

Application of economic instruments for adaptation to climate change

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Table of Contents

List of figures.....	7
List of tables.....	8
List of abbreviations.....	10
Executive summary.....	12
Background and introduction to the work.....	38
Task 1: Overview of economic instruments to tackle adaptation challenges posed by climate change	40
1 Introduction.....	40
1.1 Objective of Task 1.....	40
1.2 Concepts and definitions	40
1.3 Methodological approach in task 1	48
1.4 Categorisation of policy instruments analysed.....	49
2 Overview of Economic Instruments	50
2.1 Subsidies	50
2.1.1 General description of the policy instrument category	50
2.1.2 Direct payments / grants.....	50
2.1.3 Tax reductions	52
2.1.4 Price supports.....	53
2.2 Taxes and fees	54
2.2.1 General description of the policy instrument category	54
2.2.2 Carbon Taxes	56
2.2.3 Land use taxes and fees	57
2.2.4 Energy taxes	58
2.3 Licences, permits and variations.....	59
2.3.1 General description of the policy instrument category	59
2.3.2 Tradable Units	59
2.3.3 Project based offsets.....	61
2.3.4 Possible design of a tradable unit scheme: Adaptation Market Mechanism (AMM)	62
2.3.5 Advance market commitment	63
2.4 Other Market-Based Instruments.....	64
2.4.1 General description of the policy instrument category	64
2.4.2 Payments for ecosystem services	64
2.4.3 Water markets	67
2.4.4 Habitat banking	69
2.5 Financial instruments.....	70
2.6 Public-Private-Partnerships	72
2.6.1 General description of the policy instrument category	72
2.6.2 Public contracts	73
2.6.3 Service concessions.....	74
2.6.4 Joint Technology Initiatives.....	75
2.7 Risk financing instruments.....	75
2.7.1 General description of the policy instrument category	75
2.7.2 Insurance.....	76
2.7.3 Catastrophe bonds	80
2.7.4 Weather derivatives	81

3	Conclusions	81
Task 2: Analysis of economic instruments in terms of promoting adaptation		
1	Methodological approach in task 2	83
2	Analysis of economic instruments in terms of promoting adaptation action	84
2.1	Subsidies	84
2.1.1	Grants	85
2.1.2	Tax reductions	90
2.2	Taxes	93
2.2.1	Land taxes and fees	93
2.3	Licences, permits and variations	99
2.3.1	Tradable quotas and variations: Adaptation Market Mechanism	99
2.4	Other market based instruments	106
2.4.1	Payments for Ecosystem Services (PES)	107
2.4.2	Water markets	114
2.5	Financial Instruments: loans and guarantees	126
2.5.1	Loans	127
2.5.2	Guarantees	136
2.6	Risk Financing Instruments	145
2.6.1	Role in disaster risk management and climate adaptation	145
2.6.2	Overview of risk financing instruments	146
2.6.3	Assessment: criteria to analyze and compare risk-financing instruments	152
2.6.4	Assessing Insurance instruments	152
2.6.5	Weather derivatives	164
2.6.6	Catastrophe bonds	165
2.6.7	Summary scores	167
Task 3: Analysis of risk financing instruments for coping with extreme climate-related risks		
1	Introduction	168
2	Assessing economic instruments in terms of risk financing	168
3	Gaps and obstacles to demand and supply for risk financing instruments	170
4	Supply-side gaps and obstacles	171
5	Demand side barriers	173
6	Analysis of exposure, risk and coverage of insurance-related instruments	175
7	Methodology for estimating risks	176
7.1	Hazard	177
7.2	Vulnerability	178
7.3	Exposure	178
8	Risk estimates	180
8.1	Flooding	181
8.2	Drought	190
8.3	Windstorms	195
8.4	Relation to and implications for Solvency II	199
9	Analysis of insurance instruments for climate risk financing	201
10	Insuring households and businesses	203
10.1	A roadmap across national systems	204
10.2	The Netherlands: tax-financed government compensation	205
10.3	Austria: statutory public compensation combined with private insurance	205
10.4	Germany: private insurance with ad hoc public compensation	205
10.5	Spain: public monopoly with compulsory participation for all hazards, flat premiums	205
10.6	Switzerland: public monopoly with compulsory participation for all hazards, flat premiums	206
10.7	France: state-backed national all-hazards insurance	206
10.8	The US: privately administered public flood insurance system	206
10.9	Hungary: subsidized public flood insurance program for high risk areas	207
10.10	The United Kingdom: private market bundled hazard insurance	207
10.11	Summary	207

11	Ranking national insurance programs	208
11.1	Capacity for providing a reliable safety net	208
11.2	Effectiveness for advancing adaptation.....	209
11.3	Efficiency in terms of system costs	212
11.4	Equity in providing security to low-income population.....	212
11.5	Applicability to other national contexts	213
12	Summary and policy options	214
12.1	Summary.....	214
12.2	Policy options for expanding insurance density and advancing adaptation.....	215
13	Insuring farmers: crop and livestock insurance	217
13.1	An overview	217
13.2	Reviewing the systems	219
13.2.1	The Netherlands: moving from government compensation to state-backed agricultural insurance, single risk	219
13.2.2	Greece: public compulsory, combined agricultural insurance	220
13.2.3	Spain: private-public agricultural and yield insurance	220
13.2.4	France: Minimal subsidies, single and combined, yield insurance, no subsidies	220
13.2.5	UK: minimal government support for agriculture	220
13.2.6	United States: highly subsidized private agricultural insurance	221
14	Rating the systems with respect to their applicability, effectiveness, capacity, efficiency and equity	221
14.1	Applicability across Europe	221
14.2	Effectiveness for incentivizing adaptation.....	222
14.3	Capacity for providing a secure safety net	222
14.4	Efficiency.....	222
14.5	Equity	223
15	Summary and policy options	223
15.1	Summary.....	223
15.2	Policy options.....	224
16	Insuring and pooling public assets and government relief expenditure	225
16.1	Sovereign insurance in Mexico using insurance and catastrophe bonds	226
16.2	Sovereign insurance using weather derivatives: The Ethiopian case	227
16.3	Regional pools.....	227
16.3.1	Effectiveness for incentivizing adaptation	231
16.3.2	Capacity for providing a reliable safety net	231
16.3.3	Efficiency	231
16.3.4	Equity	232
16.4	Summary and policy options	232
16.4.1	Summary	232
16.4.2	Policy options	233
Task 4: Summary of findings and policy options.....		234
1	Summary of evaluation of market based instruments to promote adaptation.....	234
1.1	Comparison: General characteristics of market based instruments	235
1.2	General characteristics of risk financing instruments.....	236
1.3	Comparison: Applicability and effectiveness of economic instruments by sector	238
2	Policy options for the economic instruments	240
2.1	Grants and tax reductions	240
2.2	Land use taxes	241
2.3	Payment for Ecosystem Services	242
2.4	Water markets	243
2.5	Adaptation Market Mechanism AMM.....	244
2.6	Concessional Loans	245
2.7	Guarantees	246
3	Policy options for the risk financing instruments.....	247
3.1	Options to improve the adaptive effectiveness of RFIs.....	247

3.2	Options for making markets and partnerships for risk financing work	250
3.3	Insuring households and businesses: policy options	250
3.4	Demand-related options.....	251
3.5	Supply-related options.....	252
3.6	Policy options for coupling property insurance with adaptation	252
3.7	Insuring farmers: policy options	253
3.8	Insuring governments: policy options.....	254
4	Further research needs	256
	References	257
	Appendix	267
	Annex I	272
	Annex II	273
	Annex III	305
	Annex IV	310

List of figures

Figure 1: Annual average flood losses including confidence bounds.....	20
Figure 2: Annual average drought losses in agriculture.....	20
Figure 3: 200 year event windstorm losses including confidence bounds.....	21
Figure 4: Estimates of today's and future annualized flood risks	22
Figure 5: Country models for flood insurance as they reflect private and public liability	28
Figure 6: Conceptual framework for climate change adaptation assessment.....	40
Figure 7: Overview: functioning of an adaptation market mechanism	63
Figure 8: PES at the example of forest conservation	65
Figure 9: Land use in European cities.....	94
Figure 10: PES flow chart	108
Figure 11: Shares of sectoral water use in five European regions	116
Figure 12: Water prices in selected European countries in the late 1990s	117
Figure 13: Water price increases in selected European countries in the late 1980s and 1990s.....	117
Figure 14: The connection between water price increases and water use in Hungary, 1990-1999	118
Figure 15: The connection between water price increases and water use in Denmark (1990-2005, left) and in Estonia (1992-2004, right).....	118
Figure 16: Schematic functioning of loans (example)	129
Figure 17: Cost elements of an annuity loan and cost reduction potential through guarantees	136
Figure 18: Cross-country sample of financing modalities of disaster losses by insurance, government assistance, and private sector and net loss (as a percentage of direct losses)	147
Figure 19: Insurance and reinsurance	149
Figure 20: Catastrophe bond transaction and market volume	151
Figure 21: Costs contributing to catastrophe insurance premium	162
Figure 22: Operational framework for modelling flood risk as a function of hazard, exposure and vulnerability.	177
Figure 23: Depth-damage function for a residential building.....	178
Figure 24: Current and future capital stock estimates for European countries.....	180
Figure 25: Maximum annual average flood damage for European provinces and regions (NUTS 2 level) as a percentage of GDP for today's climate regime	181
Figure 26: Annual average losses including confidence bounds for minimum and maximum estimates. Source: Based on Hochrainer and Mechler, 2009 and Luger et al. 2010.....	184
Figure 27: AAL in million € for baseline period.	190
Figure 28: Annualised monetary risk due to combined heatwave and drought stress for spring wheat.....	191
Figure 29: Changes in annualised drought and heat-wave risks to spring wheat over a future period i.....	192
Figure 30: Annual average drought losses in agriculture.....	194
Figure 31: 200 year event windstorm risk in absolute terms (insured and uninsured).	196
Figure 32: Distribution of flood risk including the uninsured risk over Europe	198
Figure 33: Distribution of drought risk including the uninsured risk over Europe.....	198
Figure 34: Distribution of windstorm risk for the 200 year event including the uninsured risk over Europe	198
Figure 35: Country Models for Flood Insurance as they reflect private and public liability	204
Figure 36: Agricultural insurance systems in Europe	219
Figure 37: Structure of the CCRIF.....	228
Figure 38: Governments' fiscal deficits and disaster risk liabilities in selected flood-prone European countries.....	229
Figure 39: Proposed structure for sovereign insurance pool for Eastern Europe.....	229

List of tables

Table 1: Sector-specific ability of economic instruments to incentivise adaptation	17
Table 2: Overview of general evaluation results of market based economic instruments.....	18
Table 3: Assessment of the RFI categories.....	23
Table 4: Classification of adaptation according to autonomous and planned action modes	44
Table 5: Exposure of the public and private sector to disaster risk	45
Table 6: Private and public adaptation measures in different sectors	46
Table 7: Effectiveness of grants	86
Table 8: Applicability of tax reductions.....	91
Table 9: Applicability of land use taxes.....	96
Table 10: Applicability of adaptation market mechanism by policy sector	102
Table 11: Applicability PES by policy sector	110
Table 12: Applicability of water markets by policy sector	123
Table 13: Major investment barriers for adaptation-related activities by investment type, type of investor ...	127
Table 14: Assessment: Public-to-private loans	132
Table 15: Assessment: Public-to-public loans	133
Table 16: Applicability of public-to-private sector guarantees by policy sector	139
Table 17: Applicability of public-to-public sector guarantees by policy sector.....	140
Table 18: Overview of general evaluation results of market based economic instruments.....	143
Table 19: Sector-specific applicability of economic instruments for adaptation.....	144
Table 20: Options for the management of natural disasters events	146
Table 21: Pre- and post-disaster loss and risk financing arrangements.....	148
Table 22: Insurance and adaptation according to key sectors.....	153
Table 23: Weather derivatives and adaptation according to key sectors.....	164
Table 24: Catastrophe bonds and adaptation according to key sectors.....	165
Table 25: Assessment for the RFI categories	167
Table 26: Assessing the instruments in terms of characteristics of risk financing instruments	169
Table 27: Insurance barriers and assessment criterias	174
Table 28: Capital stock estimates for the year 2011 (in billion Euro).	179
Table 29: Exposure to flooding in terms of total capital stock (in billion 2011 Euro)	182
Table 30: Distribution of flood losses over the EU 25.....	183
Table 31: Value at risk estimates for riverine flooding (current situation).	185
Table 32: Comparison of average annual losses due to flooding (current situation).	186
Table 33: Comparison of average annual losses due to flooding (current situation)	187
Table 34: Member states and relative flood risk sorted in descending order	187
Table 35: Average Annual flood losses (minimum and maximum) today.....	188
Table 36: Changes in average yield for spring wheat for the 2030-2060 period	193
Table 37: Member states exposed to drought and relative drought risk sorted in descending order	194

Table 38: Losses in billion Euro for selected EU countries for 200 year loss windstorm event for today	195
Table 39: Key member states exposed to windstorm and relative windstorm risk sorted in descending order	196
Table 40: Insurance penetration rates for flood riskMember State	197
Table 41: Comparison of our risk estimates with CEIOPS: 200 year event loss for windstorm and flood.....	199
Table 42: Pre- and post-disaster loss and risk financing arrangements for the private sector.....	203
Table 43: Assessing national property insurance arrangements according to key criteria*	215
Table 44: Summary of agricultural insurance systems.....	218
Table 45: Assessing current national crop insurance arrangements according to key criteria*.....	224
Table 46: Pre- and post-disaster loss and risk financing arrangements for governments.....	226
Table 47: Assessing sovereign loss and risk financing arrangements according to key criteria*	232
Table 48: Overview of general evaluation results of market based economic instruments.....	235
Table 49: Assessment for the RFI categories	237
Table 50: Overview of market-based economic instruments and their applicability/effectiveness	238

List of abbreviations

AAL	Annual average loss
ABI	Association of British Insurers
ADAM	Adaptation and Mitigation to Climate Change
AMM	Adaptation Market Mechanism
ART	Alternative risk transfer
ARTEMIS	Embedded Computing Systems
BASIX	Bhatia Samruddhi Finance Ltd.
CCAP	Climate Change Adjustment Program
CCR	Caisse Centrale de Réassurance
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CEA	Comité Européen des Assurances
Clean Sky	Aeronautics and Air Transport
CSS	Countryside Stewardship Scheme
DAFF	Department of Agriculture, Fisheries and Forestry
DALYS	Disability-adjusted life years saved
DRM	Disaster risk management
EC	European Commission
EEA	European Environment Agency
EDI	Ethiopia Drought Index
EIB	European Investment Bank
ELGA	Greece Hellenic Agricultural Insurance
ENIAC	Nanoelectronics Technology 2020
ES	Ecosystem Service
ESA	Environmentally Sensitive Area
ESFM	European Financial Stability Mechanism
ESPON	European Spatial Planning Observation Network
EUSF	EU Solidarity Fund
FCH	Fuel Cells and Hydrogen
FEMA	Federal Emergency Management Agency
FP7	Seventh Framework Programme for research and technological development
GDP	Gross Domestic Product
IEA	International Energy Agency
IMI	Innovative Medicine
IPCC	Intergovernmental Panel on Climate Change
JTI	Joint Technology Initiative
KGV	Cantonal property insurer
LGTT	Loan Guarantee instrument for TENs Transport projects
LLFA	Lead Local Flood Authorities
MBI	Market Based Instrument
MRN	Mission Risques Naturels
MRV	Monitoring, reporting and verification
NAPA	National Adaptation Plans of Action
NFIP	Flood National Insurance Program
NGO	Non-governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PES	Payments for Ecosystem Services
PESETA	Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis

PI	Policy Instrument
PPP	Public Private Partnership
PSNP	Productive Safety Net Programme
RFDC	Regional Flood Defence Committees
RFI	Risk Financing Instrument
SCaMP	Sustainable Catchment Management Programme
SFLG	Small Firms Loan Guarantee Scheme
SMEs	Small/ medium enterprises
SoP	Statement of Principles
SRES	Special Report on Emission Scenarios
SRSA	Swedish Rescue Services Agency
SW	Saved Wealth
UKCIP	UK Climate Impacts Programme
UMZ	Urban Morphological Zone
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value added tax
WFD	Water Framework Directive
WFP	World Food Programme
WHO	World Health Organisation

Executive summary

1. Economic instruments for adaptation

Adaptation to anthropogenic climate change has gained prominence in recent years, as policymakers realize that even aggressive climate change mitigation strategies are unable to prevent a significant change in key climatic parameters. This change is likely to manifest itself through gradual changes in averages, but also through changes in extreme events, as suggested by scientific modelling of future hazard potential. Moreover, evidence and public perception is growing that some types of extreme events are already increasing in frequency and intensity, as evidenced by the heat wave of the summer of 2003 or the cluster of river floods in Germany in the mid-1990s. There is, with important exceptions, a continuity and consistency between the observed changes and those projected for the future. Negative impacts will include increased risk of flash floods, more frequent coastal flooding and increased erosion due to storminess and sea-level rise. Climate change is also projected to exacerbate heat and drought problems and to reduce water availability, hydropower potential and crop productivity. As one example, a heat wave, such as that of 2003 which led to 70,000 additional deaths in the EU, was more likely to occur than historically, and could become normal summer weather in the late 21st century. Therefore, preventive actions need to be taken to reduce the impacts of climate change. Preventive adaptation covers a wide range of activities that can have a private but also a public good character.

The EU has embarked on the development of an adaptation strategy, which complements member state strategies that have been developed since the mid-2000s. In the context of this strategy, the assessment of adaptation policy instruments plays a key role. To harness private sector engagement in adaptation, specific policy instruments for the internalization of positive externalities are required. If these instruments involve financial measures, adaptation activities could emerge as business opportunities. As adaptation is a costly activity, it may be worthwhile considering adopting the most efficient instruments; these instruments can also prevent deterioration in both income and wealth distribution.

Experiences from mitigation show that economic instruments play a key role in generating mitigation action. But in contrast to mitigation policies, economic instruments have so far played a minor role in adaptation. We therefore have looked at a range of economic instruments that can incentivise the reduction of climate change impacts through preventive action. These include tried-and-tested instruments as well as novel, untested and in some cases theoretical concepts. We distinguish four generic categories:

- Market Based Instruments (MBIs), which can promote proactive adaptation through monetary incentives.
- Public Private Partnerships (PPPs), which can cover contracts between public and private entities to finance adaptive activities or cover losses.
- Financial instruments (FIs), which include increased accessibility of loans for adaptation activities in the private and public sector.
- Risk Financing Instruments (RFIs), which compensate losses through pre-arranged risk sharing and pooling mechanisms, may help with coping with the additional burdens imposed by climate change and may incentivise proactive adaptation.

Market Based Instruments

Market failures, such as lack of information and free riding behaviour, can lead to sub-optimal adaptation. Market based instruments can contribute to reducing these market failures. As literature on market-based mechanisms in adaptation is almost non-existent, we have expanded our analysis to climate change mitigation and ecosystem services. We thus find the following MBI categories that might have a link with adaptation activities

- Subsidies, differentiated into grants, tax reductions and price supports. They could be used to finance improvement of infrastructures and adaptive activities with a public good character. Subsidies have already been applied for adaptation in several countries.
- Taxes and fees, differentiated into carbon, energy and land use taxes. Taxes can be used if myopic behaviour of private actors leads to overly risky investments, as taxing specific behaviour can internalize and at the same time signal its negative externalities. Carbon and energy taxes have already been widely applied, land use taxes only sparingly.
- Licences and permits, covering tradable units, project-based offsets and advance market commitments. A trading system can limit a “bad” or require production of a public good, which is denominated in tradable units. Government specifies which entities have to surrender tradable units and how the units are allocated. While trading and project-based offsets are widespread in mitigation, they have not yet been applied for adaptation. A combination of the two approaches in the form of an “Adaptation Market Mechanism” seems promising. Advance market commitments have not been used to date for adaptation purposes.
- Other measures, including payments for ecosystem services (PES), water markets and habitat banking. All these instruments have in the past not specifically aimed at adaptation, but do provide positive adaptive externalities. PES have been used in the context of forest and biodiversity protection in- and outside the EU, with a mainly local / regional character. Water markets exist in Australia, Chile and the dry Southwest of the US.

Public Private Partnerships

In the context of PPPs that involve the private sector in adaptation activities and thus increase effectiveness and the funding base of adaptation activities, we assess public contracts, service concessions and joint technology initiatives. PPPs have routinely been used for large infrastructures, such as the Thames flood defence barrier in London. Service concessions can include risk sharing elements. Joint technology initiatives might only be relevant for large-scale research initiatives such as development of crops resistant to climate-related stress. Financial instruments as a form of PPP could include public guarantees for loans as well as concessional loans.

Financial instruments

Financial instruments (FIs) are applicable for adaptation actions that generate direct revenues, such as the development of drought-resistant crops and infrastructure whose users pay fees. We have looked at concessional loans and loan guarantees.

Risk Financing Instruments

Risk Financing Instruments (RFIs) are “priced” market-based instruments that are put in place before a disaster and share and pool risks in order to create entitlement to compensation after a disaster. We select three RFIs for our analysis; insurance, catastrophe bonds and weather derivatives. Insurance, including reinsurance, is the predominant instrument. In a separate section, we examine national arrangements throughout Europe, and in detail for selected countries, that provide catastrophe insurance for households, businesses and farms. We also examine selected sovereign insurance arrangements for government assets and relief expenditures, including catastrophe bonds, catastrophe risk pools and the European Union Solidarity Fund. RFIs can also provide incentives for adaptation (risk prevention). This feature is analysed in detail in the report.

2. Approaches for evaluating economic instruments

Applicability, effectiveness, efficiency and distributional aspects are the key criteria used to evaluate the policy instruments described above with respect to their usefulness for adaptation to gradual changes in average climate parameters as well as extreme events (in addition, for RFIs which are covered in a separate section we examine their capacity to provide a reliable safety net). Applicability covers the ability of an instrument to affect adaptive behaviour, institutional feasibility, consistency with other policy instruments, overall acceptability to interest groups, and in general their applicability outside the current usage or country. Effectiveness concerns how strongly the instrument contributes to adaptation. An instrument is efficient if it achieves adaptation benefits at minimum cost, including transaction costs. Distributional aspects relate to the redistributive impacts of an instrument i.e. an instrument should not burden low-income groups while benefiting high income people.

Furthermore, the conditions for proper functioning and barriers to implementation are assessed. Instruments have to take the different characteristics of adaptive activities into account and also should avoid moral hazard that could lead to mal-adaptation.

The subset of instruments assessed includes grants, tax reductions, land use taxes and fees, an Adaptation Market Mechanism, water markets, payments for ecosystem services, concessional loans and loan guarantees. The other instruments are not covered because they are unlikely to fulfil the criteria, they have an insufficient link to adaptation, or they have a predominantly regulatory character.

3. The most promising instruments

The following instruments are likely to incentivise adaptation effectively:

Grants can be applied to a wide variety of adaptive activities and can be made consistent with other policy instruments. They will provide a strong incentive and allow the capture of positive externalities. On the other hand, grants might finance activities that would have been undertaken autonomously anyway. From an incentive point of view, grants can be disproportionately costly. Instead of direct grants, tax reductions would probably provide more favourable incentives to engage in activities that increase the resilience of production sites and real estate in general, as direct grants

tend to be even more prone to the generation of windfall gains and lobbying than tax reductions. Besides, tax reductions are probably more suited to address larger target groups while having less budgetary consequences than a set of programmes defining direct grants for a number of beneficiaries.

Land use taxes could influence land use in areas exposed to extreme events or slow-onset change of parameters which would not allow continuation of current use. Sealed soil increases vulnerability to climate change impacts such as intensification of flooding and heat waves, so by providing incentives for less soil sealing this instrument could positively affect adaptation actions. Taxes can be levied on land values or land area sealed, providing incentives for densification and avoiding further soil sealing. There is no inconsistency with other policy instruments.

