟢	🟢	🟡	🟡	🔴	🟡	🟡	🟡	⚫	🟢
Germany	🟠	🟢	🔴	🟢	🟢	🟠	🟢	🟢	🟡	⚫	🟠
Estonia	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🔴	🔴	🟠	🔴
Ireland	🔴	🔴	🔴	🔴	🟢	🟠	🟠	🟠	🟡	⚫	🟢
Greece	🔴	🟡	🟡	🟢	🔴	🟡	🟡	🟡	🟡	⚫	🔴
Spain	🔴	🔴	🟠	🟠	🟠	🟠	🟢	🟢	🟢	⚫	🟠
France	🔴	🔴	🟡	🟠	🟢	🔴	🟡	🟡	🟡	⚫	🟢
Croatia	🟠	🟠	🟢	⚫	🟠	🟡	🟢	🟢	🟢	⚫	🔴
Italy	🔴	🟠	🟠	🟡	🟡	🟠	🟡	🟡	🟡	⚫	🟡
Cyprus	🔴	⚫	🟢	🟠	🟠	🟠	⚫	⚫	⚫	⚫	🟠
Latvia	🟢	🟡	🟡	🔴	🟡	🟢	🔴	🔴	🔴	🟠	🔴

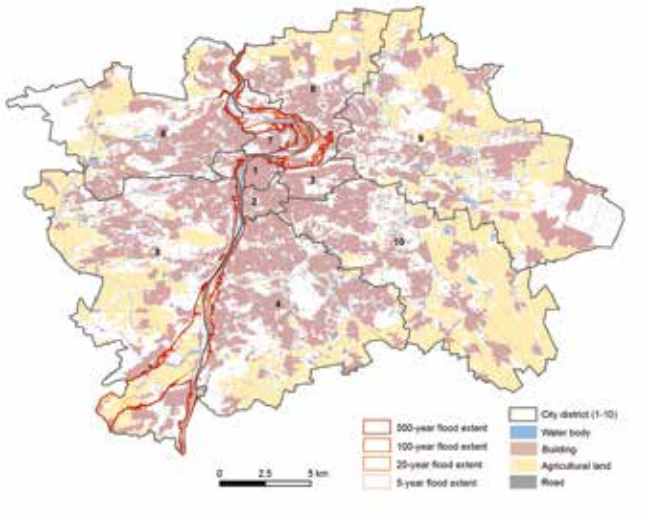
	Underlying Fiscal Pressure				Variability		Climate Change Extreme				
Country	Debt/GDP	Primary balance needed for debt stability	Ageing Cost	Climate change mitigation	Growth adjusted interest rate	Semi-elasticity parameter	AAL 2015	AAL 2050		Reserve fund/budget item	Average insured losses
Lithuania	🟢	🟡	🟡	🔴	🟡	🟢	🔴	🔴	🔴	🟠	🔴
Luxembourg	🟢	🟢	🔴	🔴	🟡	🟡	🟢	🟢	🟢	⚫	🟠
Hungary	🟠	🟠	🟢	🔴	🔴	🟡	🔴	🔴	🔴	⚫	🟡
Malta	🟡	⚫	🔴	🟢	🟠	🟡	🟢	🟢	🟢	⚫	🟢
Netherlands	🟡	🟢	🟠	🟡	🟢	🔴	🟢	🟢	🟢	⚫	🟡
Austria	🟠	🟠	🔴	🟠	🟡	🔴	🔴	🟠	🟠	⚫	🟠
Poland	🟡	🟠	🟢	🟢	🔴	🟠	🟠	🟠	🟠	🟡	🟡
Portugal	🔴	🔴	🟠	🟠	🟢	🟡	🟡	🟡	🟡	🟢	🟢
Romania	🟢	🟡	🟠	🔴	🟢	🟢	🟠	🟠	🟠	⚫	🔴
Slovenia	🟠	🔴	🔴	🟡	🟠	🟡	🟠	🔴	🔴	🟢	🟡
Slovakia	🟡	🟡	🟡	🟡	🟠	🟢	🔴	🔴	🔴	🟠	🟠
Finland	🟡	🟡	🟠	🟢	🔴	🔴	🟠	🟠	🟠	🔴	🟡
Sweden	🟡	🟢	🟢	🟡	🔴	🔴	🟡	🟡	🟡	⚫	🟠
United Kingdom	🟠	🔴	🟢	🟡	🟢	🔴	🟠	🟠	🟡	⚫	🟢

Project appraisal

The second major policy theme in ECONADAPT was to explore the consideration of adaptation into economic project appraisal.