The *Adaptation Market Mechanism* (AMM), a concept developed within this project, could harness a wide range of adaptive activities, particularly those involving actual investment, provided their effect is measurable. It should be institutionally feasible provided there is a political will to agree on the definition of one or several tradable units. We propose two adaptation units: “saved wealth” and “saved health”. An adaptation target level needs to be specified by decision-makers and allocated to a set of entities, which have to surrender units generated by adaptive activities. Specific adaptation project developers can then generate adaptation units that are verified by third party auditors and sell them to the entities covered by the AMM. The AMM would be consistent with the legal system of the EU and needs to be coordinated with other policy instruments to avoid double coverage, e.g. of subsidies and the AMM. Its attractiveness to stakeholders strongly depends on the type of entities that have to contribute to the adaptation target. Efficiency of the AMM would be high as it incentivises the development of highly cost-effective adaptation activities and would lead to the development of an “adaptation service industry”, provided an agreement on the tradable unit and methodologies for generating tradable units by projects can be found. However, depending on the detailed design of the AMM, significant transaction costs could accrue. Distribution might be regressive unless the definition of “saved wealth” includes elements that relate to the share of wealth saved by an adaptive activity. A key barrier to the implementation of the AMM is the currently high uncertainty regarding expected climate change and its future impacts – an issue that also applies for all other policy instruments promoting prevention of climate change damages to a large degree.

Payments for ecosystem services, e.g. for the protection of forests and wetlands, can only mobilize adaptive activities indirectly through the remuneration of certain land uses. Its effectiveness is however reduced due to this limited scope of application. Duplication of incentives needs to be avoided and thus a consistency check of policies is required. Interest groups would not oppose this instrument due to its voluntary character; which also means that redistribution will be minor, but that might limit the adaptive benefit. Costs are unclear, but transaction costs seem to be sizeable.

Water markets provide an indirect adaptive benefit as (efficient) water pricing will lead to a reduction of water consumption and thus increase the water resources available in case of drought or water scarcity. Water trading increases the availability of water in areas with water scarcity. Effectiveness of water pricing is high; it is especially applicable in areas where water availability is projected to decrease due to climate change. Institutionally, no major challenges occur. Consistency with other instruments influencing land use such as payments for ecosystem services and land use taxes needs to be ensured. Farming interest groups that have benefited from underpriced water in the past are likely to oppose water markets. Transaction costs will accrue if metering equipment

needs to be introduced. Redistribution depends on the income level of water users compared to the rest of the population.

Concessional loans can be applied to finance private activities that generate revenues but are not yet commercially attractive and public activities that are so far not implemented due to budget constraints. Examples would be investments of a seed production company in the design of drought-resistant crops, the upgrade of a tourist resort by beach nourishment, or the investment of a state public infrastructure agency into a toll road that is more resilient to heavy rainfall than a road built to standard specifications but has a higher construction cost. Therefore, concessional loans require a general willingness to invest in an adaptive activity. In such cases, concessional loans can address all kinds of adaptive activities and thus become quite effective in the limited context described above. Institutionally, public financial entities like the EIB would offer loans at interest rates that are lower than rates offered by private financial institutions. Technically, some training would be required to enable bankers to evaluate failure risks for adaptation projects. Loans could be combined with grants in order to expand their applicability. Efficiency depends on the ability to identify bad risks before loans are granted, and on the ability of project investors to correctly estimate returns. However, those ~~all~~ projects that do not have revenues do not really benefit from this instrument. Transaction costs should not be a major obstacle.

Guarantees can reduce borrowing costs for investors (either governments or private actors) in adaptive activities that can generate revenues as specified above. Thus, they increase the volume of adaptive activities on the margin. They will have similar effects to concessional loans and are effectively a substitute for them. Efficiency can be quite high, especially in the case of a guarantee for a member state with a bad credit rating, where the guarantee leads to a strong reduction in the required interest level.

Risk financing instruments (RFIs) price, share and pool risks for a set fee or premium, thus they are directly applicable for adaptation. RFIs do not reduce the direct losses (destruction through flood), but redistribute them. They do however reduce consequential losses, e.g. from business interruption or bankruptcy and thus facilitate coping with the indirect effects. Further, they can also provide incentives for the prevention of climate change damages. The latter is achieved in two ways: i) Through specific design adjustments and dissemination of information to the customers, RFIs can incentivise and enable risk reduction, and clients, theoretically, would take action to reduce their cost associated with financially managing risk. (ii) RFIs share risks before events occur and so provide a safety net that enables productive risk taking. However, RFIs may also lead to maladaptation if agents rely on the financial security provided and relax preventive efforts.

A sector-specific evaluation of the economic instruments can be found in Table 1 below which summarises the evaluation of their applicability to incentivise adaptation.

Table 1: Sector-specific ability of economic instruments to incentivise adaptation

	Subsidies		Taxes	Licenses, permits	Other MBIs		Financial instruments		RFI
	Grants	Tax reductions	Land use taxes & fees	AMM	PES	Water pricing	Loans	Guarantees	
Production Systems (= Industry)	Medium	High	Low	Medium	Low	Low	Low to medium	n.a. to medium	High
Physical infrastructure (public)	Low	Low	Low	High	Low	n.a.	Low to high	Medium	High
Physical infrastructure (private)	High	High	Low	Medium	Low	Low	Low	Low	High
Health and social policies	Low (social policies) to high (health policies)	Low (social policies) to medium (health policies)	Low	High (health); n.a. (social)	Low	n.a.	Low to medium	Low	Low
Agriculture & forests	Medium	Medium	Medium	Medium	Medium	High	Medium to high	Medium to high	Medium
Biodiversity, ecosystems, water	Medium	Low	High	Low to medium	High	High	Low to high	Low to medium	Low
Coastal and maritime areas	Low	Low	n.a.	Low to medium	Medium	Low	Low to high	Low to medium	Low

Scale: From High for very applicable and relevant to n.a. not applicable/relevant at all

The overall evaluation of policy instruments (excluding RFIs) according to our four criteria is shown in Table 2.

Table 2: Overview of general evaluation results of market based economic instruments

	Subsidies		Taxes	Licenses, permits	Other MBIs		Financial Instruments	
	Grants	Tax reductions	Land use tax/fees	AMM	PES	Water pricing	Loans	Guarantees
General applicability to incentivise adaptation ¹	Medium	Medium	Low	High	Low - Medium	Low - Medium	Medium	Low
Institutional feasibility	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium
Consistency with other instruments	High	High	Medium	Medium	Low to medium	High	High	Medium to high
Acceptability to interest groups	High	High	Medium	Medium ¹	High	Low	High	Medium
Little resource requirements (Low = positive)	High	High	Low	Low - high ²	High	Low	Medium to low	Low
Transaction costs (Low = positive)	High	High	Medium	Medium to high	High	Medium	Low	Low
Distributional aspects (High = positive)	High	High	Medium	Medium to high	High	Medium	High	High
Conditions and barriers (Low = positive)	Medium	Medium	Low	Medium to high	Medium	High	Medium	Medium

¹ This criterion reflects the broad applicability of the instrument as described in the table 1 above. If the EI is applicable in many sectors it receives a „high“ grade, vice versa a „low“ one.

² Depends on demand system

4. Risk financing instruments and adaptation

Risk financing instruments include all financial instruments that promote the sharing and transfer of risks and losses. They generally can be classified as pre-disaster arrangements, and comprise insurance, catastrophe bonds, weather derivatives and risk pools. Risk financing instruments help to finance losses caused by events induced by climate and geophysical variability. Climate change is projected to change the intensities and frequencies of hazards and potential losses (risks). Indeed it is already doing so in the case of temperature almost everywhere, and precipitation in some places, although today key drivers of risk are exposure and vulnerability. With climate change ongoing and projected to increase the intensity and frequency of extremes, insurance, if properly adjusted for dynamic changes, is a useful tool for adaptation. RFIs are distinct from loss financing as the former are purchased and organized by the persons or community at risk before the disaster, whereas the latter is provided after the disaster and usually on an ad hoc basis by, for example, the persons at risk (self insurance), donors and/or the state. Insurance is the best known and most widely used instrument for risk sharing and transfer. Risk averse agents make contractual arrangements by, for example, purchasing property or agricultural insurance, in order to have a rightful claim to post-disaster capital. Insurance against natural disasters is typically offered as a voluntary extension of property and household contents insurance, or in stand alone mode for agricultural and sovereign insurance. The most common and traditional types of insurance is indemnity-based, where claims are paid out for losses experienced by the risk cedent. A recent and innovative alternative is index based schemes, where the event occurrence and not the loss is insured. Catastrophe bonds are instruments whereby disaster risks are packaged (securitized) in the financial markets. Weather derivatives are two-party contracts where payouts are linked to physical triggers of a non-catastrophic nature, e.g. number of days with temperatures below or above a specified threshold, or rainfall above or below a pre-specified level. They are contracts, where given a pre-specified trigger, one party provides a payout to the other. Risk financing instruments can also serve as important re-distributive instruments if the premiums for insurance or the interest for capital market securities are cross subsidized by persons within the victim community or subsidized by persons outside. In fact, cross-subsidization and flat premiums are often the case (such as in France and in Spain), and risk financing instruments hold a substantial potential to provide for EU burden sharing arrangements in a warming climate that may lead to increased disaster burdens in some regions, such as for flood hazards in Eastern Europe, and drought and heatwaves in Southern Europe.

Assessing flood, drought and windstorm risks

The report assessed the assets in the EU exposed to flood, drought and windstorm hazards (for which data were available) and the associated level of risk, as well as the coverage of these risks in terms of insurance. Figure 1 and Figure 2 show those risk estimates for the annualized losses for flood and drought risk in 25³ EU countries, and Figure 3 gives the 200 year event for windstorm risk in key exposed countries.

³ Estimates were not available for Cyprus and Malta.

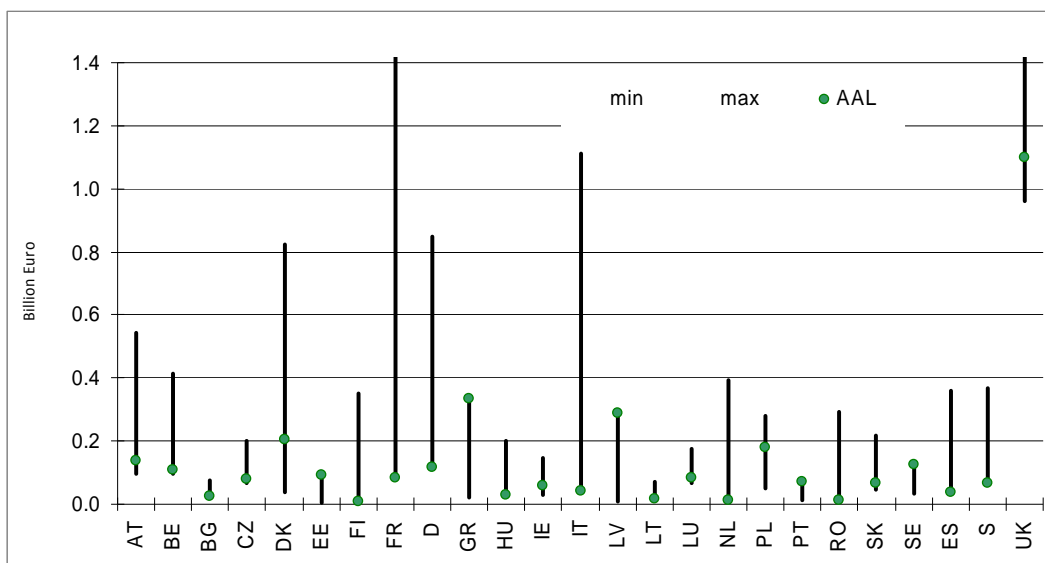


Figure 1: Annual average flood losses including confidence bounds

Note: confidence bounds comprise minimum and maximum estimates according to our study.

Source: Based on Hochrainer and Mechler, 2009 and Luger et al. 2010

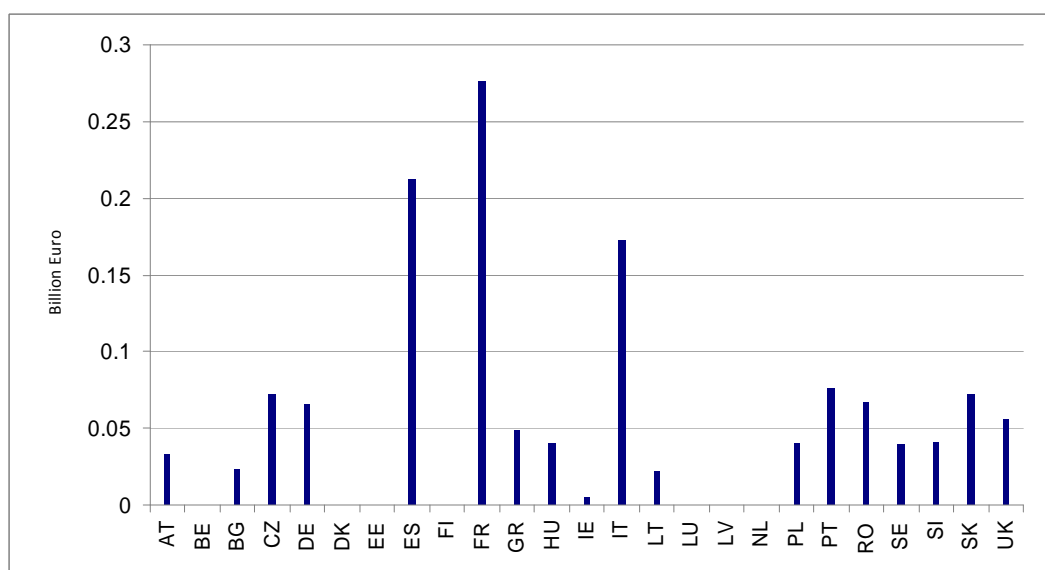


Figure 2: Annual average drought losses in agriculture

Note: Crop losses comprise losses to spring wheat, sunflower and soybean, and estimates do not account for uncertainties. Only one central estimate was available for drought losses

Source: Based on Luger et al. 2009, and Mechler, 2009.

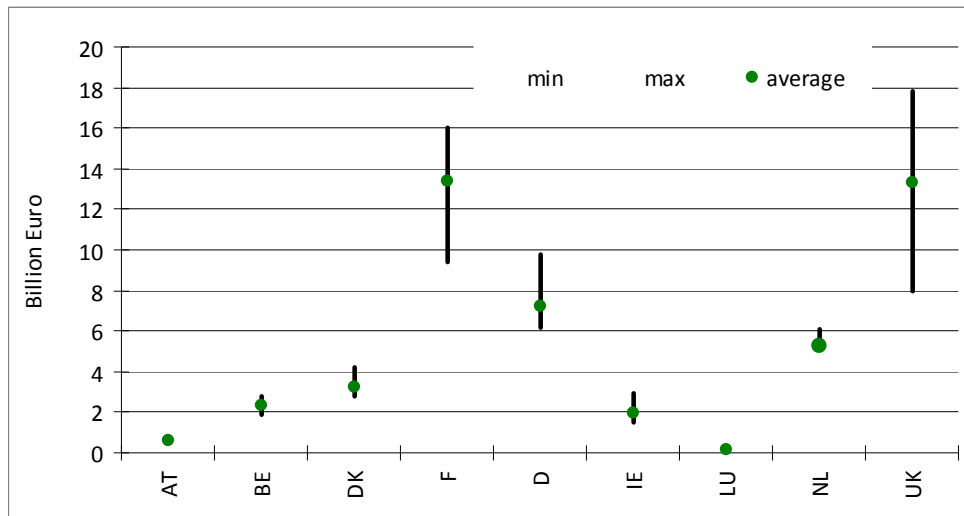


Figure 3: 200 year event windstorm losses including confidence bounds

Note: Estimates were available only for the 200 year event in key exposed countries. Confidence bounds indicate the variation of estimates across different studies

Source: Based on PERILS (2011); Guy Carpenter (2011), CEA (2010) and Word Bank (2010).

In terms of loss potential, windstorm risk is highest with losses potentially up to tens of billions of Euros. Key 'hotspots' in terms of absolute losses are France, Germany and the United Kingdom. Flood risk is similarly high, and here the key exposures are France, Germany Italy, United Kingdom and Denmark. Estimates for crop losses due to droughts are a magnitude lower, and according to the estimates here Southern European countries are most at risk. (However, it should be noted that many other sectors are exposed to drought risk, but it is not currently possible to estimate those risks properly).

Climate change is projected to alter the frequencies and intensities of hazards, yet there are very large uncertainties associated with projecting risks into the future, particularly for flooding. Figure 4 sets out projected flood risks for today, the 2020s, 2050s, and 2080s.

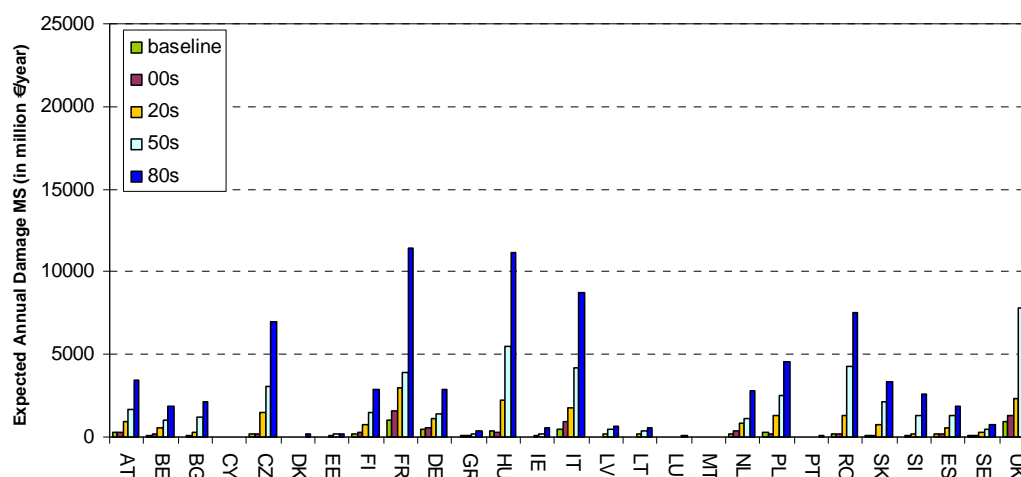


Figure 4: Estimates of today's and future annualized flood risks

According to these estimates, the strongest increases would occur for the UK, Ireland, Italy, Slovenia, Belgium and the Netherlands, mainly due to a strong increase in the frequency of currently rare floods (e.g. today's 100-year floods may occur every 10 or 20 years by the end of this century). Yet, estimates of future extreme event risk in Europe, and almost everywhere else, are currently subject to great uncertainty and thus cannot be considered a reliable basis for taking key decisions.

5. Incentivising adaptation with RFI

This report focuses primarily on insurance for property, agricultural and sovereign losses. As discussed below, insurance can both incentivise and enable risk reduction (adaptation).

Incentivising risk reduction

- By pricing risk, well-designed insurance contracts can provide incentives for risk reduction. In particular, risk pricing has served to discourage construction in high-risk areas;
- Insurers and other providers can require risk reduction as a contractual condition, for example, requiring fire safety measures as a condition for insuring a home or business. In some cases, insurers have reduced premiums on catastrophe insurance to reward investments in risk reduction, but this practice is exceptional.
- Insurance can also provide disincentives for people to prevent losses, what is referred to as *moral hazard*, if those insured become less diligent in reducing losses due to their 'safety net'.
- Because insurance instruments (and other RFIs) require detailed analysis of risks, they can both raise awareness and provide valuable information necessary for responding to and reducing risk. In some countries, insurers with other partners have made flood and other hazard maps publicly available;
- Providers can liaise with governments and communities to promote land use planning, emergency response and other types of risk-reducing behaviour. In many countries, for example, insurers have co-financed research institutes and disaster management centres, and in other cases, have partnered with government to achieve changes in the planning system and more investment in public protection measures.

Enabling financial risk reduction

- By enabling recovery, insurance (and other RFIs) reduce long-term indirect losses – even human losses – which do not show up in the disaster statistics. RFIs thus directly lead to the reduction of post-event losses from extreme weather events, what is commonly viewed as financial adaptation.
- Insurance (and other RFIs) allow households and businesses to plan with more certainty, and by providing a safety net they facilitate cost-effective, yet risky, investments.

Our review in terms of the criteria specific above leads us to the following conclusions. All the RFIs examined are considered generally highly applicable for adaptation as they all price risk, thus deal explicitly with potential impacts. Saying that, the incentive effect, while theoretically large, in practice is often rather weak for many reasons. Also, where RFIs are used to finance and transfer public sector and business sector risk, the incentive effect is low to medium, as the climatic risk is often given less attention than, say, fire and explosion. The efficiency of the RFIs depends very much on the actual implementation, but generally can be considered medium to high, as risks are priced and traded (transferred). Equity in terms of the distributional outcomes of the RFIs is a contentious subject, but we argue that equity is low to medium for the RFIs as they price risk and assign ~~put~~ the burdens to those potentially affected. This equity-efficiency trade-off is the key defining aspect for the evaluation of instruments as they are adopted in EU member states, and we find that there is no single best solution for any of the instruments.

Table 3: Assessment of the RFI categories

Instrument	Property and goods insurance	Agricultural insurance	Sovereign insurance	Sovereign risk pools	Weather derivatives	Catastrophe bonds
Applicability for risk sharing	High	High	High	High	High	High
Effectiveness for incentivising physical adaptation	Medium-High	Medium-High	Medium	Medium	Low	Low
Effectiveness for sharing risk	Medium-High	Medium-High	Medium	Medium	Low-medium	Low-medium
Efficiency	Medium – High	Medium-High	Medium-High	Medium-High	Medium-High	Medium-High
Distributional aspects	Low-medium	Low-medium	n.a.	n.a.	n.a.	n.a.

Barriers encountered in incentivising adaptation through insurance

Our review of the adaptation incentive function of insurance-related instruments leads to the conclusion that currently in practice the incentive effect is rather small. While price incentives have had some success in discouraging development in high-risk areas, insurers have shown little willingness to differentiate premiums for other adaptive measures arguing that monitoring and other transaction costs would be prohibitive. Moral hazard – i.e. the disincentive to embark on preventive adaptation provided by the knowledge that losses are covered by the insurance - exists at both the individual and collective levels, and any system of premiums that is not actuarially fair must necessarily have some adverse incentive effects. On the other hand, insurers in some instances require specific standards of risk-resilience as a pre-requisite to providing cover, but often clients are resistant to incurring additional expenditure. They also in some cases provide risk-related information to their clients, but in practice this is often ineffective, since insurance customers do not always make good use of it. Also, risk ambiguity plays a role and insurance premium calculation is plagued with uncertainties, particularly for climatic risks. This means that the price charged is often much higher than the long-run price, to build in a safety margin.

Options to improve the adaptive effectiveness of RFI

In terms of recommendations to further incentivise adaptation we suggest the following:

Provide information on risks and risk prevention measures

To overcome risk myopia, insurers in partnerships with the public sector and the communities at risk should consider involving clients in active risk management through supporting community action groups. Insurance intermediaries might become more actively involved in the communication and explanation of risk-relevant advice, and lenders could insist that assets purchased on credit are covered against natural hazards. There is evidence that shows that such partnerships or collaborative relationships between insurance operators, government authorities, civil society and risk management institutions are crucial for encouraging adaptation in the public and private sectors, and further support may be extended for such arrangements from the EC and MS.

Improve the incentive effect

As insurers do not reward risk reducing behaviour because of their simplified rating procedures, and the fact that often the client cannot modify the risk greatly without significant capital expenditure, solutions may include

- Insurers could develop all-in financial packages that could feature finance for risk reduction with concessionary loan terms for the necessary capital expenditure and reduced premiums/less restrictive conditions (e.g. lower deductibles, higher compensation limits) after standardized risk reduction measures have been implemented.
- Insurers could maximise the use of IT in order to be more flexible in their pricing structure, including where intermediaries are agents for them e.g. by micro-modelling flood risk to individual property level, rather than at a generalised postal zone level.