This is a priority for large infrastructure projects (including European Structural and Investment Funds), because of their long life-times and high exposure to future climate change. This involves two types of projects: first, addressing future climate risk in existing planned investments and second, new projects designed specifically to address climate change (e.g. new barriers for sea-level rise).

The project undertook two real-world case studies that engaged policy makers and applied alternative decision-support methods to project appraisal.



The first case study apprised adaptation to flood risks in the city of Prague, which has been heavily impacted by floods in recent years. The study looked at an ex-post appraisal of adaptation using a cost-benefit analysis which considered a full range of social costs and benefits, including environmental effects.

The study used a suite of hydrological and damage-cost models, for a number of future shared socio-economic pathways and detailed climate model projection, with consideration of uncertainty.

The quantitative analysis projected flood return periods and expected (annual) damages – now and under future climate change scenarios – and estimated the economic costs and benefits of adaptation. Details are presented in the box later.

The study used sensitivity analysis to undertake a detailed analysis of uncertainty, considering how different attributes/factors affected the CBA results, and thus assessed the robustness of the investment under varying conditions.

The second case study appraised a new urban development in Zorrotzaurre, Bilbao, looking at adaptation options to reduce coastal and river flooding by opening a canal on the Deusto channel to convert the area from a peninsula into an island.

The analysis used a Real Option Analysis to appraise this potential investment in flood reduction.

It used detailed climate model projections and hydrological modelling, assessing the full economic costs of climate change (including on cultural heritage, human health and indirect second order effects).

It then applied the real options framework to investigate whether to invest or wait in relation to the option, testing this with additional sensitivity analysis (for example around the discount rate).

The results of the two case studies were used to investigate which key factors have most effect on the economic results. The analysis found the climate model and socio-economic uncertainty, along with the discount rate, were most important and therefore require most attention in uncertainty analysis.

The lessons from the case studies – along with the earlier methodological development work – was used to produce guidance on project economic appraisal. This sets out the core activities for appraisal with a series of steps, using the case studies to provide examples.

Policy appraisal

As well as investigating the project level, ECONADAPT has looked at economic appraisal at the policy scale, looking at (regulatory) impact assessment. This is especially important for the mainstreaming (integration) of adaptation into policy: a key priority of the EU Adaptation Strategy. In this context, a key consideration is to provide adaptation information that is directly policy relevant and considers uncertainty.

The project undertook a policy appraisal case study to advance this, applying the ECONADAPT methods. This investigated the agriculture sector looking at the consideration of mitigation and adaptation in the framework of the common agricultural policy (CAP) and recent reform.

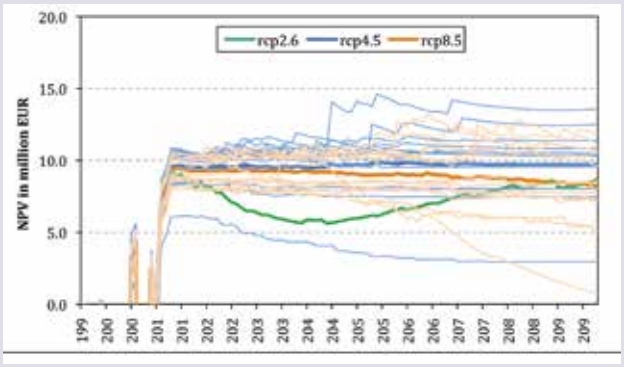
The case study started with a detailed policy review, recognising that policy measures can, in some cases, stimulate adaptive responses to climate change risks and strengthen overall resilience, especially when using an adaptive management (iterative) approach.

It then assessed the potential introduction of adaptation policy options at the European scale, using an extended stochastic version of an integrated agriculture-land-use-forestry model (the Global Biosphere Management Tool, GLOBIOM) that allows consideration of mitigation and adaptation within an analysis of production, trade and competition.

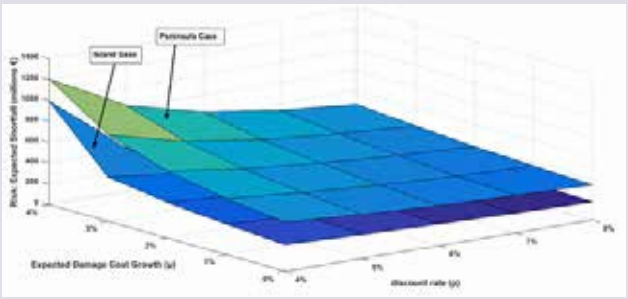
Rather than use a standard approach, where the performance of adaptation intervention was assessed against defined outcomes of climate change impacts, the priority was to identify options that performed well across a range of possible outcomes (i.e. that are more robust).

Box 2: ECONADAPT project and policy appraisal case studies

The Prague case study considered adaptation options to flooding in the Vltava river basin. The analysis estimated baseline losses of different flood return periods (5-, 20-, 100-, 500-year) and simulated the effect of climate change using climate model outputs for different Representation Concentration Pathways (RCPs) using a hydrological model. It estimated expected annual damage (EAD) for housing, commerce and public sector buildings, road infrastructure and loss of agricultural production, using exceedance probability loss curves.



It then looked at adaptation through strengthened flood protection standards, and considered the investment, maintenance and variable and lump-sum costs, and estimated the (expected) net present value (NPV), a metric of the economic efficiency. Overall, the results show highly positive findings, with a high justification for the investment. However, sensitivity analysis showed there was a large variability between RCPs (see figure – thin lines represent individual RCMs, bold lines the average for each RCP) and discount rates.



The Bilboa case study looked at a new urban development that has been approved in a flood risk area within the estuary, looking at adaptation options to address potential sea level rise and increased river flood risk. The analysis used downscaled data (for RCP4.5 and 8.5) in a hydrologic model to look at potential peak-discharges for different return periods, generating flood risks maps and assessing potential damage.

The adaptation option was to open the Deusto channel and convert the area from a peninsula into an island, lowering the height of flooding. The study estimated the economic benefits of this option, as well as how it might reduce the risk, the latter considering Value-at-Risk (VaR) and Expected Shortfall (ES, the average damage of the 5% worst cases). The option was found to reduce the average expected damage (reducing these damages by 41 to 58 M€) and also the level of risk (reducing ES by 174-205 M€) during the period under assessment. The analysis also applied a Real Options Analysis (ROA) to assess the investment risk under uncertainty, i.e. whether to invest now or to wait.

The **agriculture policy case study** focused on the use of an Integrated Assessment Model (IAM) and the shift away from a deterministic analysis which runs one scenario at a time, recognising this leads to scenario dependent results. This study used a stochastic approach to analyse robust trade-offs for climate change adaptation in land use systems, taking scenarios and uncertainties into account.

The GLOBIOM IAM was applied to compare synergies and trade-offs between structural policy measures (which are costly, often irreversible, and imply high sunk costs and lock-in) and non-structural measures (measures that can be reversed or adjusted for on short notice) in the Common Agricultural Policy (CAP).

The results indicate that robust policy making has large benefits compared to deterministic analysis. Furthermore, strong synergies and trade-offs between non-structural and structural measures were found. It also showed that the effects of agricultural policies are interdependent and depend on the location, agricultural activity, risk exposure, etc. Direct payments lead to an increase in demand and cropping area for some regions and crops, but a decrease for other regions and crops. Therefore, effects differ when analyzing direct payments alone or in combination with other policy measures.

The adaptation analysis was undertaken within an integrated analysis of competing objectives of food, water, energy, and environmental security, i.e. cross sectoral / cross-regional dependencies and interactions.

The findings of the case study demonstrated that robust recommendations enabled a more efficient (re)distribution of CAP funds and required less natural resources, as compared with scenario-dependent adaptation. The analysis also found that the distributional effects were important: reforms in one region can affect others, both within and outside Europe.

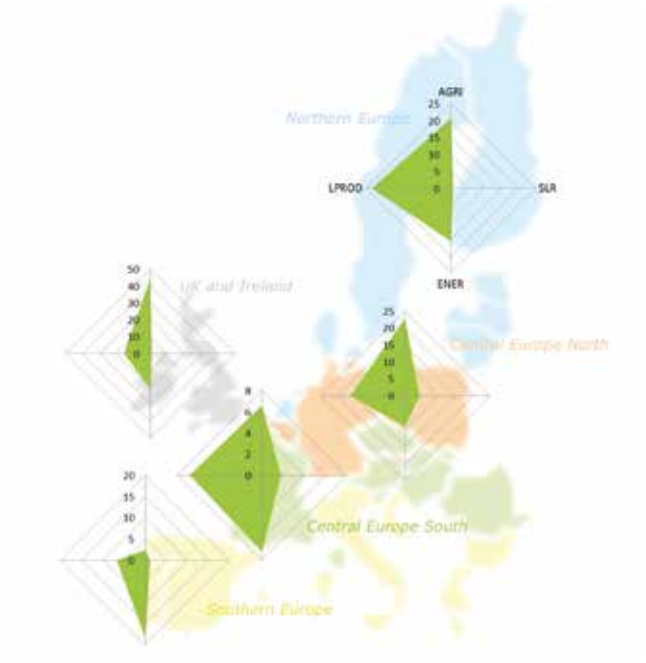
Complementing this, a survey was undertaken in Greece looking at farmers' perceived risks and attitudes to climate change adaptation, as well as their preparedness and capacity to adapt and future actions. It identified additional adaptation options at the farm level, and the WTP for these, noting that private adaptation is unlikely to be optimal alone because of various market failures.