Encourage risk-based pricing

As discussed, risk-based premiums are particularly well suited for addressing losses from floods and other hazards where a key determinant of loss is exposure, by discouraging development. Price is generally combined with a range of terms and conditions, which can be effectively targeted to improve incentives for adaptation. Financial regulators and rating agencies should be more prescriptive in ensuring that insurers are setting adequate prices for climate-related risks. Solvency II will likely reinforce this due to requirements to calculate the value at risk (Solvency Capital Requirement) at the 99.5% level, i.e. the 200 year event loss.

Monitor and adjust risk pricing and contract conditions

An important element in the risk pricing would be a more responsive pricing mechanism. If a client undertakes risk prevention measures, then the premium and terms could be adjusted according to the changes in risk levels. Premium adjustments would provide incentives for risk prevention in cases where premiums are high enough. The difference in adjusted premiums should also be significant enough to lead to preventive behaviour, which can be a problem if the insurance premium is a rather small part of income. It thus is also important to consider adjustments in contract conditions, such as reducing the deductible or raising the maximum claim, just as done as, for example, in car insurance, in order to provide stronger incentives.

Risk reduction requirements

In addition to insurers requiring risk reduction as a contractual condition, as discussed above, insurers could help clients to acquire finance for installing risk-reducing equipment and damage-resilient materials, and be more proactive in exploring the potential of such measures. Also after events, restoration from payouts could be required to be in compliance with climate resilient standards. The main difficulty with these ideas, is that they mean that the client has to pay more, since either the client has to fund the cost of upgrading before an event occurs, or the insurer has to increase the premium to pay for the upgrade after the event occurs. In a competitive market, and hard economic times, these propositions are not attractive. If the risk reduction requirements were mandated in building standards, then insurers could be instrumental in applying the regulations, by tying their contracts to compliance with the regulatory standards. Insurers can also contribute to setting new climate resilient standards as they are well informed about the risks.

Work with altered timescales

Currently the standard contract length is one year. Insurance contracts could operate over longer time scales, including profit/loss calculation, which would reduce the uncertainty loading, and also ensure a more even flow of profit (and tax), and perhaps less reliance on the sometimes unstable reinsurance market. Longer contracts would also encourage insurers to participate in risk reduction measures with their clients, and set more flexible premiums.

Provide transparent data on climate-related risks

To date, data on hazard, exposure, vulnerability and losses are typically the property of insurers and consulting firms, which have invested large sums in collecting the relevant information. Although in some cases there are public risk maps, the underlying data is classified. This is a major problem for analyzing cost-effective risk reduction. The EU member states could consider further collecting and

disseminating such data for widespread use as a common good. As our analysis shows, the uncertainties around risk estimates are large. For example, Figure 1 shows the annual average losses (AAL) for flood risk in Europe including the uncertainty in terms of minimum and maximum estimates.

Regarding the role of EIOPA and the requirements of the Solvency II directive demanding a more risk based accounting from the (re) insurance industry, we do not see a need for revising the recommended methodology at this stage (e.g., by suggesting a climate mark up to current risks), as risk estimates and drivers, particularly the contribution of future climate change, are very uncertain, and insurance anyway operates with short, mostly 1 year time scales. In fact the focus of the quantitative tests under Solvency II on the 200 year event as “extreme loss” is well in line with the disaster risk calculus, which often takes this event as the probable maximum loss. Instead, we suggest, as is done by insurers, reinsurers and risk modellers that risks are continually monitored and any major changes accounted for in solvency and premium calculations, overall suggesting an adaptive management approach. Here EIOPA could play an important role, and it has stimulated catastrophe risk assessment exercises already, such as in the 5th Quantitative Impact Study (QIS5).

6. Making markets and partnerships for risk financing work

In order to have insurance effectively provide incentives for adaptation and help with sharing an increasing loss burden, natural catastrophe insurance markets need to function properly. Yet, in the EU around 70% of disaster losses are not covered. Based on our risk estimates for flood, drought and windstorm, as well as an assessment of insurance cover, insurance penetration is highest for windstorm with only about 1/3 of the risk uninsured according to our calculations (total risk: €60.4 billion Euro, uninsured risk €22.4 billion Euro), as windstorm cover is often included already in household insurance. Yet, as the risk is substantial (we had to rely on the 200 year event), there is a sizeable uninsured risk, which remains, also owing to the fact that public assets are generally not insured. For flood and drought risks, which are generally insured on a voluntary basis, about 2/3 of the private and public asset risk is uninsured (flood risk: total risk: €3.4 billion, uninsured risk €2.3 billion; drought risk: €1.4 billion, uninsured risk €0.9 billion).

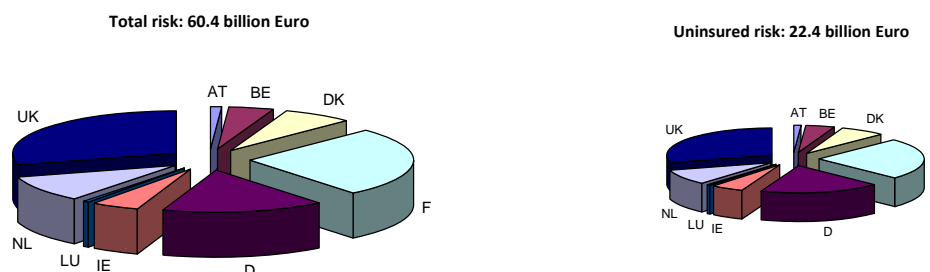


Figure 5: Distribution of windstorm risk for the 200 year event including the uninsured risk over Europe in absolute terms
Note: Estimates were only available for key hotspots countries. The uninsured risk comprises private and public assets, and the latter are generally uninsured

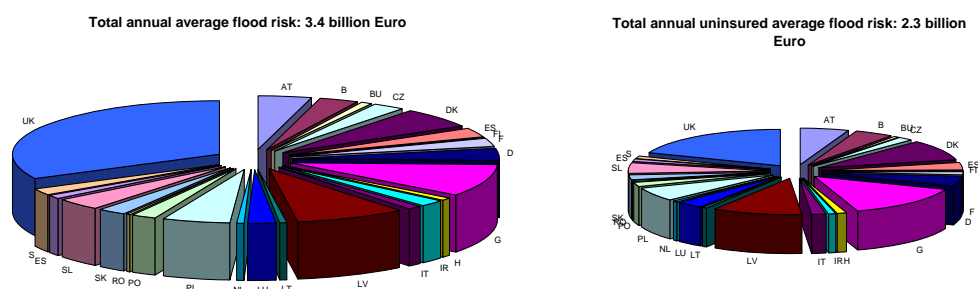


Figure 6: Distribution of flood risk including the uninsured risk over Europe in absolute terms
Note: the uninsured risk comprises private and public assets, and the latter are generally uninsured

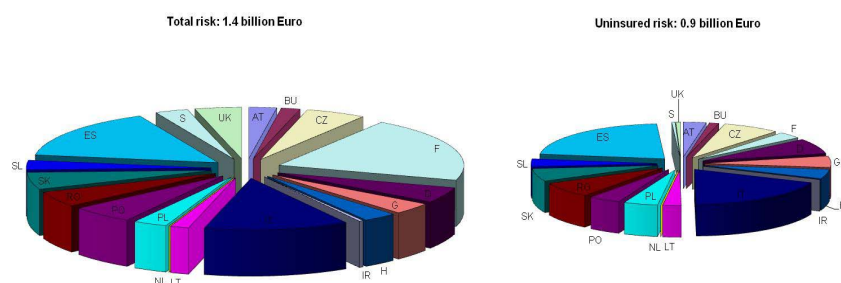


Figure 7: Distribution of drought risk including the uninsured risk over Europe in absolute terms
Note: the uninsured risk comprises private and public assets, and the latter are generally uninsured

The public sector often intervenes to promote viability or establish (re-)insurance arrangements so that some sort of cover is provided for households, insurers or reinsurers.

The intensity and frequency of extreme weather events is projected to increase. This would lead to increased risk to be covered by the insurance industry, which would normally mean increases in premiums (or setting more stringent conditions in terms of higher deductibles or lower limits). For high risk areas, this might even mean that insurance becomes less affordable and finally unaffordable. Also climate change might add new risks that are not insurable.

Barriers to increased availability of RfIs

Commercial insurers are reluctant to provide cover for high consequence climate events, particularly if little historical data exist, because of the covariate nature of the risk (i.e. multiple, simultaneous claims). Other common causes of (re-)insurance market failure are adverse selection, moral hazard, biased risk perception and non-affordability of premiums (administration including marketing costs can be 30% or more of the premium, or the risk may be so severe that it is a virtual certainty i.e. uninsurable).

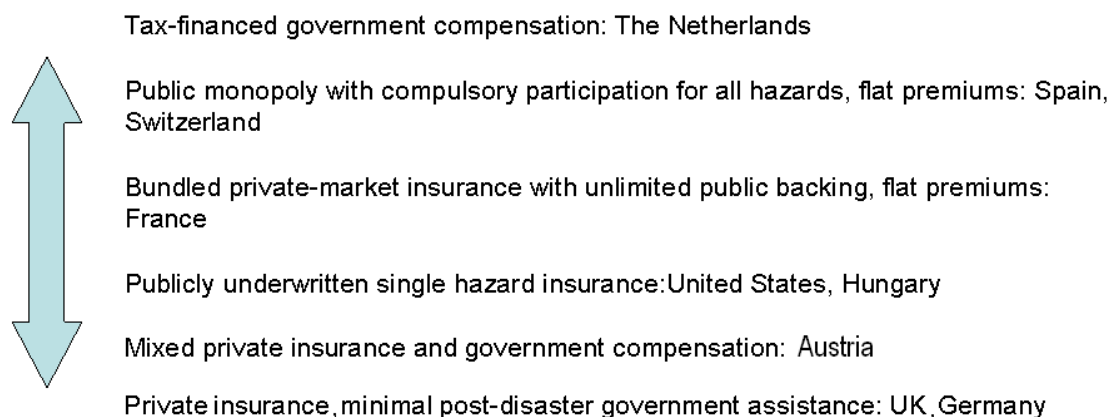
Assessment of current RFI systems

Since risk reduction (adaptation) is not the sole criterion for assessing risk-sharing systems, we examine the applicability of insurance instruments in different social and cultural contexts, their efficiency in sharing risks and their distributional impact in providing post-disaster support to vulnerable households, businesses and governments. In terms of specific insurance types we arrive at the following conclusions.

Property insurance

Europe displays a wide variety of RFIs that provide protection for property and assets against natural hazards. There are many ways to organize national insurance systems, and although some systems, such as in Spain or France, have a very strong public sector involvement, these systems can not be said to be in non-compliance with rules and regulations of the EC, yet in a further developing internal EU market, there is scope for further examining the different systems and their pros and cons, which falls within the remit of DG Markt. We have assessed the most prevalent flood insurance arrangements in nine countries: the Netherlands, Austria, Spain, Switzerland, France, Germany, Hungary the UK and (outside Europe) the US, representing the main characteristics of insurance systems across the EU, according to “who pays” or along the public vs. private liability continuum.

Public liability



Private liability

Figure 5: Country models for flood insurance as they reflect private and public liability

At one end of the continuum are models where the state absorbs a large part of the financial burden or liability. For example, in the Netherlands the government typically compensates victims following major flood and other types of “uninsurable” disasters. At the other end of the spectrum is the UK, which has extensive private insurance penetration, and the government typically does not provide post-disaster financial support to private persons. In between is a range of public-private partnership arrangements that differentially allocate the disaster burden. In Spain, as an example of a public insurance monopoly, the government acts as insurer with compulsory participation, and taxpayers can be called upon in the case of very high losses. In France, the government does not act as primary insurer, but taxpayers provide a backup for the compulsory all-hazard policies offered by the private market.

The discussion highlights the variety and complexity of national insurance arrangements addressing the risks of weather-related hazards and the ways in which they encourage or require risk-reducing measures. The lessons that can be drawn from the analysis include:

- No system ranks consistently high on all criteria – there is no “best” national insurance arrangement; yet, public systems, like in Spain and Switzerland, rank high on a number of criteria, including their propensity to advance adaptation, efficiency, provide reliable capacity (only Switzerland) and improve distributional outcomes;
- All systems appear to have sufficient capacity for providing needed post-disaster capital and financing the needs of the most vulnerable. This capacity is in the form of public (taxpayer) backup or reinsurance; however, it can be ad hoc (for example, the Netherlands, Germany) or insecure (e.g., Spain given its budgetary financial crisis, and UK- reliance on external reinsurers);
- Insurers do not generally enjoy a strong record of effectively incentivizing , requiring or enabling private-sector risk reduction and climate adaptation measures;
- Public responsibility and liability, and particularly public insurance systems, appear to be relatively more effective in supporting collective (public good) loss reducing measures; the Swiss, US and Hungarian systems stand out particularly as they work closely with public authorities in advancing land-use planning and other crucial regulations, and as they (US and Hungary) move towards differentiated (by location) risk-based pricing;
- As discussed above, differentiated risk-based pricing (by location) of insurance can be an effective adaptation measure especially for discouraging construction in high-risk areas, and premium discounts can incentivise other types of adaptive behaviour; however, it is not a magic bullet. Experience shows that insurers are reluctant, and in some cases unable, to monitor risk-reducing behaviour and investment, and adjust premiums accordingly. Moreover, even informed individuals do not mitigate risks “optimally” even if insurance incentives exist. Information alone does not appear to improve behaviour.
- As systems move towards differentiated risk-based pricing (as in the UK, US and Hungary), they confront the efficiency-equity trade-off (higher incentives for risk reduction vs. affordability of insurance for the most vulnerable). France has confronted this trade-off by intentionally rejecting differentiated risk-based pricing, yet investing heavily and pursuing top-down regulation for mitigating risk, and increasing deductibles with each successive loss claim. Systems adopting risk-based solutions might address the distributional issues with subsidies and tax reductions for those confronted with high prevention costs and corresponding high insurance premiums, or ‘pools’ for legacy risks i.e. areas which have become risky due to climate change.

Agricultural insurance

European farmers have many ways of managing, pooling and sharing risks in addition to so-called “on farm risk management” strategies, such as diversification of the crops and livestock portfolio, vertical integration (in terms of producing, packaging and marketing), and stabilisation as a form of insurance. Coping options include production and marketing contracts, commodity price hedges, mutual funds, government disaster funds and finally insurance and weather derivatives as RFIs. We have examined insurance systems in six countries: Greece, Spain, the Netherlands, the UK, France and the US. Our findings suggest that

- Agriculture insurance systems vary across the EU, for example, in terms of how they are bundled (e.g., single-risk insurance, combined insurance, yield insurance) and whether they are operated by the private and public sector. .
- In terms of effectiveness for incentivizing adaptation, with the exception of the UK, none of the European systems examined differentially equates premium to the risk (except to the extent that premiums differ across crops), although most programmes incorporate deductibles. Nor are there accompanying programmes to help farmers minimize their weather-related losses through diversification and other strategies. In sum, the systems lack strong incentives or necessary conditionality for promoting adaptation to climate change.
- Concerning their capacity to provide a secure and reliable safety net, Greece and Spain would appear to rank high with their mandatory cover and well established public-private system, respectively; however, the fiscal insecurity of these countries may be a problem for the government providing a reliable backup. In the Netherlands, there is generous compensation as in France, although limited subsidies in the latter. In the US, coverage is high, thus providing a comprehensive safety net, due to generous premium subsidies.
- There is a great deal of controversy surrounding efficiency and subsidized agricultural insurance. Subsidized programmes in North America and Europe are viewed by many economists as failed policy. Some voices suggest that distorting market prices has led to vast inefficiencies and high costs to the government, as well as international trade imbalances.
- Finally systems with large subsidies and compensation might be considered more equitable if they provide affordable protection to the most vulnerable (this is not the case, however in the US, where subsidies tend to support wealthier farmers).

7. Sovereign risk financing

Governments typically have responsibility for a large portfolio of at-risk public infrastructure, and, most governments are obligated to provide post-disaster emergency relief and assistance to affected households and businesses. The inability to restore public infrastructure or provide relief to the most vulnerable can have serious repercussions on households, businesses and the economy.

As an alternative to loss financing, some countries are exploring sovereign insurance and in fact, some governments carry insurance, including states in the U.S., Canada and Australia. Another option pursued by the Mexican government is a catastrophe bond as a way of hedging its infrastructure and post-disaster relief risks. Regional intergovernmental risk pooling has found its application, e.g. in the Caribbean, and is also being considered in Europe.

An important instrument in Europe for providing additional capacity to governments following major disasters is the European Union Solidarity Fund (EUSF). The stated purpose of the EUSF is “to show practical solidarity with Member States and candidate countries by granting exceptional financial aid if these were the victims of disasters of such unusual proportions [...] that their own capacity to face up to them reaches to their limits” (Commission Report, 2004, p. 25). The Fund can be called upon to cover non-insurable damages, such as public expenses for restoring public infrastructure, providing services for relief and clean up, and protecting cultural heritage.

In setting up the EUSF, the European Commission recognized the dangers of moral hazard if governments take on less preventive measures because they can rely on post-disaster support from the EU. In fact, the EUSF was not intended to increase adaptation, but rather to serve as a solidarity

instrument, but a recent analysis shows that in practice it has awarded proportionally more grants to countries that can better cope with disasters. Another *raison d'être* of the EUSF is to provide capacity across Europe to assure a reliable safety net; yet there is an appreciable risk of depleting the EUSF capital. The EU Commission also seems to have recognized the risk that the Solidarity Fund crowds out private insurance, which would explain the inclusion of the important provision that EUSF assistance should only cover non-insurable damages. Most risks covered by the EUSF, however, are insurable.

While these shortcomings are not intrinsic to the EUSF concept, they do raise the questions whether it could be reformed to better promote adaptation and fulfil other criteria examined in this report.

8. Policy options

Overall, we would further suggest the Commission considers the following regarding the use of economic instruments for adaptation:

General suggestions

Market-based instruments should be tested to understand which ones are most appropriate to incentivise private sector adaptation action and whether they are institutionally feasible with low transaction costs. The general idea to use MBIs is to internalize either negative externalities by taxation or positive externalities by different forms of subsidies. Depending on the economic sector, different instruments are optimal and accordingly the suggestions below will list the most appropriate instruments relating them to the different sectors if applicable. Some instruments such as payment for ecosystem services may already be used to some extent, and we recommend upscaling or introduction in new fields.

Suggestions for MBIs

From an incentive point of view, *grants* are most suitable for the improvement of infrastructure resilience and health sector adaptation: the absence of revenues from adaptive activities means that private incentives are insufficient to mobilize adaptation autonomously. To ensure an efficient use of public funds, grants should be provided through a competitive tender system prioritizing those activities that have high adaptive benefits. Grants for adaptation could be co-financed by revenues from auctioning EU greenhouse gas emissions allowances.

Land use taxes beyond those levied today may be introduced in areas highly threatened by climate change impacts. Through such taxes, only activities with high value added would be retained in the area, which reduces the overall damage potential; other activities would move out. If the tax rate is set appropriately, an optimal amount of land use considering climate change impacts is achieved. If some activities remain in the said area, this reflects the result of individual optimization. Then a possible clustering of assets of higher value is harmless from a welfare point of view. Tax rates might increase over time in line with the increase in expected damage as driven by changes in exposure and hazards. The tax increase would need to be communicated well in advance to allow stakeholders to shift to less impacted areas or increase their value added. Being politically very challenging, the EU Commission may invite member states to engage in land tax pilots in particularly vulnerable areas.

Payments for ecosystem services (PES) are an interesting policy field and an emerging niche for adaptation policy. Ecosystem services offer co-benefits also in the context of adaptation to climate

change. Nevertheless, PES schemes are to date not set up in order to promote adaptive behaviour. Besides, some conflicts can arise between protecting ecosystem services and facilitating adaptation via other instruments or addressing different issues respectively. For example, potential conflicts could arise between flood protection (provision of retention areas) and the conservation of ecosystem services. With this in mind, forests and wetlands are key for the resilience of an area exposed to climate-related events, and PES could be introduced or expanded to maintain and protect the forest / wetland from conversion. This necessitates studies to further assess the resilience contribution by forest / wetland areas. As the success of PES depends very much on the national and regional circumstances, no tailor-made suggestion can be given. Instead, the EU as well as national and regional governments should verify whether existing schemes were successful or future schemes appear worthwhile. This also holds true for existing or planned private schemes.

Water pricing and water markets could be introduced in areas that are likely to suffer from increased water scarcity and for sectors that hitherto had no or only a weak incentive of actually reducing water consumption. Given that such sectors – e.g. agriculture and industry are likely to oppose an increase of water costs, the revenues from water pricing could be redistributed to the sector while keeping the incentive for reduced water consumption intact. There is already much discussion in this area and a water pricing initiative could be embarked upon by the Commission and selected member states.

The *Adaptation Market Mechanism (AMM)* could be tested in two pilot schemes. In the first pilot scheme, the EU Commission could publicly tender the acquisition of a certain volume of adaptation units denominated in “saved wealth”. Any company could submit projects whose adaptive effect would be evaluated according to methodologies specified in the tender. Project documents would have to be audited by third parties accredited by the Commission. The projects would be ranked according to the price per adaptation unit until the total volume of adaptation units is reached. The second pilot scheme would acquire “saved health” units. Given the literature estimates about project cost per adaptation unit, to get a critical mass of experience – i.e. several dozen adaptation projects, both pilots could have an underlying budget of at least 50 million € and run for five years, with a final evaluation after a decade. While a substantial share of payments should be made ex ante to enable project implementation, a significant share should be paid out over time after monitoring and verification of project performance.

Suggestions for financial instruments To allow the financing of e.g. ten to twenty large-scale adaptation projects in the public infrastructure and private agriculture sector, a window of about 100 million € *concessional loans* with an interest rate of 2-3% below commercial rates (i.e. 200 – 300 basis points) could be offered by public financial institutions through a budget grant from the EU. A clear set of criteria focusing on effectiveness of projects would have to be applied. This could be coupled with an offer of *loan guarantees*, administered by an institution like e.g. the EIB for loan volumes of up to 100 million €, applying the same criteria for projects. The loan guarantee would require a budget line to cover potential loan failures in the future. Both activities could be open for a period of five years and then be evaluated jointly.

Suggestions for RFIs

RFIs are right at the heart of adaptation as they explicitly deal with extreme event risk which is projected to increase due to climatic and exposure changes. There is a wealth of evidence and novel ideas are being developed. RFIs, particularly insurance have been an important cornerstone of

disaster risk management strategies in Europe and elsewhere. Yet, as our analysis shows, insurance currently often does not provide sufficient incentives for preventive action. Moreover, moral hazard is substantial as often governments cover losses from climate-related extreme events for uninsured people. We thus provide the following suggestions:

General suggestions for overcoming barriers for adaptation

We identify four channels, through which RFI may incentivise adaptation: (i) risk based pricing, (ii) risk reduction requirements; (iii) providing risk-relevant information and (iv) subrogation. Our review of the adaptation incentive function of insurance-related instruments identifies many barriers, such as risk ambiguity, lack of competition, short term contracts, inadequate government policy, uncertain benefits, non-competitive contract terms and high up front capital costs of risk reduction measures. This leads us to the conclusion that currently in practice the incentive effect is rather small. While price incentives have had some success for discouraging development in high-risk areas, insurers have shown little willingness to differentiate premiums for other adaptive measures arguing that monitoring and other transaction costs would be prohibitive. Moral hazard – i.e. the disincentive to embark on preventive adaptation due to the knowledge that losses are covered by insurance - exists at both the individual and collective levels, and any system of premiums that is not actuarially fair must necessarily have some adverse incentive effects. On the other hand, insurers do generally require specific standards of risk-resilience as a pre-requisite to providing cover, but often clients are resistant to incurring additional expenditure. They also provide risk-related information to their clients, but in practice this is often ineffective, since insurance customers do not always make good use of it. In terms of policy options to further incentivise adaptation we suggest the following key measures are considered, which often work with more than one of the channels and tackle several barriers at the same time.