The macro-economic effects of adaptation

There is an increasing interest in the macro-economic effects of adaptation, i.e. the economy-wide effects. The ECONADAPT project has assessed these effects using computable general equilibrium (CGE) models. The project has looked at market-driven adaptation (autonomous) which involves demand and supply reactions to changes in relative prices. It has also extended these models to look at planned adaptation.

The market driven adaptation was assessed with a global multi-country, multi-sector CGE model (CAGE-GEME3). The analysis assessed how market driven adaptation could reduce potential climate change damages. It considered three key responses: labour mobility, both across sectors and region; the degree of substitutability between capital and labour in the production function; and the degree of substitutability for trade flows and domestic production.

At the global level, the study found that market based adaptation reduced climate change damages by approximately a third (compared to a case without adaptation) for both GDP and welfare losses. The analysis also focused on Europe, and investigated the effects by region. Within the EU, the welfare-enhancement effect of adaptation is



EU Welfare improvements from autonomous adaptation (sector and region)

smaller at lower latitudes. The greatest benefits are in the UK & Ireland, followed by Northern Europe and the Central Europe North regions – shown in the figure for land productivity (LPROD), agriculture (AGRI), sea-level rise (SLR) and energy (ENER). These differences reflect the initial size of impacts but also the potential for substitution (especially for agriculture).

The analysis of planned public adaptation also used a CGE modelling analysis, undertaking two case studies – one on increased demand for irrigation to address agricultural impacts and another on public sector investment in coastal adaptation to sea level rise (SLR) – to consider the economy-wide implications of planned adaptation actions.

The analyses looked at how planned adaptation increases public expenditure and affects public budgets, considering climate related public goods (such as information acquisition and dissemination on likely extreme events) and protecting public and private assets at risk.

The agriculture case study looked at increased demand for irrigation services to reduce climate change impacts – extending an existing CGE model to consider land supply structure/rents and conversion of rain-fed land, along with the additional costs that farmers face when they decide to expand irrigation.

In the baseline (with climate change), lower latitude countries are most negatively affected in terms of decreased crop production and lower GDP. Under the adaptation scenarios, irrigation expansion reduces these productivity and GDP losses and is considered an effective option (especially for lower latitude countries), though converting rain-fed into irrigable land is costly and increases agricultural prices which reduces demand expansion.

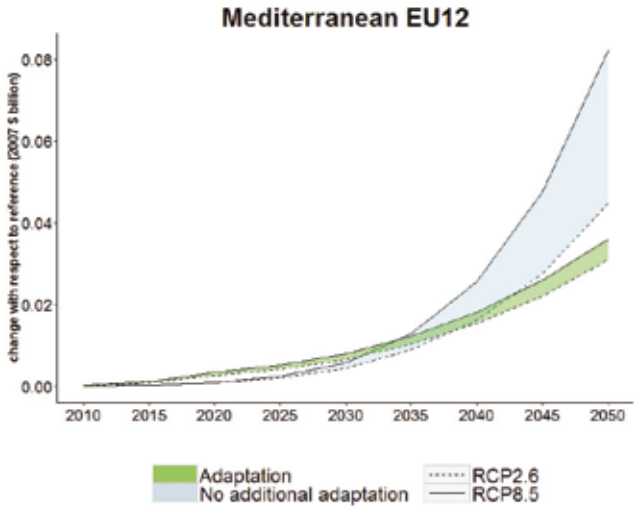
The overall macro-economic effects (globally) are small, as agriculture is a low contributor to value-added and GDP, though international trade effects also influence this result, as regions with lower increases in domestic prices (compared to world prices) export more and vice versa.

Climate change – and the planned adaptation response – will thus reallocate crop production from more to less affected sectors / countries, and from developed to developing countries, as the latter have relative advantages from lower irrigation costs.