In terms of recommendations we suggest *governments* including regulatory authorities should consider tackling these barriers as follows:

- Further support for multi-stakeholder partnerships. The evidence shows that partnership or collaborative relationships between insurance operators, government authorities, civil society and risk management institutions are crucial for encouraging adaptation in the public and private sectors.
- Encouraging moving to more risk-based premiums in insurance services. Price is generally combined with a range of terms and conditions, which can be effectively targeted to improve incentives for adaptation. Financial regulators and rating agencies should be more prescriptive in ensuring that insurers are setting adequate prices for climatic risks. The *European Insurance and Occupational Pensions Authority* (EIOPA), which is charged with helping to support the stability of the financial system as well as furthering transparent markets and products across member states and sectors could play an important role here, in terms of assessing risks, as well as suggesting improved insurance products that work with altered risks. Solvency II requirements including the quantitative solvency test run by EIOPA are likely to reinforce that insurers are setting transparent and adequate prices for climate related risks.
- Addressing distributional outcomes, e.g. by providing tax cuts on insurance contracts for those facing high damage prevention costs and at the same time grants to communities where risk management plans are enforced

- Making risk prevention measures a prerequisite for insurance coverage for property and crop insurance: In the sectors private property, production systems, and coastal and maritime areas, governments could require that certain building or infrastructure standards are observed when insuring the property. For agriculture, they might consider suggesting the uptake of drought resistant crops. Similarly, after events affecting built structures, restoration financed by insurance should be in compliance with climate resilient standards. Insurers should be brought into planning resilience measures with building regulators and infrastructure developers.
- Encouraging the development of long-term insurance contracts coupled with low-interest loans for risk reduction. This might include subsidies to low-income households (perhaps similar to food stamps) for purchasing longer term insurance.
- Sponsoring research on consistent and comparable risk estimation including the collection and publication of data regarding extreme events and climate change risks. The EU Clearinghouse may be an appropriate repository for such information.
- Encouraging 'best practice' vs. 'race to the bottom': Insurance regulators ought to be more proactive in encouraging the use of 'best practice' contracts, and allow these to be marketed with a dispensation from 'cartel' regulations.
- Regulators could also mandate that repairs must meet climate-resilient standards, or that high-risk sites must be vacated.
- The increased use of subrogation - the process of insurers acquiring the rights of those whom they compensate-, can be a useful, albeit complex tool for insurers to enforce risk management discipline. In order to decrease complexity, regulators could simplify the procedures concerning how to prove breach of duty/negligence, and introduce penalties for tardy conduct in the legal process.
- As a very broad consideration, governments and regulators may also consider the introduction of mandatory natural hazard cover to standard property insurance products such as is done in France and Spain.

Insurers should consider:

- Developing all-in financial packages that could feature benefits and finance for risk reduction with concessionary loan terms negotiated with lenders for the necessary capital expenditure by the insured party and reduced premiums/less restrictive conditions (e.g. lower deductibles, higher compensation limits).
- An important element in such packages would be a more responsive pricing mechanism. If a client undertakes risk prevention measures, then the premium and terms could be adjusted according to the changes in risk levels. The difference in adjusted premiums should be significant enough to lead to preventive behaviour, which can be a problem if the insurance premium is a rather small part of expenditure.
- Work with longer term insurance contracts, which would reduce the uncertainty loading, and also ensure a more even flow of profit (and tax), and perhaps less reliance on the sometimes unstable reinsurance market. Longer contracts would also encourage insurers to participate in risk reduction measures with their clients, and set more flexible premiums.
- Maximising the use of IT in order to be more flexible in their pricing structure, including where intermediaries are agents for them e.g. by micro-modelling flood risk to individual property level, rather than at a generalised postal zone level.

- Better demonstrating the benefits of RFI: The main benefit of RFI including insurance consists of avoiding the consequential detrimental effects of disasters. Also, insurance helps to transfer systemic risk and thus allows a shift to more risky, yet productive activities. Not enough is known and reported on these key functions of RFI. There is little documentation of these benefits in the scientific and applied literature. Brochures and publications oriented towards lay people and the public could broadly outline the benefits (maybe using cases studies) of being able to quickly recover from disaster events.
- In order to reduce the cost of providing such services, insurers can also collaborate with each other, or with other parties like the emergency services, to produce generic advice packages that spread the cost. There are many examples of this by national insurance industry associations.
- Insurers could help clients to acquire finance for installing risk-reducing equipment and damage-resilient materials, and be more proactive in exploring the potential of such measures. Also after events, restoration from payouts could be required to be in compliance with climate resilient standards.

Suggestions for making insurance markets work

The overview of insurance arrangements yields no overall preferred system, nor does it give a full endorsement to move radically from public compensation to private insurance. Indeed, the most successful systems for advancing adaptation currently appear to be public in collaboration with private operators. But there is a fine line between a public insurance system and tax-based public compensation. What is perhaps most striking from our overview is “incorrect” price signals plague both individual and collective decisions. It follows that adaptation can best be encouraged with insurance instruments that place responsibility across the public and private sectors proportional to their capacity to reduce risks in a cost-effective manner. Thus, one suggestion is to provide layered insurance systems that place commensurate liability on the public and private sectors proportionally to their responsibility for the risks and ability to absorb these. This would entail for private sector risk that households and business would be (more) responsible for high-medium frequency risks and losses. Above that, up to a certain high-level collective threshold, private insurance could take the majority of the losses. Above that layer, for very low-frequency, high-impact events beyond insurability and planning routines, public compensation would then be provided

Reduced taxes for risk-based insurance contracts, reductions in other taxes or increases in the tax exemption limit if insurance is purchased, as well as subsidising community risk-reduction efforts may be additional avenues worth exploring.

Where this balance between public and private liability is misaligned, countries may see advantages in moving towards increased private responsibility through insurance and other market-based solutions that embed incentives and conditions for risk reduction and adaptation. There are many different policy options for increasing the supply and demand of public/private insurance and linking these systems to risk reduction and adaptation. Many, such as differentiated risk-based pricing, have been mentioned above. The analysis of national systems adds to this list:

- Insurance can be made compulsory as in Spain, France and Switzerland (assets), and in Greece (crops) or required for a mortgage as in the US;
- Those most vulnerable can receive subsidies or tax breaks for the purchase of insurance as in Hungary; and perhaps foremost, the governments can reduce “free” post-disaster compensation

as in the UK. Subsidies for crop insurance have proven, however, problematic, which raises the question whether other forms of support might be more appropriate.

- Central authorities can grant low-cost government capital backups to reduce reinsurance costs, post-disaster lending to insurance programmes or elimination or reduction of taxes on insurers' catastrophe lines surpluses (this was practised until recently in the UK and Germany). Making this support conditional on risk management planning would advance adaptation.

Specific policy options for property insurance

In terms of property insurance, insurers should be involved by public agencies in land-use planning and other policy processes that focus on reducing risks. Conditional insurance contracts with "must do" clauses for risk mitigation could be introduced for property insurance. Insurers could market microinsurance contracts for low-income segments of society, and actively support the research and development and testing of risk reduction measures. Regulators could consider special arrangements for high hazard areas, particularly where climate change has significantly increased the hazard (legacy risks). This could include risk pooling, the use of long-term contracts to facilitate adaptation planning and financing, and relocation if appropriate.

Specific policy options for crop insurance

In terms of crop insurance, policy options comprise moving to multi-peril, multi-crop compulsory systems. Index-based contracts may be introduced, which have the advantage of eliminating moral hazard, yet the disadvantage that they are expensive to put into place and suffer from basis risk. Subsidies may be reduced and substituted with other forms of support for farmers. The suggestion that a central authority provide tax cuts on insurance contracts for those facing high prevention costs can apply to agricultural insurance as well. Also post-disaster government assistance could be constrained, or replaced by granting partial assistance only to those who have part of their losses covered by insurance. Low-cost government capital backups to reduce reinsurance costs, post-disaster lending to insurance programs, or the elimination or reduction of taxes on insurer reserves (this was practised until recently in Germany) may be utilized. Finally, insurers may participate in farmer cooperatives and public policy processes that advise and regulate for risk reduction.

Suggestions for sovereign insurance incl. government risk pooling

There is little experience in Europe with sovereign risk transfer, weather derivatives or catastrophe pools, and for many countries these instruments will not be necessary. Still, given the high exposure (hot spots) in Europe and the fragility of the budgets in some exposed member countries, it may be useful to explore the relevance of these instruments. The consideration of intergovernmental risk pooling schemes, similar to the Caribbean pool, is an interesting development in this direction and should be further analysed.

A key role pertains to the EUSF. We suggest that the EC consider introducing requirements for pre disaster risk management in the EUSF scheme. As one example, also currently discussed at the EC in the wake of considering droughts as reimbursable events, requirements for implementing drought risk management are being considered. Similar measures could be required for flood and windstorm risk, for which a host of risk management measures could be identified and suggested. Full conditionality will be very difficult to apply and actually implement. Yet, some broad generally verifiable indicators suggesting the level of risk reduction measures implemented in a given country could be the return period of design flood events that need to avoided by flood management

authorities (often 50 year events in the EU), or building codes implemented for structures liable to windstorm damage. Another promising measure would be to further harmonize the loss assessment methodologies, which vary considerably across countries, but are the basis for granting support via the EUSF.

.A more radical suggestion would relate to reorienting the EUSF from a post-disaster response and aid instrument to a pre-disaster, risk-based solidarity instrument. In one variant, the EUSF would provide reinsurance cover at no cost to national or regional insurance systems, thus increasing insurability and lowering premiums. It could also support government (sovereign) insurance through a disaster insurance pool, where governments would insure public infrastructure, cultural heritage sites, clean-up and other relief expenditures, eventually arriving at an intergovernmental risk pooling schemes, as implemented in the Caribbean. The backup offered by the EUSF could be made conditional on governments' meeting adaptation and risk reduction goals. Given these additional roles and rising losses as well as the fact that the EUSF has been depleted a few times already, it is worthwhile considering providing additional finance for the EUSF.

Background and introduction to the work

Losses from weather extremes including floods, droughts, and other climate-related events in Europe (and elsewhere) have escalated in recent decades. Annual monetary losses from large-scale events globally have risen by an order of magnitude within four decades in inflation-adjusted monetary units. This increase has been more rapid than population or economic growth can fully account for (Mills, 2005). According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, anthropogenic climate change is *likely to very likely* to lead to increases in intensity and frequency of weather extremes (Parry *et al.*, 2007).

In Europe, far-reaching impacts of current changes in climate extremes have been documented regarding sudden-onset events such as floods and storms, as well as slower-onset disasters such as droughts and heat waves. Among others, the 2002 large-scale flooding over central Europe and the 2003 heat wave of unprecedented magnitude resulting in 70,000 deaths, placed risk management and adaptation at the top of the agenda (EC, 2007b). Agricultural practices are climate (especially heat and rainfall) dependent and the agricultural sector has been particularly exposed to changes in climatic mean values and inter-annual variability with about 3/4 of drought and heatwave losses reported in Europe over the last 30 years accruing in agriculture (EC 2007b). Increases in temperature, as already observed and simulated by climate models, are expected to have a great impact on agriculture. The summer heat wave of 2003 accompanied by precipitation deficits (Schär *et al.* 2004) led to agricultural losses exceeding €13 billion and a 30 per cent reduction in gross primary production of terrestrial ecosystems (Parry *et al.*, 2007).

There is, with important exceptions, a continuity and consistency between the observed changes and those projected for the future. Negative impacts will include increased risk of flash floods, more frequent coastal flooding and increased erosion due to storminess and sea-level rise. Furthermore, regional climatic differences are expected to become more pronounced. In Northern Europe, reduced demand for heating, fewer winter deaths, increased crop yields, longer vegetation seasons, expansion of agricultural land areas, increased forest growth and an expanding use of water power are projected. In Southern Europe, a region already vulnerable to climate variability, climate change is projected to exacerbate heat and drought problems and to reduce water availability, hydropower potential and crop productivity.

Adaptation is an important component of any policy response to climate change in this and other sectors (Mizina *et al.*, 1999; Hulme *et al.* 1999). As one exemplary sector, studies show that without adaptation, climate change may create considerable problems related to agricultural production and agricultural economies and communities in many areas; with adaptation, however, vulnerability can be reduced and there are numerous opportunities to be realised. For example, changes in the growing season or enhanced irrigation may actually have a positive impact on agriculture in some regions (Rosenzweig and Parry, 1994; Wall and Smit, 2005).

A systematic approach in the EU is laid out in the White Paper on adaptation of the European Commission (EC, 2009). This strategy paper argues in favour of a multilevel approach to the governance of adaptation ultimately assigning differential roles to specific member states and the EU at different governance levels. As well, the White Paper calls for “optimising the use of insurance and other financial services products, specialised Market Based Instruments (MBIs) and public-private

partnerships with a view to the sharing of investment, risk, reward and responsibilities between the public and private sector in the delivery of adaptation action.”

Yet, overall, no specific rationale for adaptation intervention is given in this and other adaptation reports, and the economic case for adaptation remains vague with the report stating that autonomous adaptation responses of individuals and businesses to price signals or climate change stimuli are unlikely to be optimal given barriers imposed by large uncertainties, imperfect information and financial constraints.

This project report on economic instruments for adaptation, commissioned by DG CLIMA, systematically examines these barriers, the economic case for adaptation and the potential of key instruments for incentivizing and enabling adaptation. The instruments we look at are differentiated according to the Commission’s classification of economic instruments into three types:

- Market Based Instruments (MBIs) are instruments administered by government regulators that provide a monetary/economic incentive promoting adaptation.
The Commission’s definition is broad and in the interpretation of the report includes natural resource pricing, taxes, subsidies, marketable permits, payments for ecosystem services, licences, property rights and habitat banking.
- Public Private Partnerships (PPPs) are more comprehensive and crosscutting and include contracts between public and private entities to manage natural resources, provide insurance etc.
In this report major types of PPPs are public contracts, service concessions, joint technology initiatives and various types of financial instruments.
- Risk Financing Instruments (RFIs) are all financial instruments that promote the sharing and transfer of risks and losses. They generally can be classified as pre-disaster arrangements, and comprise insurance, weather derivatives and catastrophe bonds.

We examine and discuss how these instruments can address climate change impacts described above and lead to both autonomous and planned adaptation directly and indirectly. Overall, we seek to specifically identify such economic policy instruments and develop a shortlist of options which can serve the purposes set out in the strategy. The objective of the project and this document is to assess the applicability, effectiveness and efficiency of economic policy instruments, including conditions for their proper functioning, barriers for their implementation and requisite regulatory frameworks, and to provide policy options. This document meets this objective by assessing a range of economic instruments along these criteria. The following discussion and report is organized into four tasks:

- Task 1: Overview of the use of economic instruments to tackle challenges posed by climate change,
- Task 2: Analysis of economic instruments in terms of promoting adaptation options,
- Task 3: Analysis of economic instruments for climate risk financing,
- Task 4: Policy options for the use of economic instruments to address climate change.

Task 1: Overview of economic instruments to tackle adaptation challenges posed by climate change

1 Introduction

1.1 Objective of Task 1

The objective of task 1 is to compile a comprehensive list of policy instruments (PIs) for adaptation to climate change in terms of

- promotion of autonomous adaptation by various actors, and
- sharing of climate change related risks.

Doing so, we differentiate between PIs that already have been applied and those that are yet to be tested and or/conceptualized in detail. In addition, we sketch novel policy instrument(s) that have not been suggested yet to reach the above targets. The discussion starts with a number of introductory paragraphs on adaptation and relevant instruments, then moves on to categorising key PIs, before describing each category and prominent options in more detail.

1.2 Concepts and definitions

Adaptation can be described as all activities aimed at preparing for or dealing with the impacts of climate change, be it at the level of individual households, communities and firms, or of entire economic sectors, governments and countries. Adaptation serves to reduce the damage resulting from the unavoidable impacts of climate change, as well as to protect lives and livelihoods. As shown in Figure 6, adaptation involves dealing with the potential impacts of climate change as well as building adaptive capacity.

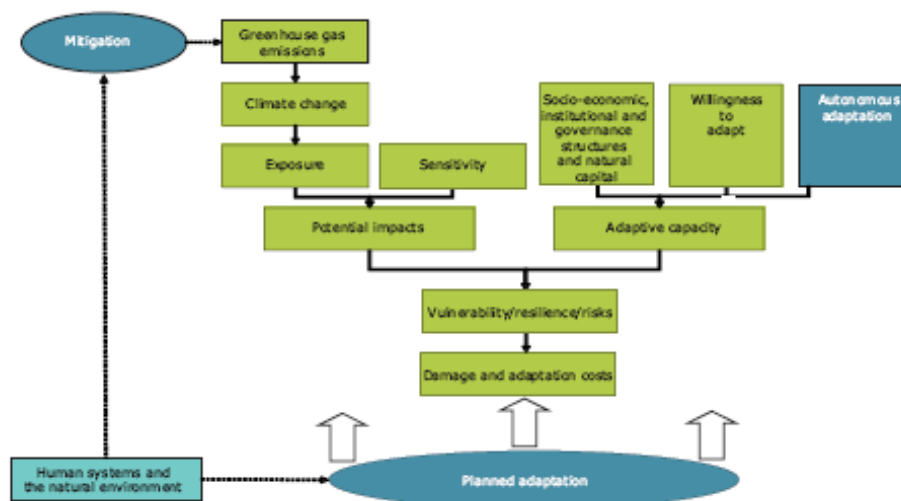


Figure 6: Conceptual framework for climate change adaptation assessment

Source: EEA, 2010.

While initially adaptation to climate change was viewed as less relevant than mitigation, over the last 15 years experience with adaptation programmes in industrialised and developing countries has accumulated. The pioneer was the UK with its UK Climate Impacts Programme (UKCIP). In the developing country context, the UNFCCC has initiated a process of countries preparing National Adaptation Plans of Action (NAPAs). Since the mid-2000s and especially since the publication of the Fourth Assessment Report of the IPCC in 2007, conceptual analyses of adaptation and possible policy instruments have been undertaken by international institutions, such as the OECD and the World Bank. Lately, as national, regional and international organizations are moving towards actual implementing of adaptation measures, there has been considerable progress in identifying, planning and assessing the pros and cons and costs and benefits of adaptation.

The EU Commission *Green and White Papers* on Adaptation to Climate Change (EC, 2007; EC, 2009) have started to address this need and for the first time marked the onset of a consolidated EU climate adaptation strategy. The papers argue in favour of a multi-level approach to the governance of adaptation with specific member states and EU roles at different governance levels.

The four pillars indicated in the White Paper are:

- Use and improve the knowledge base: where current knowledge is sufficient, adaptation strategies should be developed at all relevant levels of decision-making in order to identify optimal resource allocation and efficient resource use for guiding EU action through sectoral and other policies. In turn, for significant knowledge gaps, research, exchange of information, and preparatory action should be enhanced to further contribute to expanding the knowledge base and managing uncertainty;
- Mainstream adaptation into EU policies;
- Develop effective mixes of policy instruments consisting of market-based instruments, public-private partnerships and risk management instruments;
- Develop strong partnership models with the Member States, and mainstream adaptation into EU's external policies including development cooperation.

Yet, overall, no specific rationale for adaptation interventions is given in these official documents, and the economic case for adaptation remains vague with the report stating that autonomous adaptation responses of individuals and businesses to price signals or climate change stimuli are unlikely to be optimal given the large associated uncertainties, imperfect information and financial constraints. We are tackling these and other questions in our report.

Types of adaptation options

There are many adaptation options; a standard, albeit general classification can be found in the IPCC Third Assessment Report (IPCC, 2001):

- Bearing losses,
- Sharing losses,
- Modifying the threat,
- Preventing effects,
- Changing use ,
- Changing location,
- Stimulating research,
- Encouraging behavioural change through education, information and regulation.

All of these functions are important in their own right and will be discussed in the document. Also, adaptation instruments and responses can be organized, as done by the EEA (2010), into:

- technological solutions — “grey” measures;
- ecosystem-based adaptation options — “green” measures;
- behavioural, managerial and policy approaches — “soft” measures.

The green and soft options are focused on building resilience by decreasing sensitivity and enhancing adaptive capacity of actors within social and ecological systems. EEA (2010) suggests that these often come at low cost but not a lot is known about the actual hidden costs of changing behaviour of individuals, companies and institutions on a societal scale. “Hard” options, in contrast, are considered to often require significant funding, research and training efforts.

Need for policy intervention

Overall, in the EU adaptation white paper and elsewhere, the economic rationale for adaptation remains vague. A very limited number of studies has examined this. Klein and Tol (1997) argue that public policy related to adaptation should have four objectives: increasing robustness of infrastructures; increasing flexibility and adaptability of vulnerable managed systems; reversing trends that increase vulnerability; and improving awareness and preparedness. Berkhout (2005) points out that, *prima facie*, it is not evident that governments should actually play a role in influencing adaptation to climate change, compared to the clear-cut case for mitigation action to protect public goods like the climate system. Yet, he further proposes seven objectives for public adaptation policy (some of which overlap with Klein and Tol’s): to inform the potentially vulnerable; to assist in the provision of disaster relief; to provide incentives for and enable adaptation; to mainstream climate-proofing of public policy; to plan and regulate long-term infrastructural assets to reduce future vulnerabilities; to regulate adaptation ‘spillovers’; and to compensate for the unequal distribution of climate impacts. Contrary to this, Niggol Seo (2010, pp. 11 ff.) argues that adaptation per se is a public good.

In our view, adaptation to climate change requires many different private and public actions. From an economic point of view, the implementation of these actions depends on costs and benefits as well as distributional considerations. In some cases it is clear that the implementation of adaptation measures is a private sector issue, i.e. the costs as well as the benefits accrue to a distinct individual or entity. This would for example be the case if a householder living in a coastal lowland builds an artificial hill to place his house above the reach of the highest storm surges, as has been done on the German North Sea coast for many centuries. Such measures will normally be undertaken if the benefits exceed the costs. Thus, there is no necessity for public intervention. However in many cases there is a high degree of uncertainty with respect to the benefits of adaptation measures. This is particularly the case when benefits only occur in some distant future. Then, even if today’s adaptation costs are low, due to uncertainty and discounting individuals might not take action. Thus, there would be a case for government intervention even in the case of pure private goods.

Many adaptation measures result in benefits for other people than those undertaking and financing them, and thus cannot be seen as a generating a purely private good. Again using the example of coastal lowlands, several households may join in building a common hill, which has historically frequently been the case. Each participating household depends on the contribution of the other ones.

Finally, important adaptation measures or their consequences can be a public good, such as flood protection measures or the development of drought-resistant cultivars. Again using the coastal lowland example, building a dike around a large area is likely to be more effective than having many individual hills for houses. But the dike is costly and may be difficult to implement by private contribution, as households will try to minimize their own financial contribution. A famous German novel (Storm, 1888) deals with the issue of how in the early modern period private contributions to dike building were insufficient due to free-riding behaviour and thus led to dike failures. In other cases, private adaptation measures lead to externalities. Under both circumstances a pure private provision of the adaptation measure leads to an underprovision of adaptation. Hence, there is a case for government intervention.

In the case of public goods, the benefits of adaptation measures are non-rival and non-excludable. Therefore they do not have a market price. Still, individuals benefit very differently from the provision of the public good and therefore the individual willingness - not to say ability - to pay might be different. It therefore raises the question how these measures should be financed, e.g. by a (general) tax or a (specific) fee. Additionally, it might be worthwhile to climate-proof public goods requiring large investments in rebuilding in order to avoid the clustering of costs in the case of an extreme event. Besides, public infrastructure has positive externalities, e.g. for the functioning of everyday life as well as for (international) production chains. Thus, their temporary loss incurs much larger costs than the pure costs of rebuilding. While this reasoning implies stringent (protection) measures, public investment decisions in this regard suffer from the same problem as private decisions: the costs of adaptation measures are immediately visible and their benefits only become apparent in the future and with some uncertainty. On the one hand a “wait-and-see”-approach might be called for in some cases, but on the other hand over-adaptation could be the better option when dealing with areas where irreversible damage is a possibility – see for example ecosystems or unique (cultural) assets.

With positive externalities the social benefits of an adaptation measure exceed the private benefits. As a consequence, the expenditure for adaptation measures will be too low. In that case, it might be optimal to support these expenditures. But there might also be individual actions which have negative externalities. In these cases the market solution will lead to too much of these actions. Hence, the government should tax these actions to pursue a social optimum.

When shaping governmental actions to either promote or to implement adaptation, one has to take account of unwanted side effects. Moral hazard by private agents is the likeliest consequence of badly designed adaptation measures or programmes. Firstly, it could occur when incentives are set to mal-adapt. Secondly, moral hazard could be reflected in private under-investment in adaptation measures in the expectation of being bailed out by the state.

Finally, the role of information has to be addressed. In the absence of other market deficiencies like externalities there could still be some scope for government intervention if private agents are not sufficiently aware of the potential impacts of a changing climate. However, it is difficult to detect a lack of adequate information directly. Still, market behaviour could indicate that at least one of the market sides does not take all available and necessary information into account. For example, the level of land prices in flood prone areas could reflect a lack of knowledge on flood risks. In those cases, either simple informational policies or other measures would be advisable. But often seemingly irrational land pricing may be due to moral hazard, e.g. presuming government bail-outs.

Another important distinction with relevance for adaptation decisions taken by different actors can be made concerning the types of adaptation. There is autonomous, market-based adaptation vs. planned adaptation, as well as public sector and private sector (households and business) adaptation (see Klein et al., 1999; Smit et al., 2001) with important overlaps between these definitions. Table 4 organizes key adaptation decisions across these distinctive features.

Table 4: Classification of adaptation according to autonomous and planned action modes

Type Actors	Autonomous/Reactive	Planned/Anticipatory
Private Sector	Purchase of air conditioning Changed farming practices in agriculture Agriculture commodity price response	Retrofit of housing Purchase of insurance
Public Sector	Relief and reconstruction assistance Compensation payments Beach nourishment	Spatial and regional planning Early warning systems Improved building codes Government contingency liability planning

Source: Expanded based on Smit et al., 2001

To an important extent, adaptation is dependent on the way in which impacts and events unfold and are anticipated, i.e. whether events proceed as more gradual changes in climate or temperature unfolding over years and decades (“warmer weather”), or as extreme events and changes strongly concentrated in space and time (more “extreme weather”). While slow onset adaptation often is prospective as it tackles adaptation to future changes in weather and climate, extreme event adaptation importantly overlaps with the management of today’s climate variability, termed disaster risk management (DRM). Many managed systems such as agriculture, forestry, or water resource management have exhibited autonomous adaptations to smaller deviations from regular conditions. For extreme events the evidence shows that due to many factors such as myopia, lack of credible risk estimates, perceptions of risk and missing markets, individual actors are less able to make well informed decisions and planned interventions organized by public sector actors are more strongly required (Smit et al., 2001).

Table 5 lays out the fact that the time horizons for relevant adaptation planning decisions to protect against the consequences of extreme events are often very large.

Table 5: Exposure of the public and private sector to disaster risk

Sector	Exposed Agents/Actors	Time scale (year)	Degree of exposure
Land-use planning (e.g., in flood plain or coastal areas)	Public	>100	+++
Bracing coastline and flood defences (e.g., dikes, sea walls)	Public	>50	+++
More resilient urban structures (e.g., urban density, parks)	Mostly public	>100	+
Securing water infrastructure (e.g., dams, reservoirs)	Public and private	30-200	+++
Climate proofing buildings and housing (e.g., flood proofing)	Public and private	30-150	++
Climate proofing transportation infrastructure (e.g., port, bridges affected by flooding)	Public and private	30-200	+
Climate proofing energy production (e.g., nuclear plant cooling systems affected by droughts)	Public and private	20-70	+

Source: Hallegatte, 2009

Table 6 provides a speculative list of key private and public adaptation measures, sorted by the sectoral categorisation given by the EU-White Paper, including a short sector-wise discussion.

Table 6: Private and public adaptation measures in different sectors

	Possible impacts	Private action	Public intervention (excluding information policies)
Coastal and maritime areas	Flooding Loss of touristic attractiveness	Individual (additional) flood protection of private property Resettlement (of households or firms) Adapted business concepts in tourism Insurance	Dikes Provision of flooding areas / zones
Production systems and physical infrastructure	Extreme events Water scarcity	Resilience of supply chains, factories and their inventory etc. Insurance	Public infrastructure Energy systems
Health and social policies	- Human diseases - Heat stress	- Adapt everyday behaviour - More flexible working hours - Air-conditioning in buildings	- Working conditions - Cooling of buildings - Improvement of urban microclimate
Agriculture and forests	- Water scarcity, droughts - Crop and animal diseases	Use of new crops, agricultural methods etc. - Technical improvements for efficient use of water - Insurance	Land use management Fire protection - Water pricing
Biodiversity, ecosystems and water	- Overuse - Irreversible damage, destruction		Water pricing Payments for Ecosystem Services - Green spaces in cities

Relevant policy instruments for the economics of adaptation

Moving forward from the more general discussion on private and public sector adaptation decisions and gaps, we now discuss key policy instruments that can be harnessed to improve adaptation outcomes.

Private and public sector agents are capable of adapting to adverse or beneficial climate and weather, yet, the evidence shows that many sectors and societies are less than optimally adapted (Agrawala and Fankhauser, 2008, IPCC, 2007). Apart from insurance-related instruments, few adaptation instruments work directly via economic principles and using markets to adapt to impacts and risks. On the other hand, economic instruments can be used to incentivise behaviour and increase the uptake and efficiency of adaptation measures. As one important reference, Agrawala and Fankhauser (2010) distinguish the following incentive-providing instruments relevant for key sectors:

- Insurance schemes (all sectors; extreme events),
- Price signals / markets (water; ecosystems),
- Financing schemes via PPPs or private finance (flood defence, coastal protection, water),
- Regulatory measures and incentives (building standards; zone planning),
- Research and development incentives (agriculture, health).

We follow the Commission's categorisation of economic instruments for the promotion of adaptation, which largely overlaps with the above classification, but only distinguishes three types:

- Risk Financing Instruments (RFIs),
- Market Based Instruments (MBIs), and
- Public Private Partnerships (PPPs).

MBIs are instruments administered by government regulators that provide a monetary/economic incentive promoting adaptation; the Commission's definition is broad and includes natural resource pricing, taxes, subsidies, marketable permits, payments for ecosystem services, licences, property rights, habitat banking. In our analysis, we will categorise these instruments systematically and provide detailed definitions of the PI type and variations that will be analysed.

RFIs include all financial instruments that promote the sharing and transfer of risks and losses. They generally can be classified as pre-disaster arrangements, and comprise insurance, weather derivatives, catastrophe pools, and also public sector compensation clauses.

The PPP category is more comprehensive and crosscutting and includes contracts between public and private entities to manage natural resources, provide insurance, etc. Major types of PPPs are public contracts, service concessions, joint technology initiatives and various types of financial instruments.

These instruments can lead to both autonomous and planned adaptation directly and indirectly. MBIs incentivize autonomous adaptation through price signals, economic incentives etc. and thus indirectly lead to more adaptive behaviour. RFIs and adaptation are linked via 3 routes. RFIs directly lead to adaptation through two channels: i) they provide financial compensation post event for premium and other payments pre-event, and thus reduce the follow on consequences, (ii) they share risks pre-event and, by taking out systemic risk, permit resource-allocating decisions. RFIs also indirectly lead to adaptation as the pre event premium provides an incentive to reduce risk and the

premium by taking action. They may also lead to mal-adaptation if agents rely on the financial security provided and relax preventive efforts, which thus may lead to increases in risk over time.

It may be noted that regulation also is a relevant policy type in the context of adaptation. For example, standards for buildings in flood-prone regions or prohibition of certain land use types in certain regions - such as building settlement structures in flood prone regions – can be very effective, low-cost measures to prevent negative impacts of climate change. However, regulation is not part of our analysis. We nevertheless recommend policymakers to explicitly assess this policy type.

1.3 Methodological approach in task 1

Our analysis proceeds in five steps:

1. Identifying and reviewing a comprehensive list of policy instruments that are used inside and outside the EU for adaptation or related policy objectives.
2. Structuring policy instruments into categories and developing an overview of each policy instrument.
3. Assessing whether instruments can provide a concrete incentive to engage in adaptive activities or reduce secondary effects from damages caused by climate change. The assessment takes into account whether there is a sufficient direct or indirect link to adaptation. A link is considered sufficient if the instrument has potential to impact adaptive behaviour of relevant stakeholders, if the instrument in some form already been successfully implemented or if economic reasoning warrants further investigation. Instruments that fulfil these criteria are shortlisted and analysed in depth in the subsequent tasks.
4. We list possible applications. In the initial selection we also look into instruments that have been used for climate change mitigation, as they could provide lessons for adaptation policy instruments, with a view to make recommendations regarding novel policy instruments.
5. Providing examples of the current application of existing policy instruments as “case studies” that contain an initial evaluation based on analysis entailed in the information sources.

In our analysis, we have collated and reviewed available literature describing policy instruments which could be relevant for adaptation. The relevant literature and internet sources are summarized in the reference section and the long list of examples of applying various instruments in practice in Annex A (see electronic Excel-File: EU Adaptation Literature Research). For the identification of PIs that have been applied in practice, a major information source were the National Adaptation Strategies developed by many EU Member States and also other countries. In addition, we conducted a comprehensive literature and internet research to identify additional PIs inside and outside the EU. Communications to the United Nations Framework Convention on Climate Change (UNFCCC) were another source of information.

While there is a fair amount of evidence and information on RFIs, one challenge that became obvious in this context is the very limited availability of literature specific to policy instruments promoting adaptation through MBIs and PPP. Our literature search revealed that there is no detailed literature whatsoever on using market mechanisms for adaptation.

We therefore expanded the horizon and included literature on policy instruments that might be relevant for adaptation but have not yet applied and/or discussed in this context. We also used literature on market mechanisms for climate change mitigation and ecosystem preservation to draw analogies, such as payments for ecosystem services, habitat banking and carbon taxes.

The results of the review and initial assessment are summarised in chapter 2 of this report.

1.4 Categorisation of policy instruments analysed

As mentioned above, we have – on the basis of a comprehensive literature and our own expertise on policy instruments - identified policy instruments that could theoretically be applied in the context of adaptation. In addition, we have identified a couple of novel instruments that could also be applied. We have categorised them as shown below:

1. Instrument category: Subsidies

- Grants
- Price supports

2. Instrument category: Taxes and fees

- Carbon taxes
- Land use taxes and fees
- Energy taxes

3. Instrument category: Licences, permits and variations

- Tradable units
- Project based offsets
- Adaptation market mechanism (novel adaptation policy instrument)
- Advance market commitment

4. Instrument category: Other MBI

- Payments for ecosystem services
- Water markets
- Habitat banking

5. Instrument category: Public Private Partnerships

- Public contracts
- Service concessions
- Joint technology initiatives
- Financial instruments

6. Instrument category: Risk Financing Instruments

- Insurance
- Catastrophe bonds
- Weather derivatives

2 Overview of Economic Instruments

2.1 Subsidies

2.1.1 General description of the policy instrument category

Subsidies can be defined as “direct payments, tax reductions, price supports or the equivalent thereof from a government to an entity for implementing a practice or performing a specified action” (Gupta et al. 2007, p. 750). While subsidies have been criticised as an inefficient policy instrument that leads to rent seeking by interest groups and eventually reduces economic competitiveness (Porter 1990), public opinion and political decision makers have been more favourable to this instrument (Sikora, 2005). Thus subsidies have retained an important place in the catalogue of public policy instruments. Subsidies could be used to induce any type of proactive adaptive investments and behavioural changes. Below, we differentiate subsidies into the categories direct payments and indirect payments (including price support).

2.1.2 Direct payments / grants

1. Description and purpose

Direct payments or grants constitute the purest form of a subsidy. An economic entity receives an amount of money which is supposed to induce the recipient to undertake a specific action bound to that payment. In the absence of the payment, the action is presumably not undertaken, or not to the desired degree.

Hence, grants aim to mobilize an investment that is not attractive to the recipient without receiving an incentive. The level of a grant should be just sufficient to make the investment economically attractive as otherwise public money is wasted. Therefore, policymakers need to assess the economics of the activities before introducing grants and to reassess grant levels periodically.

2. Link with adaptation

Generally, improvement of infrastructures for adaptation purposes that aims at protection of economic activities from extreme weather events - such as the raising of dyke levels - does not generate direct revenues. Therefore, it suffers from a lack of an incentive – an investor cannot capture all the benefits. In such a situation, government may provide a grant that is sufficient to mobilize the investment, taking into account any revenues that the investor might be able to generate.

In other words, direct payments to promote adaptation would aim at inducing individual actions with positive externalities or at supporting individual actions where sufficient financial means are lacking. The payment then hinges either on the estimated value of the positive externality or on the (residual) funds needed by the potential recipient.

Grants may be paid for improvement of infrastructures protecting against impacts of stronger and more frequent meteorological extreme events as well as providing an improved resilience against changes in important climate parameters such as rainfall and temperature.

3. Possible applications

Direct payments could for example be used for the following adaptation measures:

- Education and information dissemination on potential risks and preventive measures
- Use of new cultivars
- Afforestation of degraded land
- Building or improvement of dykes and other flood-protection measures
- Weather-proofing of buildings
- Early warning systems
- Installation of water supply, desalination and irrigation systems in areas threatened by droughts
- Installation of rainwater infiltration facilities for existing public and private buildings

Grants can also induce prevention of new or removal of existing economic activity from areas likely to be impacted by extreme weather. The grant could for example be paid for:

- Removal of housing from floodplains or coastal areas endangered by storm surges
- Resettlement of farms

Grants are not appropriate for activities where the investor can reap all the benefits and thus no societal benefits accrue. This is likely to be the case for behavioural changes that reduce losses from extreme weather events or long-term changes in key climate variables on the level of an individual, household or enterprise. Here, instruments are more appropriate that prevent stakeholders from relying on government to cover losses once a meteorological extreme event has occurred.

4. Practical examples of grants in the context of adaptation

The grants are described by three illustrative examples in [Annex II](#):

- Grants for preventive measures, Sweden
Municipalities may apply for grants for preventive measures against disasters which are not common or do not follow a slow incremental course.
- FarmReady program, Australia
Australian government initiative to improve productivity and help farmers manage climate change and climate variability through soft adaptation measures.
- Climate Change Adjustment Program, Australia:
Australian government initiative to assist farmers managing impacts of climate change. Either adjustment advice and training grants or transitional income support is available. The latter includes support for resettlement of the farm.

Due to its strong link with adaptation, this instrument is further analysed under task 2 in section 2.1.1.

2.1.3 Tax reductions

1. Description and purpose

Tax reductions belong to the group of indirect subsidies (or subsidies in a broader sense). They reflect a (partial) exemption from the obligation to pay a tax, but they can also take the form of a (partial) payback of taxes which have already been paid. Tax reductions can be interpreted as the exception from a rule. This deviation can either be justified with equity or incentive motives. In the context of this study only incentive motives play a role.

The aim of tax reductions is to relieve economic agents from (parts of) the tax burden, thus expecting them to undertake more of the taxed action. In order to achieve any steering effect, the tax reduction has to be sufficiently large and the economic agent has to be able and willing to change his behaviour. Otherwise public revenues would be foregone without inducing the desired consequences.

Compared to grants, tax reductions are often easier to administer. However, there are some basic arguments against tax reductions: they have equity implications, they add to the complexity and opacity of tax systems, their budgetary consequences are sometimes difficult to estimate and they are prone to lobbying before implementation. All these aspects have to be carefully judged before introducing tax reductions (OECD 2010a).

2. Link with adaptation

Tax reductions could promote adaptation in cases where the adaptive action is not undertaken or the desired action is greater than the actual position. The decisive factor is whether the tax reduction actually sets the incentive correctly. Therefore, this instrument needs to be designed carefully: On the one hand, the signal has to be strong enough. On the other hand, windfall gains by taxpayers for actions they would undertake anyway and large revenue losses by the government have to be avoided. Besides, the positive effects of (additional) adaptation have to be weighed against the distortions created by tax exemptions.

3. Possible applications

In principle there are various possibilities to use tax reductions as a means to incentivise adaptation. The following examples are noted here:

- In the agricultural sector, it might be possible to reduce goods taxes if production costs increase due to adaptation measures. For example, VAT exemption could be granted for sales of drought- and heat-resistant crop seeds. Another option would be to partially exempt sales revenues from corporate taxation.
- Supporting research and development of solutions to climate change adaptation by scaling up their costs in taxable profit calculation. VAT exemption could be granted for R&D expenses of companies.
- Households and businesses might be allowed to reduce taxable income by costs covered for climate-proofing of buildings - again through VAT exemption and/or exemption of revenues from corporate taxation.

4. Practical examples of tax reductions in the context of adaptation

Tax reductions could apply to direct personal taxes or to goods taxes. So households could be allowed to deduct adaptation expenditures like those for insulation of buildings or greening of taxable income. Firms could deduct more than actual adaptation expenditure from profits. Goods taxes could be reduced if production costs increase due to adaptation measures. An example might be a reduced VAT for agricultural goods which are more resistant to climate change than others. This reduces prices for these goods and thereby makes their production more attractive. This implies that the more resilient good is preferred.

Due to its strong link with adaptation, this instrument is further analysed under task 2 in section 2.1.2.

2.1.4 Price supports

1. Description and purpose

Price supports belong to the group of indirect subsidies although some direct payment is usually associated with them. In its most common form, the government defines a price floor for a good and pays the differential amount to the producers of the good as soon as the market price falls or is below this minimum level. This prevents the price falling short of the minimum price. This instrument can also take the form of a price control, i.e. the market prices would not be allowed to fall below some legally binding threshold; in other words no seller can sell his products for a price below the defined limit.

Traditionally the reason for providing price support is to back producers of certain sectors or branches in order to secure them an appropriate income level. Price supports need to be carefully designed and assessed because they distort markets and individual decisions, they redistribute income and resources between economic sectors and between producers and consumers and they may require significant financial resources from the government responsible for delivering the support. Besides, high administrative costs are possible and the instrument is prone to lobbying.

2. Link with adaptation

A link between price supports and adaptation can be constructed for goods and services, which in comparison to some substitutes are seen as favourable. In that case it would make sense to foster the sales of them. If for example some crops need less water than comparable crops, the water budget is seen as essential for climate change adaptation but the crops in question are less attractive to the farmers it could be an option to bring their sales forward by price supports. This minimum price then needs to be higher than the price for the alternative crop to ensure the “right” crop-choice by the farmer.

3. Possible applications in the context of adaptation

In principle there are some fields in which price supports might promote adaptation:

- In agriculture the sale of specific climate-adapted crops could be promoted.
- New technological solutions, e.g. in cooling of buildings, flood-protection or the health sector, could be supported.

4. Practical examples of price supports in the context of adaptation

Practical examples of price supports could not be identified in the context of adaptation.

The experiences with price supports have notoriously been bad. As described above, they usually come with a lot of (costly and efficiency-reducing) secondary effects. Besides, price supports would have to be sizeable and even then their adaptive incentives are uncertain at best. Thus, we will not look into this instrument any further.

2.2 Taxes and fees

2.2.1 General description of the policy instrument category

Taxes are monetary payments by economic agents to the state which do not trigger any service in return. Contrary to this fees or levies have to be paid in exchange for a service by the state or for the use of (usually) state-owned facilities.

First and foremost taxes are needed to generate government revenue. These revenues are necessary to finance public expenditures. These public expenditures might also be a part of a public adaptation policy. This is clearly the case if these measures are public goods such as sea and river dikes. If finance is the only objective of taxation, then taxation should be non-distortionary, i.e. taxation should influence private behaviour as little as possible. In this case the optimal tax would be a lump sum tax, since this is the only tax which has no influence on behaviour. An alternative would be to tax individuals according to their willingness to pay which is related to the benefits they receive from public spending for the public good.

There are some markets where private behaviour does not lead to an optimal outcome. This is normally due to differences between the individual cost of consumption and the social cost. In this case taxes can be used to direct private behaviour towards a socially optimal behaviour. Then taxation has a double dividend: it improves market behaviour and leads to government revenue at the same time. The tax on a good or a factor of production leads to an increase in the market price and therefore reduces the difference between private and social costs. In principle a Pigovian tax which is levied on the market activity that generates the negative externalities can improve welfare (Baumol 1972). Typical examples are environmental and energy taxes. In 2008 revenue from environmental taxes in the EU was between 1.6 % of GDP in Estonia and 5.6 % in Denmark with a weighted average of 2.4 % (European Commission 2010).

There is another reason to tax some private goods. If individuals are myopic they might underestimate the true long run costs of their consumption. As an example take areas where forecasts show that they will be vulnerable to flooding in the future. If this is not taken into account adequately by market participants the government could levy a tax on the use of this land area. Therefore the land becomes less attractive and potential users might decide to use other less vulnerable land. However, this kind of instrument implies that the government has a better knowledge of future costs than the market. This is not at all clear, since one of the features of a functioning market is that all available individual knowledge is gathered and feeds into market results. (However, many markets are imperfect in respect of access to and use of information).

Finally, a tax could prevent or at least hinder (private) adaptation as it extracts money from economic agents that could have been used for adaptive purposes. This should be kept in mind when advocating tax-solutions in this context.

Practical examples of taxes in the context of adaptation

The policy instrument of taxes and fees in the context of adaptation is described by two illustrative examples in Annex II (pages 277-283).

- Local flood defence levy, UK:
The funding will be allocated to Lead Local Flood Authorities (LLFAs). LLFA's are established under the Flood and Water Management Act 2010. The levy finances grants to help councils to protect and support their own communities when managing flood risk. The funds have been/will be allocated based on the individual risk that each local authority has. Each local authority decides where the money will be of most use.
- Temporary Flood Reconstruction Levy, Australia:
A new progressive levy, at a rate of 0.5% on annual income exceeding A\$50,000 (approx. €40,000) and 1% on income over A\$100,000. Flood-stricken households are exempt. This tax funds a multi-billion-dollar rebuilding program after floods devastated infrastructure and ruined thousands of homes and businesses on the eastern coast in January 2011.

At first sight, the Temporary Reconstruction Levy appears to be a novel instrument with specific adaptation purposes. However, it simply serves financing purposes after the occurrence of a disaster. With the event being sufficiently large, general tax revenues might not be able to cover the losses (in the absence of other compensation mechanisms) and the reconstruction costs. Besides, the Temporary Reconstruction Levy sets no adaptive incentives, because households affected by the flood are exempt and completely bailed out. Thus, this instrument encourages mal-adaptation as households in flood prone areas can expect to be saved by government funds, inducing a sub-optimal level of (private) flood protection or relocation activities. Due to this reasoning we do not consider this kind of tax an appropriate instrument to promote adaptation. The same holds true for any kind of ex post tax to finance the damages and losses of prospective extreme events. In addition to incentivising mal-adaptation by providing a bail-out it is also doubtful that this instrument in an ex post fashion is consistent with tax laws in some European countries as the raising of tax revenues for specific purposes is forbidden e.g. in Germany.

Using a fee is also not a solution on the national level because this requires some direct return service which by definition of disaster repair is only possible after a specific event occurred. In essence any kind of (temporary) tax, levy or fee to finance disaster losses does not warrant further consideration in the context of adaptation.