The sea level rise case study investigated coastal adaptation in a CGE model and considered the impact on public finances, by extending the model to consider government as a separate actor.

Planned adaptation requires increased public expenditure. These measures are implemented locally, but often require large scale upfront investments and can induce additional indirect economy-wide effects through an increased demand for adaptation services and the reallocation of resources to produce them.

A no adaptation scenario was considered, which showed high GDP losses in all regions. It also showed worsening public deficits as sea-level rise impacts on land, capital and labour and ultimately GDP. The analysis then considered a planned adaptation scenario (with investment funded by public debt).



Impacts on public deficit for Mediterranean EU12 in 2050 (with and without adaptation)

GDP gains are observed everywhere but especially in developing countries where sea-level rise impacts are higher and adaptation is particularly effective. It also translates into lower deficits, lower debt accumulation, and consequently lower debt service which allow for more resources devoted to growth.

Public deficits are initially higher when adaptation investments are being put in place, but become lower only in the long run (see figure). This is a direct consequence of the long-run nature of sea-level rise. What is interesting is that adaptation expenditure can enable virtuous processes, and the positive effects on public finance sustainability can be positive, even though initially financed with debt.

International adaptation finance

One of the major flows of adaptation finance – consistent with international pledges – will be from Europe (EU and MS) to developing countries. There is a strong role for economic appraisal in helping to assess the effective use of these resources and the links to financing.

While these involve project and policy appraisal, there are several key differences (to the EU) with the application of adaptation economics to developing countries.

First, the impacts of current climate variability and extremes are much higher, and combined with the higher discount rate / interest rate, this means a greater priority on the short-term.

Second, data availability and capacity are much lower, making quantitative analysis more challenging. There also tends to be a greater emphasis on non-market and informal sectors, and the issue of equity (especially amongst the most vulnerable) is more important.

To develop this further, the ECONADAPT project undertook two case studies – with real implementation examples, working with policy makers – and applied and transferred the ECONADAPT methods to economic appraisal.

The first case study looked at agricultural land-use planning and development policy, looking at

mainstreaming climate change into the tea and coffee sectors in Rwanda. Tea and coffee are long lived crops, and current plans to expand production will lock-in land-use for decades, thus the consideration of uncertainty is important.

The case study undertook an economic and financial analysis to appraise potential adaptation options using the ECONADAPT policy approach.

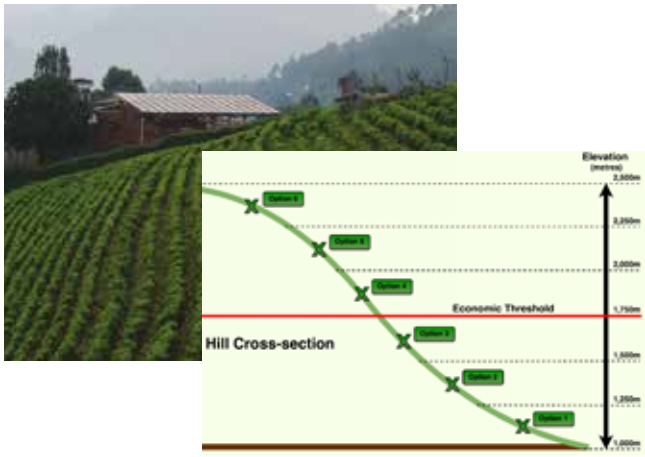
The study undertook a cost-benefit analysis and found high benefit to cost ratios from investing in early low-regret options that address current weather risks, especially climate-smart agriculture. These options showed high initial economic benefits which increased under climate change. The analysis also found high benefits from investing in capacity building, notably with farmer field schools.

The study also assessed future oriented options, using light-touch rule based decision criteria and portfolio analysis to assess the climate smart planting of future tea expansion areas. This considered which areas might be suitable for tea planting given the shifts in agro-climatic zones with climate change.

Finally, the analysis adopted some iterative risk management (adaptive management) and recommended investment in early monitoring and planning to help inform future decisions (the value of information), especially in relation to emerging pest and disease problems.

The economic appraisal was used to justify the project and the options as part of a climate finance application and has now been successfully approved for implementation.