2.2.2 Carbon Taxes

1. Description and purpose

According to the glossary of the EEA a carbon tax is a “compulsory tax levied on fuels in accordance with their carbon content, with the aim to encourage using less carbon-intensive fuels and to reduce energy consumption”. The glossary of statistical terms of the OECD adds to this by stating that a carbon tax is “an instrument of environmental cost internalisation”. Thus, a carbon tax is a regulatory tax with the goal of internalising the negative externalities created by CO₂-emissions. The main negative externality caused by CO₂-emissions is climate change and its impacts.

The success of a carbon tax hinges on its ability to change the behaviour of economic agents. Thus the tax rate should not only reflect the external costs of the emissions but it also needs to be set in a way that incentivises behavioural change. This also implies that such changes, like using less carbon-intensive or alternative fuels, are possible at all for the consumers. Otherwise a carbon tax could only be interpreted as a pure means of revenue collection. The extent of the steering effect is also influenced by the number and scale of exemptions from the carbon tax. While the carbon tax particularly affects large emitters, in some real world cases they have been exempted from the obligation to pay the tax. This can greatly undermine the desired purpose and apart from that has distributional and allocative implications.

Carbon taxes have been implemented in a number of countries, especially in Europe. In addition to several EU-member states and other European countries (Norway, Switzerland), for example Costa Rica and some provinces in Canada have already introduced carbon taxes. The amount of literature on the general effects of a carbon tax is huge, but there is also an abundance of sources dealing with the assessment of existing systems. For some discussions in the larger context of environmental taxation see e.g. OECD (2006) or Rayment et al. (2009).

2. Link with adaptation

The link between a carbon tax and adaptation to climate change is indirect at best. A working carbon tax, in the sense of being able to internalise the negative externalities of CO₂-emissions, would mitigate climate change and thus would also reduce its impacts in the future. This in turn would also reduce the future need for adaptation. A carbon tax generates revenues which could be used for the support of adaptation in the private sector or for public sector measures on adaptation. However, earmarking of tax revenues for specific purposes generally is less efficient than the reduction of other distortionary taxes. Instead, the financial resources should be taken from the overall budget and/or be financed by non-distortionary (specific) taxes or fees. Besides, if a carbon tax actually serves its purpose, the generated revenues should – assuming a constant tax rate – fall over time with decreasing emissions. If some constant level of adaptation is desired, other financial resources are necessary anyway.

3. Possible applications in the context of adaptation

We cannot identify sensible applications in order to induce or promote adaptation. Considering for example the rising demand for cooling, a carbon tax could induce adaptive as well as mal-adaptive behaviour. On the one hand, more efficient cooling might be induced. On the other hand, the higher

costs for cooling might reduce its use thereby exacerbating the potential effects of higher average and maximum temperatures. Therefore this instrument does not warrant further consideration.

4. Practical examples of carbon taxes in the context of adaptation

Practical examples of carbon taxes with earmarking of funds for adaptation could not be identified.

2.2.3 Land use taxes and fees

1. Description and purpose

Land use taxes – in the context of this study we understand them as a tax on land and buildings – represent a payment either for the land ownership itself or for its kind of use. Land use fees are similar in nature, but they would by definition require some type of service from the collecting (public) institution in return. Land use taxes are capital-based taxes, typically using the value of the land as the tax base. The value in turn commonly depends on the way the land is used, e.g. for business purposes or as a living space.

Another kind of tax relevant in the context of adaptation to climate change could be a land purchase tax. It represents a transaction tax levied on the execution of a sale of land.

While both kinds of taxes are normally used to generate revenues they could also act as a regulatory tax. For this to work, the tax has to be sufficiently high, behavioural changes – at least in the long term – have to be possible, and the tax base has to be chosen wisely.

In the following we will apply the term “land tax” to summarize land use taxes and land purchase taxes.

2. Link with adaptation

Land use and land management is important for the use of natural resources including water, soil, nutrients, plants and animals. Besides land use has a major impact on the resilience to climate change. This holds on the national as well as on the regional or urban level; on the national level land use affects deforestation and has effects on erosion and thereby on water quality. Retention areas close to rivers prevent flooding of urban areas. Within urban areas open land is important for recreation and mental health as well as for micro climate regulation. Therefore, the amount of unsealed area is an important determinant of resilience to climate change.

If the tax is somehow related to the grade of soil sealing, less sealing by the land owner could be induced and therefore lead to adaptation in particular cases.

3. Possible applications in the context of adaptation

Land taxes can be divided in three categories:

- land sales tax (capital profit tax),
- purchase (registration) tax,
- usage (real estate) tax.

4. Practical examples of land use taxes and fees in the context of adaptation

Taxes on sales or purchases affect the trading of land and might help to avoid price bubbles. However, they will have only very little impact on the use of land and therefore on the environmental quality. A land use tax has the purpose to increase the cost for the use of land.

As the description shows, land use taxes and fees as well as land purchase taxes should be further investigated as an instrument to promote adaptation to climate change through land use change, e.g. more extensive agricultural or industrial activities. Task 2, section 2.2 provides more details on this instrument.

2.2.4 Energy taxes

1. Description and purpose

Energy taxes are imposed on the use of certain forms of energy, e.g. on fossil fuels. In most cases the tax base is the physical unit of consumption. Normally the tax aims at reducing energy use, either by enhancing efficiency or by decreasing the energy consuming activity itself. Thus it is a consumption tax with the characteristic of a steering tax. Often energy taxes are also introduced on environmental grounds, trying to internalise the externalities of energy use. In that sense they are similar to the concept of carbon taxes. In addition to this, energy taxes might under certain conditions foster innovation and green growth (see OECD 2010b) and could be introduced accordingly. Some preconditions need to be fulfilled for energy taxes to work properly. The tax base has to be well-defined, there should be as few exemptions as possible and – if they are supposed to have a regulatory effect – there should be some price-elasticity in demand in the short and in the long term.

For quarterly comparisons of world-wide energy end-use prices and the respective energy taxes please refer to the IEA (2011). The tables in the IEA show that the majority of countries has different kinds of energy taxes, differing by tax base, tax rate etc. Furthermore there exists a vast amount of literature on energy taxes and their theoretical and empirical effects. Both topics shall not be discussed here.

2. Link with adaptation

There is no clear-cut link between energy taxes and adaptation to climate change. However, two chains of reasoning could be brought forward for indirect links. Firstly, energy taxes reducing the use of fossil fuels thereby also reduce CO₂-emissions. This internalises the negative externalities from those emissions mitigating climate change. Hence, the need to adapt to future impacts of a changing climate decreases with a reduction of (potential) impacts. Secondly, energy taxes enhancing the efficiency of some utilities might facilitate adaptation. If for example the need for the cooling of buildings rises due to a changing climate, more air conditioning – apart from different kinds of buildings – might be necessary. This counteracts emissions targets. If on the other hand energy taxes lead to an increase in more efficient air conditioning systems, they would make the operation of new systems cheaper, more attractive and would ultimately serve an adaptive purpose. This example shows however, that the effect would be very indirect in nature and would depend on a number of conditions and intermediate effects to hold. Besides, more ground-breaking innovations might be restrained, if orthodox cooling systems are merely enhanced instead of substituted by completely new solutions. In that case energy taxes would even be an obstacle to sustainable adaptation.

3. Possible applications in the context of adaptation

For energy taxes the conclusion is the same as with carbon taxes: There is no obvious and direct justification for energy taxes to promote or incentivise adaptation. Thus, we will not look any further into this instrument.

4. Practical examples of energy taxes in the context of adaptation

Practical examples of energy taxes could not be identified in the context of adaptation.

2.3 Licences, permits and variations

2.3.1 General description of the policy instrument category

While markets are as old as humanity, tradable units have first been proposed as instruments of environmental policy in the late 1960s. Initially, policymakers did not take these proposals seriously and it took a decade until the first cautious attempts to test the instruments were made in the US. However, since the 1990s, there has been a strong upswing of environmental markets, starting with air pollutants but eventually extending to include greenhouse gases.

Environmental markets are based on the generation of demand for tradable units through regulatory decision. This demand then triggers the supply of units. There can be “capped” systems where the total amount of an environmental pollutant is limited and tradable units can only be generated by reducing the pollution below the limit. “Open” systems allow the generation of offset credits through projects that reduce the pollutant compared to a baseline. While voluntary markets have existed for some periods, in the long run they have always suffered from a collapse of prices due to the lack of a sustained demand.

So far, markets have not yet been used to promote adaptation. Therefore, the following description is based on the experience in pollution abatement and greenhouse gas mitigation. While pollution is a “bad” and thus tradable units are called “licences”, “allowances” or “permits”, adaptation is a good and this has important consequences for instrument design.

2.3.2 Tradable Units

1. Description and purpose

Tradable units are defined in terms of a commodity that a government wants to be provided. If the tradable unit denominates a “bad”, its volume has to be lower than the volume that would normally be produced; the volume would be defined by the politically palatable maximum. If the tradable unit denominates a “good”, its production must entail a cost while the benefit cannot fully be appropriated by the producer. To generate a price and make a market for tradable units work, there needs to be a scarcity of them, which is normally created by a government mandate. The mandate specifies that certain entities have to surrender a predefined amount of units during a specified period to the government. If the unit denominates a “bad” or a commodity whose quality can be compromised, regulators need to verify that a surrendered unit is really valid. Moreover, the

regulators need to specify penalties in case the entity does not surrender a sufficient amount of units, as otherwise entities will not comply with the mandate.

2. Link with adaptation

To promote adaptation, tradable units have to be created through a governmental regulation specifying a quantity of adaptive benefits, determined in prevented 'climate change impacts'. For example, a government could specify the value of property protected from climate change impacts, and/or the number of deaths/disability/sickness prevented. In order to ease the introduction of such a mechanism, one could start with a single criterion in the initial phase (e.g. property protected/saved) and expand it to further indicators such as saved health at a later stage.

Certain entities would then be required by the regulators to take responsibility for mobilizing adaptation and to surrender sufficient units. There are numerous principles for allocating these requirements to entities, such as ability to pay, size of the company (e.g. in terms of revenue, employment numbers), the "polluter pays" principle or simply a poll tax⁴. For example, a target of protecting e.g. 10 billion € of property against climate change impacts could be allocated to industry according to their actual or historic greenhouse gas emissions level; the tradable unit could be denominated in 1,000 € property saved or protected⁵.

The entities that have to surrender the adaptation units then have the option to embark on adaptive activities themselves or to acquire units from other entities that can implement adaptive activities at a cost that is lower than the market price for the units. Since the chosen criteria "property saved" and "health saved" implicitly cover the risk and exposure of protected entities, there would not only be an incentive to minimize relative costs but also to engage in most effective activities. Hence, those options for adaptation that are economically attractive and socially effective would be utilized.

Kuch and Gigli (2007, p. 16) mention a trading system that limits "risky activities", and thus would be similar to the trading systems for classical pollutants. Such a trading scheme might for example limit the number of building permits in a zone prone to storm surges or rockfalls due to thawing permafrost in mountains, and hence would consider the fact that much of the loss that occurs to climate change related damage is also a result of socioeconomic development and a tendency of mankind to select e.g. the most scenic spots for building houses regardless their exposure to damage e.g. by floods. Building permits would be made tradable and the price required to pay for the permit would generate a disincentive to engage in the risky activity. The advantage of a trading system for risky activities would be that an efficient selection of risky activities would be triggered, i.e. those activities would be undertaken that generate the highest revenues or utility.

3. Possible applications in the context of adaptation

Trading systems for "adaptation goods" can be based on any type of adaptation whose benefits are measurable and verifiable. The main challenge here is the definition of the adaptation target and

⁴ In this case, one needs to set up an institution collecting the tax and tendering projects that generate adaptation units.

⁵ Measuring property protected would be easier, but at the same time requires a detailed definition of eligible activities in order to avoid wrong incentives. In addition, one would need to include risk categories to consider the fact that some property is more at risk than others.

agreeing on “damage baselines” against which the benefits are calculated. A universally accepted verification system would be crucial for the integrity and acceptability of the system.

For risky activities, the liquidity may be insufficient to reap the benefit from trading if the scope of the risky activity is limited. For example, covering just one village threatened by rockfalls would not lead to an effective trading system whereas covering an entire mountain range would probably lead to a highly liquid market. Challenges would be to define politically the degree of scarcity of permits given that interest groups in the areas threatened by climate change impacts will oppose the system. For example, land dedicated to build luxury houses will lose value if permits are required to actually build or maintain these houses

A solution to the above can be to establish a national or international (e.g. pan-European) trading system. This concept would be a novel policy instrument and is further defined in chapter 2.3.4 of this report.

4. Practical examples of tax reductions in the context of adaptation

So far, no concrete adaptation trading has been introduced. However, we describe in detail a possible design for an “Adaptation Market Mechanism” (AMM) as a novel adaptation policy instrument in Annex III. A brief summary of the AMM is provided in chapter 2.3.4.

A trading system that limits “risky activities” can have a strong link with adaptation as it addresses a major cause why economic value at risk increases over time in many places: it is not only because of increasing impacts of climate change, but also increasing economic or social activity. This instrument is analysed in more detail in chapter 2.3.4 of this report along with the adaptation market mechanism.

2.3.3 Project based offsets

1. Description and purpose

Offsets are tradable units generated by projects that provide tradable units in a region where there is no requirement to surrender such units. The units are used in another region that requires surrender of tradable units and declares an offset as equivalent with one tradable unit. Offsets reduce the costs of attaining the target underlying the trading system, as the availability of offsets reduces the price for the tradable units.

2. Link with adaptation

In the “goods” approach to trading, a project-based adaptation offset could be generated by projects in regions where adaptation is relatively easy to generate, but where no governmental adaptation commitment exists.

For trading of permits for “risky activities”, offsets can be generated by reducing risky activities in an area outside the area covered by the trading programme.

3. Possible applications in the context of adaptation

Offsets would be particularly attractive to harness adaptive activities in areas that have low adaptation costs but where the government does not require a relevant adaptation contribution.

This would usually be the case in poorer regions where the government does not want to generate adaptation burdens beyond those required for autonomous adaptation.

4. Practical examples of tax reductions in the context of adaptation

In practice, no system of adaptation offsets has been introduced so far. Again, the AMM described in Annex III can serve as a theoretical example of how project based offsets can be used in the context of adaptation.

2.3.4 Possible design of a tradable unit scheme: Adaptation Market Mechanism (AMM)

The objective of an Adaptation Market Mechanism (AMM) is to create a market that honours adaptation activities of private and public actors by setting financial incentives. It can be designed in a way that not only the concept of tradable permits but also the one of project based offsets are included. The paragraphs below provide a summary of a possible design of an AMM, whereas Annex III provides more in-depth information.

A universally accepted and verifiable trading unit is a precondition for a market mechanism. The unit should be applicable to all types of adaptation activities to enable maximization of the cost reduction potential. In general terms, an adaptation project can be considered successful if it delivers protection against negative climate change impacts. The protection can address private and public property as well as human lives. The perfect adaptation project would prevent any negative impact on those. Theoretically, the trading unit should thus be denominated in net present value currency units of property and human health protected. To avoid endless political debates about an equitable valuation of human life and health, we suggest defining two trading units:

- Net present value of property saved, expressed in current currency units
- Disability-adjusted life years saved (DALYS)

It may be noted that the concept of DALYs is well-tested by the World Health Organisation, which has elaborated a comprehensive system and ready-to-use standard values for quantifying the level of disability through a given event (see e.g. WHO (2010a), WHO (2010b)). The DALYs concept can be introduced to the system at a later stage when the system is up and running.

A first step of implementing an AMM is the specification of mandatory adaptation targets by governments. As discussed above, this specification would be in form of double property and human health protection targets for a predefined period. For example, the EU could set an annual target of protection of 5 billion € of property ("saved wealth", SW) and 10,000 DALYs ("saved health", SH).

Subsequently, these commitments would have to be allocated to a predefined group of entities. The defined target can then be met by the participants of the AMM either by investing themselves into adaptation activities that result in saved wealth and/or DALYS, or to buy tradable units of the same on the market, or to buy project based "offsets" from third parties.

The activities that are conducted under an AMM can be manifold and cover various sectors, such as agriculture, protection of private/public infrastructure against climate change related damage, improving cooling systems in building and improving medical care systems to save lives or avoid

disability/sickness induced by climate change related events. Figure 7 summarizes the basic functioning of an adaptation market mechanism.

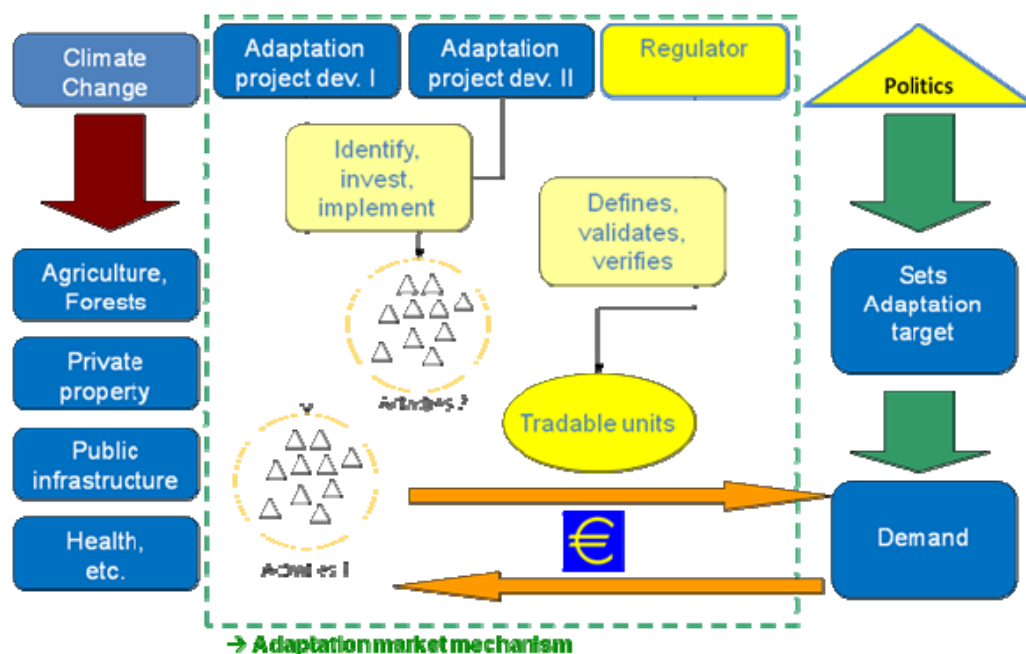


Figure 7: Overview: functioning of an adaptation market mechanism

It is obvious that a robust monitoring, reporting and verification (MRV) scheme needs to be established, and that one needs to derive solid baselines for estimating the economic and social benefits of an adaptation activity. One of the major questions is whether this can be done at sufficient confidence level, which in turn depends strongly on data availability and uncertainty in forecast on regional/local climate change impacts.

Annex II provides further information and a numerical example. The instrument is analysed in more detail under task 2, section 2.3.

2.3.5 Advance market commitment

1. Description and purpose

An advance market commitment means that a government specifies a willingness to pay a certain financial volume for a certain volume of activity implemented in the future. Essentially, the government guarantees a certain income to the entity providing a desired activity, making this instrument comparable to a subsidy.

2. Link with adaptation

The government would define adaptive activities that would be demanded in the future and the quantity of such activities to be supported.

If governments have a view about the volume of adaptive activity they want to support in the future, an advance market commitment might be appropriate. The challenge is the credibility of this commitment given the political uncertainty regarding future government action. Thus such an instrument is only conceivable in countries with high political stability and willingness of new governments to honour the commitments made by their predecessors. In addition, from the governmental point of view it would be hard to determine ex-ante a) when a particular volume of product/service is required (in particular if the lifetime of such products/services is limited as in the case of drought-resistant crops or medicines) and b) to estimate a fair price for the future. For this reason, we do not see a realistic potential for practical utilization of this instrument in the mid-term. It will therefore not be analysed in depth in section 3.

3. Possible applications

Theoretically, the instrument could be applied for promoting the research and development of medicines that may be needed in a warmer European environment, or for growing drought-resistant seeds. The limitations of the instrument have been described in the previous paragraph.

4. Practical examples of tax reductions in the context of adaptation

In practice, no system of advance market commitments has been introduced so far.

2.4 Other Market-Based Instruments

2.4.1 General description of the policy instrument category

In general terms, market-based instruments (MBIs) are defined as instruments seeking “to address the market failure of 'environmental externalities' either by incorporating the external cost of production or consumption activities through taxes or charges on processes or products, or by creating property rights and facilitating the establishment of a proxy market for the use of environmental services”, (OECD 2011).).

In the following, we will look at what we call “other” MBIs. They specifically address the problem of overuse of natural resources, partially picking up some of the broader concepts, like taxation, that we have already described. Two instruments gaining increasing interest are Payments for Ecosystem Services and Habitat Banking. Additionally, the crucial role of water in future climate change warrants a deeper investigation of several aspects of water markets.

2.4.2 Payments for ecosystem services

1. Description and purpose

Engel et al. (2008, p. 664) note, that the term Payment for Ecosystem Services (PES) is seemingly “used as a broad umbrella for any kind of market-based mechanism for conservation”. The most appropriate and thus more restricted definition is given by Wunder (2005). He states that PES is a voluntary transaction where a well-defined environmental service is being bought at least one buyer from at least one provider if that provider secures the provision of the service.

The general logic of PES can be described with the help of the following figure using the example of forest conservation. As long as the benefits from changing the ecosystem instead of conserving it are larger, a payment is needed in order to avoid e.g. conversion of forests to pasture. The difference of these benefits indicates the minimum payment, while the potential (external) costs to others mark the upper bound of the payment. The payment then has to make the ecosystem manager at least indifferent between his two alternatives, see Figure 8).

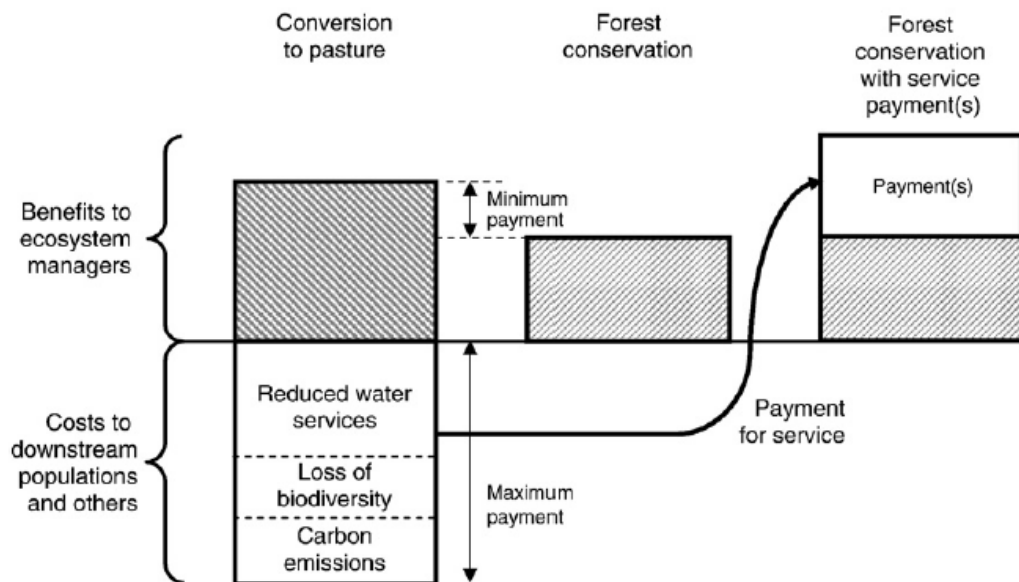


Figure 8: PES at the example of forest conservation⁶

One of the main features of PES is that the polluter-pays principle is replaced by the beneficiary-pays principle. Those who are interested in a specific environmental service compensate those actors who would have otherwise degraded the service by alternative usage. Real-world PES schemes then need answers to the questions who is the seller, who is the buyer, what is the environmental service, how is the degree of conservation measured, how do the payments work and who initiates and administers the scheme (Engel et al. 2008).

PES is by definition used for any kind of ecosystem. The nature of the related service depends on the potential buyer of the service and his interests. Thus, the buyer of the environmental service is either the user or the state, so that user- and government-financed schemes can be distinguished.

2. Link with adaptation

It is now well known that the services provided by ecosystems can play an important role in adaptation. First and foremost, the services provided can weaken the effects of a changing climate, for example by positively influencing the water balance or by dampening the consequences of extreme events. Secondly, PES in itself relates to the sectors agriculture and forests as well as biodiversity, ecosystems and water defined by the EU White Paper.

⁶ Source: Engel et al. (2008, p. 665).

While some PES-schemes have already been implemented around the globe, none of them has the explicit and exclusive goal of adaptation to a changing climate. Adaptation is rather a positive side effect of existing programmes, because their crucial aim is usually to preserve the services of specific ecosystems. One could argue though, that losing the adaptive benefits of certain ecosystems causes (external) costs, which have not yet been considered when setting up PES-schemes. Only this – probably minor factor – would justify looking into this instrument in more detail.

Additionally PES has a regional or local character, making them on the one hand easier to implement. On the other hand it might be difficult to systematically integrate them into national or supra-national strategies. Apart from this, especially state-financed programmes could suffer from (long-term) budgetary restrictions.

3. Possible applications in the context of adaptation

Applications which have already been tried mainly relate to

- Forests,
- Wetlands,
- Biodiversity,
- Watershed protection.

Principally, the goal of PES is to save the values of the environment. But as PES generates (positive) side effects with regard to adaptation to climate change, this instrument will be further analyzed in later parts of the report.

4. Practical examples of PES in the context of adaptation

While the PES systems described below have not been specifically designed for adaptation purpose, they contain several elements relevant for adaptation:

- Vittel PES (France):
Privately funded transfers that take the form of direct payments from one private entity to another and the purchase of land or development rights to land.
- Farming for Nature Pilot Programme (Netherlands):
Based on the precept that in rural areas there are ways to unite agriculture, nature, and landscapes, farmers are compensated for managing their land for the benefit of ecosystem services and the natural landscape. One online document reported in October 2008 that water quality was noted as one of the objectives of the pilot project though it is not clear, if this programme will evolve into a fully functioning PWS programme. As of the publication of this report, there were two operational sites for consideration bringing together researchers, farmers, civil servants, local residents, and regional planning experts.
- ÖPUL Programme (Austria):
The Agri-environmental Programme ÖPUL 2007, which serves as Austria's overarching rural development legislation, provides for direct payment "to promote agricultural production methods compatible with the requirements of: 1) the protection and improvement of the environment and countryside; 2) extensive agricultural production; and 3) maintenance of the countryside to promote the improvement of the environment and the countryside. This structure includes payments for reducing fertilizer and pesticide application and water protection. Some

5.67 billion euros has been allocated for these payments between 2007 and 2013. Information is not readily available on the specific amounts of payments for watershed service.

- Barrier hedgerow programme in East Friesland (Wallheckenprogramm Ost-Friesland, Germany):
The agricultural plots between the hedgerows are usually small. Maintenance of these plots requires relatively much work. A grant is paid to compensate for this disadvantage for plots below 5 ha.
- Coastal agriculture in Lübecker Bucht (Germany):
Farmers receive a payment based on income foregone as a result of a.o. zero-input, high water levels and occasional flooding.
- BIOPLEX (Germany):
Biodiversity and Spatial Complexity in Agricultural Landscapes under Global Change”
Outcome-based reward system for ecological services, ‘ecological goods’ as result of services provided by farmer (e.g. ‘grassland’).
 - ‘Botanical goods’ as indicator for biodiversity
 - Farmers are free to decide how to realize the goods
 - Supply and demand through tendering
 - Public funds
 - Regional payment scheme, region-specific goods in ‘catalogue’
 - Decentralised decisions made by a Local Advisory Board, representing local
 - Authorities, environmental agency, agricultural administration, NGO’s. The tendering procedure included bidding components in order to create competition among the participating farms. Through tendering, the initiators expected to have met the subsidiarity demand of the European Union. The university carried out a project with a small private fund, in which the university played the role of administrating body that carried out the tendering. For the project, a Local Advisory Board was established in 2001. 199 farmers made an offer, 28 eventually participated in the programme. The Local Advisory Board was supported with information out of a willingness-to-pay survey among the local population (Fischer et al., 2003).

Due to its link with adaptation, PES is analysed under task 2, section 2.4.1.

2.4.3 Water markets

1. Description and purpose

With an already changing climate, water is becoming an increasingly important resource. Not only will a rising sea level and a higher probability of weather extremes lead to an increase in flood risks, but there will also be other impacts for water, as in some regions water scarcity and the probability of droughts will rise and water quality and water-related ecosystems could be affected. Accordingly, water markets (and appropriate prices) can play an important role in adaptation.

Thus, adaptation to climate change with regard to water implies that the increasing gap between rising demand and decreasing supply has to be closed. In order to achieve this, water supply needs to be stabilized or enhanced by technical measures (e.g. rain harvesting). More importantly water demand and use has to be made more efficient. This can be done by technical measures, e.g. enhancing irrigation methods, or simply by behavioural measures, i.e. setting price signals to

incentivize thrifty use. As water prices in most European countries are still below their efficient level, correct pricing of water itself can be considered a relevant adaptation measure. Wherever additional measures are to be undertaken, water taxes or subsidies on water saving technologies might be an option. Water taxes could serve as a proxy where efficient prices are for some reason out of reach.

According to Agrawala & Fankhauser (2008), three sectors using water have to be addressed, namely the domestic/municipal, the industrial and the agricultural sector. One has to add, that these sectors, to a differing degree, consume tap and/or ground water. The challenge for tap water lies in the establishment of functioning water markets. The challenge for ground water stems from the fact, that it is very often a public good or that it at least comes at a very low price. In this case the implementation of a water market seems difficult without state intervention.

2. Link with adaptation

Around the world, fresh water resources are very unevenly distributed. To a certain extent this also holds true for Europe. An intensification of this, together with increasing average temperatures, calls for the efficient use of scarce water supplies. Therefore, the efficient (and appropriate) pricing of water is one of the key tasks for climate change adaptation.

To date, water markets in many countries are either non-existent or do not price water efficiently, which causes an overuse of the resource. In an international perspective, Australia (more specifically the Murray-Darling Basin) and Chile are cited as examples of good practice in how to establish water markets. EEA (2009) states, that good European practices in water policy can for example be found in Cyprus (subsidies on the improvement of irrigation systems), Portugal (water eco-tax), Spain (A.G.U.A. program, e.g. increasing waste water use) and the UK (GROW: Green Roof Water Recycling System). These illustrate how water policies based on market mechanisms and economic instruments can play a role in adaptation to climate change.

Correct water pricing can be an effective tool for adaptation in the regions where water scarcity is projected to increase due to the climate change.

3. Possible applications in the context of adaptation

The applications with regard to water markets are less obvious than those for e.g. flood protection. It is nevertheless clear, that water is – from a European perspective – currently overused because of inefficiently low prices. Thus, more efficient pricing or efficiency enhancing taxation (or subsidization) is a necessity. This would affect the following sectors:

- Agriculture,
- Industry (as a user and as an inventor of technological solutions for more efficient water use),
- Private households,
- Water-related ecosystems.

4. Practical examples of water markets in the context of adaptation

So far water markets have not specifically been designed to support adaptation.

Due to its very strong link with adaptation, water markets are analysed under task 2, section 2.4.2.

2.4.4 Habitat banking

1. Description and purpose

According to Eftic et al. (2010, p. ii) habitat banking is “a market where credits from actions with beneficial biodiversity outcomes can be purchased to offset the debit from environmental damage. Credits can be produced in advance of, and without ex-ante links to, the debits they compensate for, and stored over time”.

Habitat banking aims at conserving the ecosystem services of land, including biodiversity. Credits are given for the creation, restoration and enhancement of habitats, while debits occur when ecosystems are unavoidably degraded or destroyed, for example by development actions. Instead of prescribing on-site offsetting the credits facilitate compensating actions on other venues. This is often referred to as a no-net-loss policy, because the goal is not to fall short of an overall threshold of ecosystem services or biodiversity respectively. The concept adheres to the polluter-pays principle, because the economic agent reducing ecosystem services on one site has to pay for the damage by financing habitat projects on other sites (see for extensive descriptions Eftic et al. 2010, Bovarnick et al. 2009 or the website of the Business and Biodiversity Offsets Programme).

The main characteristics of habitat banking are:

- the creation of a market for offsets,
- the possible consolidation of credits to make larger projects feasible,
- the necessity to classify ecosystem services and biodiversity according to their conservation status and desirability to avoid “trading down”,
- the ensuing long-term protection of habitats,
- the need for (governmental) regulation and enforcement of such a market, especially by requiring compensating actions for environmental damages.

2. Link with adaptation

The principal idea of habitat banking is to conserve ecosystem services without geographically restricting them to the degraded site. Up to now adaptation to climate change has not been an aim of habitat banking. The effects in this respect are indirect in nature anyway, as ecosystems and biodiversity can enhance the adaptive capacity of societies. Their services mainly relate to agriculture, the water sector, the mitigation of extreme events and health aspects. Preserving habitats leads to a conservation of these services and thus serves as an adaptation measure with regard to the affected sectors. All in all, there is an indirect link of habitat banking with adaptation equivalent to the one in payments for ecosystem services.

The link between habitat banking and adaptation is obviously indirect. Hence it appears difficult to try to use this instrument explicitly for adaptation. It is really to be recommended just for its original purpose, namely the conservation of nature. The best result one might get from using habitat banking is to avoid mal-adaptation, as there is an enforcement of compensation. We consider this insufficient to warrant further investigation.

3. Possible applications in the context of adaptation

Possible applications could be for

- forests,
- wetlands or
- biodiversity.

4. Practical examples of habitat banking in the context of adaptation

Habitat banking has not been specifically applied in the context of adaptation.

2.5 Financial instruments

1. Description and purpose

The EU has numerous financial instruments at its disposal ranging from loans, sometimes combined with grants, through guarantees to equity investments. In principle, all these instruments can be implemented as Public-Private-Partnerships (PPPs) or as Public-to-Public instruments⁷. Loans are repayable debt where the creditor additionally receives a margin consisting of the interest and administrative costs. Loans can be combined in different ways with grants, so called blending, either by charging interest rates below market level or by directly awarding payments for the investment itself or its implementation. More PPP-related are funds where public and private institutions contribute to the overall funding. This enables the bundling of resources as well as the sharing of credit risks.

Guarantees transfer the default risk of a loan from the (private) creditor to the (public) institutions providing the guarantee. This instrument aims at enhancing the financing of projects without directly awarding a grant or some other form of payment. It facilitates credit transactions by lowering the costs due to default-risk-related interest payments. Guarantees can be interpreted as PPP when either the lender or the provider of the guarantee is a public institution and the other part is played by a private institution. Guarantees do not need to focus on one project but could also back a certain amount of money which then finances a larger number of projects.

In the context of PPPs, equity investments can also feature, when a public institution puts parts of its budget into funds pooling public and private capital. These funds then invest into firms or projects deemed potentially successful by the managers of the fund. Public equity investments are supposed to enhance financing by expanding the amount of available capital funding without directly influencing the decisions of the fund. Besides, the public institutions usually attempt to hold the minority of the fund's capital.

Traditionally, the scope of financial instruments as policy tools is limited to projects that are financially viable but not bankable. Hence, these projects generate sufficient income to repay a loan, but financial institutions do not offer the financial products. The reason for this market failure may

⁷ It is worthwhile noting that one can also categorize loans and guarantee schemes as risk-sharing instruments. In the context of this paper, however, this interpretation is not applied.

be that associated risks are considered too high, or a lack of knowledge of the market or a (perceived) high default risk of the borrower. In the context of adaptation a particular challenge can be that many adaptation activities are not designed to create revenue at all.

A particular feature of adaptation activities is that they do not necessarily need to result in revenues for the investor. Some of them do – e.g. such as using drought-resistant seeds, or reducing water consumption through either different types or varieties of crops. Others do not – such as building dykes or other flood defence structures. Those activities can help to prevent (uncertain) economic damage in the future, but they cannot be evaluated with standard financial tools such as Internal Rates of Return (IRR) or Net Present Value (NPV). The applicability of loans and guarantees differs between those investment types and will be assessed in more depth under task 2, in section 2.5.

2. Link with adaptation

All the financial instruments mentioned above aim at the provision (or the enhancement) of the capital to make an investment. Thus a principal link to adaptation exists, if these instruments are used in order to finance or to implement private actions which would have otherwise not taken place. In the original context innovative small and medium sized enterprises are addressed as they often face financial limitations, i.e. a lack of venture capital to start a promising business. In that approach, financial instruments are restricted to cases of industrial and innovation policy and the scope for use in adaptation to climate change would be limited.

However, as shown before, there is scope for government intervention to promote adaptation if externalities exist, the measure or its result has characteristics of a public good or if informational deficits lead to mal-adaptation. Thus, if an investment is desirable because of its welfare impacts, financial instruments could complement other measures to promote or incentivise adaptation.

It is unlikely that simply raising the amount of available loans will also raise investments in adaptation. At this point, the availability of funds does not seem to be the limiting factor. Loans, especially those offered below market conditions, could convince private agents to undertake investments in adaptive actions. Of course the allocation of the loans needs to be tied to the specific adaptive action. This could change the relative price of different investment projects and thus make firms more inclined to adapt. Accordingly combining loans with elements of a grant offer an interesting field for further investigation.

Guarantees could work in the same direction as a combination of loans and grants. Guarantees reduce the costs of a loan. Thus these loans become relatively cheaper making them comparatively more attractive. Just like before it appears interesting to look into this in more detail, especially where these guarantees are only given for potential investments in sensible adaptation measures.

Contrary to the first two options equity investments do not offer much leverage for adaptation. The main reason is that the managers of capital funds are autonomous in their financial decisions. This holds true as long as there is no control by the public agency involved. Only if a private capital fund is set up in order to explicitly finance adaptation measures or firms offering solutions in this regard, could a public participation offer explicit scope for adaptation policy.

3. Possible applications in the context of adaptation

Financial instruments could be used in all aspects of adaptation to climate change where firms are involved as a potential actor in coping with climate change impacts. Among the wide variety of possibilities the following should be mentioned:

- Climate-proofing of production processes and chains
- Climate-proofing and resiliency against extreme events in building
- Heating/cooling of buildings
- Use of new technology in agriculture, e.g. implementation of higher water-efficiency
- Research and development

4. Practical examples

EIB loans as forms of public-to-public instruments have been spent in combination with country funding for ten adaptation projects between 1997 and 2009. Examples include:

- Flood risk management projects in Germany, Netherlands and Czech Republic
- Coastal and riverbank protection in Italy, Bulgaria and Russia
- Erosion and landslide prevention in Poland

2.6 Public-Private-Partnerships

2.6.1 General description of the policy instrument category

The term Public-Private Partnership (PPP) originated from the USA after World War II and targeted partnerships between public and private investors that worked jointly on projects for urban renewal and expansion (Böhm, 1999, p. 15 and p. 20). In the past decades, PPPs have been used on numerous occasions for public infrastructure projects, such as building schools, hospitals, etc., and also for implementing specific capital projects such as the Channel Tunnel Rail Link in the United Kingdom.

Now, PPPs are designed in many ways. Their major characteristic is that in PPPs, governments/public institutions and private sector actors conclude a legally-binding contract for the provision of assets and/or the delivery of services. Doing so, there is an allocation of responsibilities and business risks among the various partners. Typically, the government/public actor remains actively involved throughout the project's life cycle. The private sector is responsible for the more commercial functions such as project design, construction, finance and operations. The degrees of public and private sector involvement, as well as levels of public and private sector risk can vary significantly.

Hence, from the government's perspective, the main driver for engaging in PPPs is the chance to reduce financial burdens and risks for the public sector; or to foster private sector investment through reducing financial burdens and risk for it.

Example: The Thames Barrier (England):

The Thames Barrier is the world's second largest movable flood barrier, which protects London and the Thames estuary from tidal surges and coastal flooding. It was undertaken as a public project by the then Greater London Council, although design, building supervision and construction were outsourced to the private sector. Three quarters of the budget was raised from central government,

with local taxpayers meeting the balance. When the Greater London Council was abolished in 1986, responsibility for the operation of the barrier moved to the regional water board, the Thames Water Authority. Thames Water was privatised in 1989 and at that point responsibility for the barrier – together with other regulatory and environmental management functions – was transferred to a newly created agency, the National Rivers Authority, which in 1996 became the Environment Agency for England and Wales.

2.6.2 Public contracts

1. Description and purpose

A public contract is defined as an “agreement to perform a particular task to benefit the community at large that is financed by government funds.” (Keynes and Noell, 2000). The agreement is concluded between a public actor, e.g. a federal, state, and local government or authority, and private individuals or corporations where the public player typically purchases goods and services. Public contracts are largely governed by the general law of contracts. Private individuals and corporations often are held to stricter standards in their dealings with the government than in their private dealings. The public actor is limited by constitutional and statutory provisions. In addition, federal laws must be observed because most public projects receive financial aid from the federal government. Many government bodies require competitive bidding in order to prevent favouritism, political graft and corruption – and to spend public money in a responsible manner. (Amended from: Legal Dictionary 2011)

2. Link with adaptation

Public contracting gives public authorities the opportunity to adopt detailed plans and specifications for the provision of work. Hence, the extent and type of the work to be done and the materials to be furnished can be defined in a manner that serves the purpose of adaptation. For example, the public authority can specify the height of bridges and dams, the amount of sudden rainfall that a highway needs to be capable of taking without passing a certain risk level for skidding of vehicles or the protection level against storm-floods of public buildings.

At the same time, public contracts typically do not involve the transfer of risk for e.g. long-term operation and maintenance, or any other risk apart for delivering the service to the agreed scope and quality. Neither do public contracts allow the government to shift part of the financial burden to the private sector (apart from making sure by the tender process that the service is offered at a competitive price).

Hence, we do not see that public contracts can play a significant role as an economic instrument to promote adaptation or to share risks - they are rather an instrument for micro-level regulation.

3. Possible applications in the context of adaptation

Not applicable as an economic instrument, see above.

2.6.3 Service concessions

1. Description and purpose

A *concession* is a business operated under a contract or licence associated with a degree of exclusivity in business within a certain geographical area. The owner of the concession (the *concessionaire*) pays either a fixed sum or a percentage of revenue to the entity with the ability to assign the exclusive rights (*the grantor*). In the case of a public service concession, a private company enters into an agreement with the government to have the exclusive right to operate, maintain and carry out investment in a public utility (such as a water supply system) for a given number of years. This also includes the right of the concessionaire to charge final users of the product. Common examples of concessions are water supply systems and toll highways/bridges on concession basis, and also railway systems (amended from IFAC, 2010, p. 9)

The Directive 2004/18/EC differentiates between work and service concessions and defines inter alia that the following principles should apply to the process of awarding concessions: equality of treatment, transparency, proportionality, and mutual recognition (EU 2011).

2. Link with adaptation

Service concessions can be designed in a way that promotes adaptation, if certain regulatory elements are included in the contracts between grantor and concessionaire. For example, the grantor can define mandatory requirements regarding the way the service/good is managed or regarding the extent of “climate-proofing” the service/good.

In many cases, service concessions would need to be of very long-term nature, i.e. 20-30 years, in order to set the right incentive for sustainable decision making from the concessionaire’s side.

It is worthwhile noting that service concessions only reach an intermediary, i.e. the concessionaire, but not the end-consumer. So any incentive that is implemented through a service concession can only have indirect effects on the general public. Hence, it seems questionable whether a “service concession with regulatory elements” can bring more value with regards to adaptation than an approach where the service/good is provided directly by a public entity.

3. Possible applications in the context of adaptation

Service concessions could for example be used in the following areas:

- Management of water resources with requirements, including water supply, desalination and irrigation systems in areas threatened by droughts (potential conflict with public responsibility to secure sufficient drinking water access)
- Installation, operation and maintenance of public transport (railway systems, highways)
- Access to recreation areas
- Building or improvement of dikes and other flood-protection measures (only if there is a general willingness of the users to pay for protection. This often is not the case today because protection often is offered “cost-free” as a public service; i.e. those services are financed by general taxes.)

4. Practical examples of service concessions in the context of adaptation

While service concessions are a commonly used policy instrument, practical examples explicitly addressing adaptation to climate change could not be identified.

2.6.4 Joint Technology Initiatives

1. Description and purpose

As a form of public private partnerships the so-called Joint Technology Initiatives (JTIs) are supposed to implement the Seventh Framework Programme for research and technological development (FP7) of the EU, i.e. a common research agenda. It focuses on large initiatives in, as of now, five strategic areas. Those areas are Fuel Cells and Hydrogen (FCH), Aeronautics and Air Transport (Clean Sky), Innovative Medicines (IMI), Nanoelectronics Technology 2020 (ENIAC) and Embedded Computing Systems (ARTEMIS). Industry funds at least 50% of the total costs of the research.

2. Link with adaptation

JTIs aim at large scale, long-term projects in cross-country industrial research. While some research results of those projects might prove beneficial to technical adaptation measures in the future, there is no foreseeable scope for JTIs to be used in adaptation, as it usually requires a smaller (regional or local) scale.

3. Possible applications in the context of adaptation

The only exception to the point made in the previous paragraph might be IMIs: JTIs could be used to support the development of innovative medicines for new diseases and health problems that can occur through climate change. Our understanding is, however, that medicines already exist on a sufficient level for the cases relevant for Europe, such as malaria and many vector-borne diseases.

Hence, we do not see major fields for applications of JTIs as economic instruments for adaptation.

4. Practical examples of JTIs in the context of adaptation

Practical examples of JTIs could not be identified in the context of adaptation.

2.7 Risk financing instruments

2.7.1 General description of the policy instrument category

There are many instruments for dealing with the financial burden imposed by disasters. At the most general level, we distinguish *risk financing* from *loss financing* instruments. The important distinction is that risk financing is purchased/organized by persons or a community at risk purposefully and in anticipation of risk, whereas loss financing is arranged by people, governments and the state, often ad hoc, after an event. Risk transfer through key tools such as insurance shares risks before a catastrophe occurs and requires the use of predisaster (ex ante) arrangements in which the risk cedent incurs a cost in return for the right to receive a potentially much larger amount of money after a disaster occurs.

Insurance and other RFIs do not automatically and explicitly lead to climate adaptation, but they can be designed to promote the reduction of climate-related risks, to aid in the recovery process thus

reducing indirect disaster losses, as well as to create an environment for exploiting opportunities. In the following, we will not further discuss loss financing instruments in isolation, as they are reactive and thus do not help to incentivize or share risks in a planned and systematic manner. However, we will discuss some of those in combination with RFIs.

In the remainder of this task we examine:

- Insurance
 - Property insurance (including household contents)
 - Agricultural insurance for crops
 - Business insurance
 - Sovereign insurance
 - Intergovernmental risk pools
- Weather derivatives
- Catastrophe bonds.

2.7.2 Insurance

As the following discussion holds more or less true for all insurance instruments, we first present general points as those relate to insurance. In a next step, we qualify our discussion according to the specific types of insurance.

1. Description and purpose

Insurance is the best known instrument for risk sharing and transfer. Risk averse agents make contractual arrangements in order to access secure post-disaster financing by, for example, purchasing property or agricultural insurance. There are many different types of insurance depending on the types of risk to be covered. While health and car insurance is widely available and used, insurance against natural disasters is usually offered as a voluntary extension of property insurance for domestic and business clients and in stand alone mode for agricultural and sovereign insurance. The most common and traditional types of insurance is indemnity-based, where claims are paid out for losses experienced by the risk cedent. However, in recent years, index-based schemes have been developed, where the prime characteristic is that the occurrence of an event becomes insured, not the loss arising from the event.