The second case study assessed seaweed farming in Tanzania (Zanzibar). This farming is a major export crop and a large source of employment for women on the islands. However, production

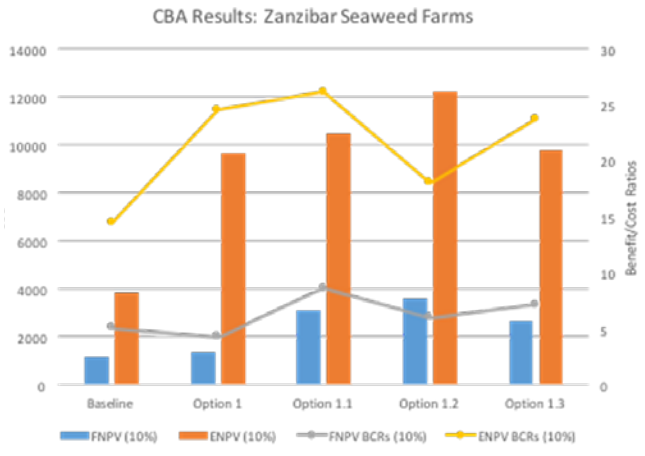


is already being affected by rising sea surface temperature and climate change will have potentially large impacts. The area was therefore selected as a priority for an early response.

The study undertook an economic and financial appraisal of early immediate options, using a cost-benefit analysis that also considered wider non-market effects, as well as a financial assessment (estimating the internal rate of return, IRR, reflecting the involvement of the private sector). The analysis used sensitivity analysis to look at short-term uncertainties, related to prices, costs and discount rates. This identified several options with very high benefit to cost ratios (see figure).

Alongside this, the analysis identified and assessed options that could help the seaweed farming sector in medium to long-term, including public planned adaptation, considering uncertainty.

It used the decision tree concepts from real option analysis and highlighted the need to invest in early sea surface monitoring and long-term planning, to provide information for longer-term decisions under future climate change and sea surface temperature increases.



Policy engagement and toolbox

A key priority of the ECONADAPT project has been to have a policy-centred approach. The research has incorporated stakeholder involvement and co-design throughout the project, and a large number of individual policy meetings were held.

The final major activity of the project was to collate and disseminate the project findings.

The project has built a web-based searchable library of studies, i.e. an inventory of the 700 studies found in the review phase, with some additional information with a data-repository on cost and benefit estimates (http://econadapt-library.eu/).

Complementing this, it has brought together the analysis of methods and guidance, and a series of insights, together in a Toolbox (http://econadapt-toolbox.eu.

ECONADAPT LIBRARY

ECONADAPT TOOLBOX

The information aims to inform the wider application of economic assessment to adaptation decision-making and thus this has used a two-track approach. There is a first set of information and guidance for a technical audience, i.e. users of economic information. A second set has a more accessible light-touch approach – to ensure broader dissemination and use by a non-economist audience

The toolbox includes more information on the findings summarised in this policy brief.

Information on the ECONDAPT policy framework is available at (http://econadapt-toolbox.eu/node/55) and how this can be applied to various policy domains, with guidance on how to assess the economics of adaptation (http://econadapt-toolbox.eu/policy-challenges).

There is also an overview of individual methods and their applicability (http://econadapt-toolbox.eu/methods) with links to more details on the individual methods and case study examples.

APPRAISING PROJECTS – AN APPLICATION TO INLAND AND COASTAL FLOOD MANAGEMENT

APPRAISING POLICIES AND PROGRAMMES – AN APPLICATION TO EUROPEAN AGRICULTURE POLICY

INTERNATIONAL DEVELOPMENT PROJECTS - AN APPLICATION TO COFFEE AND TEA IN RWANDA

DISASTER RISK MANAGEMENT – AN APPLICATON TO AUSTRIA AND THE EU

MACRO-ECONOMIC ASSESSMENT

A series of policy insights are provided (http://econadapt-toolbox.eu/insights) that summarise the information on methodological advances, as well as the results from the policy themes, including case study material, and it is possible to access the underlying technical deliverables.

The project also organised two major policy workshops on the economics of adaptation, with an early meeting in Paris with the OECD, and a final meeting in Brussels, with key relevant stakeholders and other research consortia. The synthesis and findings of the meeting are available at: http://econadapt.eu/september-2016-policy-workshop-brussels

The ECONADAPT project commenced in October 2013 and will run for 36 months. This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 603906.

To find out more about the ECONADAPT project, please visit the web-site: www.econadapt.eu.
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For further information on the policy applications, co-production and stakeholder engagement, contact Paul Watkiss at: paul_watkiss@btinternet.com

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ECONADAPT is co-ordinated by the University of Bath (UK) and involves 14 teams across Europe.