2. Link with adaptation

Insurance helps to finance losses caused by events induced by climate variability. As climate change is projected to increase the intensity and frequency of extremes, insurance, if properly adjusted for those changes, is a useful tool for adaptation as well. Insurance is useful for adaptation in two regards:

Incentivizing and enabling and risk reduction

- Because insurance instruments (and other RFIs) require detailed analysis of risks, they can both raise awareness and provide valuable information necessary for responding to and reducing risk. In some countries, insurers with other partners have made flood and other hazard maps publicly available. Insurers can inform their clients directly about the levels of risks they are facing.

Insurers can also present their clients with information on the available risk prevention measures;

- By pricing risk, insurance can provide incentives for its reduction. If climate change risks are factored into the premium calculation, it should theoretically provide incentives for the clients to reduce these risks. For this to be effective, the pricing has to reflect changes in the risk levels when risk prevention measures have been implemented.
- In particular, risk pricing has served to discourage construction in high-risk areas.
- Insurers and other providers can require risk reduction as a contractual condition. For example, insurers have required commercial goods to be stored at a specified height to avoid water damage as a condition for insuring a business, and in some cases have reduced premiums on catastrophe insurance to reward investments in loss reduction.
- Providers can serve as lobbyists or partners with government and communities to promote land use planning, emergency response and other types of risk-reducing behaviour. In many countries, for example, insurers have co-financed research institutes and disaster management centres, and in other cases, have partnered with government to achieve changes in the planning system and more investment in public protection measures.
- On the other hand, insurance often leads to *moral hazard*, which describes the disincentive for risk prevention provided by the perception of security when purchasing insurance cover. This will be discussed further below.

Enabling recovery and economic development

- By enabling recovery, insurance (and other RFIs) reduce long-term indirect losses – even human losses – which do not show up in the disaster statistics. RFIs thus lead to the reduction of post-event losses from extreme weather events, what is commonly viewed as adaptation.
- Insurance (and other RFIs) allow households and businesses to plan with more certainty, and by providing a safety net they facilitate cost-effective, yet risky, investments.

3. Possible applications in the context of adaptation

The application of insurance to key adaptation activities depends on the sector, as discussed later. Insurance-related instruments are extensively used already and there are novel forms under development. One future constraint is risk ambiguity, as the pricing of risks and premiums may become increasingly difficult in a changing climate. As discussed, although insurance can provide incentives for adaptation, often it can lead to disincentives, through *moral hazard*. In order to render it “adaptation-smart,” insurance may be coupled to

- Effective and flexible premium pricing : implement deductibles and limits, reduce premiums and relax contractual conditions when risk has been reduced
- Requirements for risk reduction for clients
- Design of longer term insurance contracts
- Tax reductions when purchasing cover
- No ‘bail out’ clauses from governments on respect of damage from disasters.

Insurance has significant potential for climate change risk sharing and transference. In combination with the incentives described above it has the potential to be an effective instrument against climate change. Tasks 2 and 3 will describe what these features would look like in each type of insurance.

There are different types of insurance depending on the types of risk covered, and we now discuss those specifically.

2.7.2.1 Property insurance

1. Description and purpose

Property insurance covers consumers for losses of property and household contents for hazards such as floods, windstorm, landslides and hail. (The business sector is similar- see later).

2. Link with adaptation

Property insurance may indirectly incentivize adaptation, by setting a price on damage from natural hazards that respond to climate change .

3. Possible applications in the context of adaptation

Theoretically, this type of insurance can incentivise measures like

- Flood proofing of buildings and property
- Retrofitting of houses (e.g. against windstorm)

4. Practical examples

- Property insurance pool: Catastrophes Naturelles, France (see Annex and discussion in Task 3)

2.7.2.2 Business insurance

1. Description and purpose

Similar to property insurance, business insurance covers property, plant and equipment and goods against damage from natural hazards. Additionally business interruption and lost profits can be insured, as well as liability for exacerbating the cost of a natural disaster.

2. Link with adaptation

Business insurance may indirectly incentivize adaptation by setting a price on damage from natural hazards that respond to climate change.

3. Possible applications in the context of adaptation

Theoretically, this type of insurance can incentivise, among others:

- Flood proofing of buildings and property
- Retrofitting of building (e.g. against windstorm)

- Local flood protection measures

4. Practical examples

Similar to domestic property insurance, in most markets in the EU businesses may purchase insurance for property and other assets.

2.7.2.3 Agricultural insurance for crops

1. Description and purpose

Crop insurance for protection mostly against drought hazard is widespread in the EU.

2. Link with adaptation

Crop insurance may indirectly incentivize adaptation by setting a price on weather-related risks

3. Possible applications in the context of adaptation

Theoretically, this type of insurance can incentivise, among others

- Switching to heat- and drought-resistant cultivars
- Implementation of additional irrigation measures

4. Practical examples

- See Spain example in Annex

2.7.2.4 Sovereign insurance

1. Description and purpose

Governments may also purchase insurance to cover costs associated with infrastructure losses and relief expenditure

2. Link with adaptation

Sovereign insurance may indirectly incentivize adaptation as with other types of insurance.

3. Possible applications in the context of adaptation

Theoretically, this type of insurance can incentivise, among others

- Flood proofing infrastructure
- Retrofitting buildings
- Building larger scale flood protection schemes

4. Practical examples

- The Mexican insurance programme (see Annex and discussion in Task 3)

2.7.2.5 Intergovernmental risk pools

1. Description and purpose

Intergovernmental risk pools are a variant of sovereign insurance, which work via governments setting up a joint pool which is fed by annual payments from participating members. Generally, such pools need reinsurance for very large losses in order to avoid insolvency.

2. Link with adaptation

Intergovernmental risk pools may indirectly incentivize adaptation as with other types of insurance

3. Possible applications in the context of adaptation

Theoretically, this type of insurance can incentivise, among others

- Flood proofing infrastructure
- Retrofitting buildings
- Building larger scale flood protection schemes

4. Practical examples

- Sovereign insurance pool: Caribbean Catastrophe Risk Insurance Facility (CCRIF) (see Annex and discussion in Task 3)

2.7.3 Catastrophe bonds

1. Description and purpose

A catastrophe bond is an instrument whereby disaster risks are packaged (*securitized*) in the financial markets (they are usually parametric i.e. index-based). The investor receives an above-market return provided a specified catastrophe does not occur during the contract, but sacrifices interest or part of the principal if the event does occur. Disaster risk is thus transferred to international financial markets that have many times the capacity of the reinsurance market.

Catastrophe bonds are used by insurers to reinsure some of their exposure. Interestingly, they can also be used by national governments to insure sovereign risks as discussed further below (see above for the Mexican case).

2. Link with adaptation

None, since payouts are not influenced by the severity of the losses.

3. Possible applications in the context of adaptation:

Pricing and conditions may be varied in accordance with risk reduction measures adopted by the party at risk.

4. Practical examples

See Mexico example (see Annex and discussion in Task 3)

2.7.4 Weather derivatives

1. Description and purpose

Weather derivatives are contracts where payouts are linked to physical 'triggers', e.g. number of days with temperatures below or above a specified threshold, or rainfall above or below a specified level. They are two-party contracts; if the trigger event occurs, one party provides a payout to the other. Thus, in this simple structure, they do not pool, but share risks. There are many variants of weather derivatives, but mostly they have been used in the energy industry, by snowmobile makers and manufacturers of air conditioners, as well as insurers. Often the instruments are traded with third parties, or retained by insurers to make a book of business. In the latter case, effectively the risks are pooled as with conventional insurance. Also, there are novel developments to link it to drought protection in a development assistance context.

2. Link with adaptation

Derivatives are similar to insurance as they price and share risk; they can also form the basis of risk pools.

3. Possible applications in the context of adaptation

Weather derivatives can be used similarly to insurance. As the instrument prices and shares risk, there is an incentive to reduce risks and foster adaptation.

4. Practical examples

The Ethiopian weather derivative (see Annex)

3 Conclusions

Based on the analysis and discussion above, we find that the following policy instruments can have relevance for promoting adaptation to climate change and for risk sharing/transfer. Hence, these policy instruments will be analysed in more depth in tasks 2 and 3.

1. Instrument category: Subsidies
 - Grants
 - Tax reductions
2. Instrument category: Taxes
 - Land use taxes and fees
3. Instrument category: Licences, permits and variations
 - Adaptation Market Mechanism
4. Instrument category: Other market based instruments
 - Water markets
 - Payments for Ecosystem Services
5. Instrument category: Public-Private Partnerships
 - Financial Instrument: loans
 - Financial Instrument: guarantees
6. Instrument category: All RFIs
 - Insurance:
 - Property insurance
 - Agricultural insurance for crops
 - Business insurance
 - Sovereign insurance
 - Intergovernmental risk pools
 - Weather derivatives,
 - Catastrophe bonds.

The remaining policy instruments that have been described in the previous sections will not be analysed in depth for the following reasons:

- Their application for the promotion of adaptation would be characterised by low efficiency, high costs, or low market liquidity (price support, tradable unit systems on the local level),
- There are insufficient links with the adaptation objectives analysed in this study (carbon tax, energy tax, habitat banking),
- They do not match with the definition of an economic instrument but rather have regulatory characteristics (public contracts, service concessions).

Note that the concept of project based offsets is integrated into the Adaptation Market Mechanism evaluated in task 2.

Task 2: Analysis of economic instruments in terms of promoting adaptation

Based on the comprehensive- and shortlists list discussed in task 1, task 2 now provides a detailed discussion of key economic instruments in terms of promoting adaptation.

1 Methodological approach in task 2

For the assessment of policy instruments below, the following criteria and sub-criteria have been applied. The criteria have been suggested by the Commission, the sub-criteria and indicators have been developed by the project team. The methodological approach for evaluating an instrument's performance for each of the indicators is purely qualitative and focuses on expert judgement – which, where applicable, reflects practical experience and scientific know-how generated with the instrument (or similar ones) in other contexts. Some more information is provided in the paragraphs below. We would like to emphasize that a quantitative assessment is not possible at this stage and in the scope of this broad study. More detailed or quantitative recommendations would require further in-depth analysis under consideration of sector- and country-specific circumstances; also see section “further research needs” in chapter 4⁸.

1. Applicability:

- Applicability of the PI to incentivize adaptation. This involves assessing which types of adaptive activities could be incentivized by the PI.
- Institutional feasibility. Here we check whether policymakers have already applied similar instruments in the past and thus have gained experience.
- Consistency with other policy instruments. We assess whether interaction of policy instruments may lead to unwanted effects or duplication of incentives.
- Acceptability to interest groups. We discuss whether interest groups are likely to oppose the PI.

2. Effectiveness:

- Effectiveness is the extent to which an activity fulfils its intended purpose or function. In the context of this study, we particularly look at the potential effectiveness of an economic

⁸ The ‘Forum for market-based instruments “The role of market based instruments in achieving resource efficient economy” comes to the same conclusion and states on pp. 4-5: “Launching any new instruments should be preceded by a careful analysis: data collection, and assessment against resource efficiency policy objectives. We need to argue why they are needed and whether it's a most efficient solution and what kind of side effect we can expect. Many instruments will be region or country specific so it is clear that the design of any new market based instrument in each country would need to consider and take account of a wide range of country-specific political, economic and social issues. Introduction must be done with a carefully designed timeframe and with a gradual approach, a holistic view and with strong political will.”

instrument for *incentivising* a desired adaptation action or outcome. Our evaluation is based on general experiences made with the respective instruments, expert judgement, and – if applicable – insights gained from the case studies of implemented policy instruments (see Annex II). In each of the following subchapters, the effectiveness of a MBI is assessed based on the instrument's ability to incentivize adaptation in each sector defined in the EU White Paper. The results of the evaluation are summarized in table-format for all selected MBIs per sector. Given the high level of aggregation of our assessment, we define effectiveness of a policy instrument to be high if the link between the policy and the adaptation action is typically direct. While indirect effects can be significant under special circumstances, generally indirect transmission of incentives will lead to their dilution.

3. Efficiency:

- What resources does an instrument need to achieve its objective? What is the relation between costs and benefits?
What transaction costs will accrue? Transaction costs relate to the administration of the PI and costs that entities that want to use the instrument face.

4. Equity:

- What distributional consequences will arise? Will they be negative, i.e. regressive?
- Conditions and barriers – are there any specific barriers or supportive conditions that are not covered under the preceding criteria?

In the following, we will structure our discussion of PIs accordingly and then evaluate qualitatively how they contribute to each of the criteria.

2 Analysis of economic instruments in terms of promoting adaptation action

2.1 Subsidies

Subsidies can be either provided directly, i.e. in the form of direct payments, or indirectly, i.e. in the form of a reduction of a payment obligation. Accordingly, we look at grants as direct subsidies and at tax reductions as indirect subsidies in this subchapter. The effect and thus the connection to adaptation of both instruments are identical: In both cases an action desirable on welfare grounds is incentivized by offering a private entity the possibility to reduce his costs of adaptation.

2.1.1 Grants

2.1.1.1 Definition of the instrument for the purpose of subsequent assessment

Grants are a form of public assistance to individuals or firms to support adaptation actions. They reduce the individual cost of adaptation measures and thereby promote them. Different adaptation measures might be subsidised. Examples are:

- Changes in crops cultivated
- Improving flood protection
- Improving insurance
- Improving working conditions by cooling or better isolation of buildings
- Increasing green areas to reduce heat island and to improve water drainage

These examples show that grants are a very general instrument which could be applied to very different areas of adaptation. Since grants directly affect the costs of adaptation measures they are in general very effective in promoting them. However, they are normally very costly and therefore grants should only be used with care.

2.1.1.2 Assessment: How can grants and their variants promote adaptation activities?

1. Applicability

Applicability of the PI to incentivize adaptation

Grants reduce the cost of adaptation measures for the implementing party. When individuals decide on adaptation measures they compare the cost of these measures with potential discounted benefits. They will undertake adaptation measures if the benefits exceed costs. Grants directly reduce the costs and therefore they promote adaptation. However, adaptation might have been undertaken anyway. In this case grants imply a high deadweight loss. Things are different if due to positive externalities social benefits from adaptation exceed private benefits. In this case the private decision on adaptation which does not take social benefits into account leads to too low adaptation activity. Hence the subsidy should cover positive externalities. See CEPS & ZEW (2010a) for a more formal analysis of positive externalities.

Institutional feasibility

Adaptation activities with positive externalities can be identified in a general way on a national level. At the regional level the influence of pressure groups asking for unnecessary subsidies could be much higher than on the national level. Therefore, decisions on the regional level are likely to be too generous and decisions on subsidies should be undertaken at an aggregate level. Tokila and Haapanen (2008) show that the deadweight loss associated with subsidies depends on the regional characteristics as well as on the activities subsidised.

Consistency with other policy instruments

Grants can be designed so that they are consistent with other policy instruments. In some cases they might even promote the use of other policy instruments. An example might be a subsidy to insurance. In some cases there are complementary instruments to grants. An alternative to an adaptation promoting subsidy might be a tax on behaviour which hinders adaptation.

Acceptability to interest groups

Since the cost of subsidies is normally borne by the general taxpayer, there are normally no special obstacles against single subsidies. In contrast it is more likely that once an adaptation promoting subsidy is introduced, different pressure groups will ask for more subsidies. In many cases it will not be clear whether the relevant activities really improve adaptation.

2. Effectiveness for incentivising a desired adaptation outcome

The following table summarizes the policy sectors where grants might have an effect.

Table 7: Effectiveness of grants

<u>Policy sector as per White Paper</u>	<u>Effectiveness</u>	<u>Comment</u>
Production Systems (= Industry)	Medium	Subsidies have very direct effects on the structure of production. However, it is not clear whether there are public benefits from a change in the production system.
Physical infrastructure (public)	Low	Subsidies go to private activities
Physical infrastructure (private)	High	Subsidies have very direct effects on the cost of infrastructure.
Health policies	High	Subsidies might help to improve working conditions.
Social policies	Low	There are no direct social effects
Agriculture & forests	Medium	Subsidies might help to change crops and make them more resistant to climate change.
Biodiversity, ecosystems, water	Medium	Subsidies might help to reduce land coverage and to reduce intensity of land use.
Coastal and maritime areas	Low	Mainly public investors

The effectiveness of grants to incentivize adaptation has been proven in different countries and circumstances. For instance the “preventive measure programme” in Sweden funds municipal preventive measures such as dykes or landslide protection against natural disasters. The Australian “Farm ready programme” and “Climate change adjustment programme” both focus on the agricultural sector. Farmers that are confronted with the challenges of climate change are able to apply for supporting grants, partly combined with PPPs or loans. These instruments have been specifically designed to cope with the impacts of changing climatic characteristics. For further information see the case studies in Annex II (page 270ff).

3. Efficiency

What resources does the instrument need to achieve its objective?

Grants reduce the cost of adaptation measures. The question is whether this is necessary or whether individuals would have undertaken the same measures without the grant. In these cases grants are just taken as windfall gains and public expenditures could have been saved.

Consider adaptation measures as a normal private good. Individuals or firms can engage in some expenditure that will tend to reduce the damages or increase the benefits from climate change. An adaptation measure will be undertaken if the cost of this measure is below the expected benefits. Normally benefits from adaptation measures are a sufficient incentive to undertake these measures. Then no subsidy is necessary. However, the future benefits of adaptation measures are uncertain. Thus individuals might underestimate the benefits from adaptation measures. In these cases the government could encourage these individuals to undertake adaptation measures by subsidizing the cost. However, this means that individuals benefit from subsidies to private investment. The return to the investment is again private. Hence subsidies of this type imply redistribution towards the subsidised individuals or firms. It might be worth noting that many economic activities – in fact all types of insurance – aim at future and uncertain benefits. So it is questionable that adaptation measures have a special feature that justifies subsidising them.

Things are very different if benefits do not only occur for those individuals who undertake adaptation measures but also for other individuals. When individuals decide on adaptation measures they will only take their individual benefits into account. Since the social benefits exceed the private benefits of adaptation measures the individual decision leads to too low adaptation investment. In this case it is socially optimal to reduce individual cost of adaptation measures by subsidizing them. Hence external benefits – the benefits of other individuals – justify a subsidy.

Consider the examples above. A change in crops cultivated improves future harvests of farmers. These are their individual benefits. There are no externalities. The same applies to a better insurance. In the case of an improvement of flood protection it depends on the area which is protected. If flood protection only covers the area owned by the individual undertaking the measure then there is no need to subsidise. However, in many cases public property or the property of other individuals will also be protected. In this case there is an externality and therefore it is optimal to subsidise. The case for subsidies is even more pronounced for the greening of city areas. Here the general public benefits from better microclimate and an improved drainage which implies better resistance to intense rains. So the social benefits of these measures are large. In contrast, the individual benefits are rather small. In case of an improvement in the working conditions it is less clear. Direct costs are covered by the employer. In contrast benefits occur to the employees. In a perfect labour market the

discrepancy would lead to a wage adjustment. However, due to insufficient knowledge about the distribution of wages and working conditions it leads to insufficient wage adjustment. In this case a subsidy financed by a wage tax might lead to an optimal outcome. Refer to CEPS & ZEW (2010a, b) for more examples and a more detailed analysis.

If the subsidies cover the external benefits of adaptation measures, then they are very efficient. The reason is that they directly support payments for adaptation measures. Leakage effects and administrative costs are rather low. However, the difficult task is to divide benefits into private and social. In many cases it will not be clear how large private benefits and social benefits are. If private benefits are underestimated or public benefits are overestimated then the subsidy will be too large. This is particularly important because it is in the interest of private actors to understate private benefits and to overstate the public benefits.

To assess the efficiency of subsidies it is important to know what the potential adaptation measures are and which adaptation measures are subsidised. Take the example of an area which is vulnerable to flood events. There are two ways to adapt to this: One way is to leave the area and settle somewhere else. The second is to improve flood protection. Leaving the area might be the individually and socially optimal response. However, if the government pays a grant to improve flood protection, individuals might decide to do so. In this case the grants reduce welfare. On the other hand, there might be the situation that the individual costs of moving are lower than the individual costs of protection and the social cost moving are higher than the social costs of protection. When there is no subsidy the individual would move which is socially inefficient. In this case the subsidy leads the individual to choose the protection measure which is socially efficient. Agrawala & Fankhauser (2008, p. 103) argue that a subsidizing insurance premium is more likely to hinder needed household adaptations to the new climatic conditions, increasing household risk in the long term.

An example for the consequences of different private and social aims in adjustment to climate change is winter tourism. Due to global warming there is less snow in the Alps and therefore some areas will not be save skiing resorts any more. This will have serious effects on winter tourism. There are several ways to adopt for this. Some areas will have to turn away from classical winter tourism. In other areas skiing resorts might move to higher altitudes. In some cases artificial snow making might help to avoid declining tourism. Even today many regions in the Alps use snow guns to offer secure skiing. There are individual benefits from artificial snow to operators of ski-lifts. Beside this are positive economic externalities associated with artificial snow. These occur to the local tourism sector. These externalities might justify subsidies for artificial snow. These subsidies increase competitiveness to other skiing resorts and require more investment in these areas. Hence, there are distortions to competition. Furthermore, adaptation by artificial snow making has detrimental environmental impacts. In particular, it reduces water supply and increases energy consumption with a consequent impact on greenhouse gas emissions (Abegg et al., 2007). In addition, interventions of bulldozers and excavators can be very destructive on the environment. The negative environmental externalities increase costs of artificial snow making significantly and therefore make subsidies very questionable.

What transaction costs will accrue?

Transactions costs of grants are commonly not negligible. Their awardance requires information, a sufficient body of administration and potentially attracts rent-seeking which additionally causes transaction costs in the private sector. All in all the transaction costs of many grants are sizeable.

4. Equity: What distributional consequences will arise?

The distributional effects of subsidies clearly depend on the goods or activities which are subsidised. If the protection or improvement of property or production systems is subsidised, then only owners of property or production systems can benefit. However, the subsidy will be financed from general tax revenue. This implies that there is redistribution from individuals not owning property or production systems to those who are the owners.

5. Conditions and barriers

In general there are few barriers for subsidies. Their costs are hidden in the general budget and they are paid for activities which are generally regarded as welfare improving. However, it is often difficult to distinguish between private and public benefits from subsidies. This particular holds because externalities are difficult to measure. They have to be estimated by economic models and therefore they depend on assumptions and uncertainties (Honkatukia, 2002). Subsidies should only be considered as an instrument if public benefits exceed the private. However, pressure groups might have an interest to overstate the public benefits and to understate private benefits.

In the case of subsidies for production systems and private infrastructure there might be conflicts to the EU State aid rules. This governs the application of subsidies to industry, such as direct grants, cash injections, loans, tax deferrals or exemptions. EU State aid rules aim to ensure that no Member State supports its own industries to the potential detriment of those in other Member States. A grant paid for adaptation behaviour in one country and not in the others might induce a distortion to competition.

2.1.1.3 Recommendations

Grants are a powerful instrument to promote adaptation behaviour. However, they are very costly and they are unnecessary if benefits from adaptation only occur for the individual undertaking the adaptation measure. Hence, subsidies should only be applied if there are large positive externalities associated with the relevant adaptation measure. Furthermore, different adaptation measures have to be compared to ensure that a subsidized measure is socially the most efficient.

Grants are widely applied in different contexts. The case studies from Sweden and Australia in Annex II (pages 264-276) exemplify that they are already used to support preventive measures and adaptation in the agricultural sector. An evaluation of these programs is not available yet though.

2.1.2 Tax reductions

2.1.2.1 Definition of the instrument for the purpose of subsequent assessment

Tax reductions are like grants a form of public assistance to support adaptation actions. There might be several different tax rates which could be adjusted for different adaptation measures. First think of household liable to a wage or income tax. Normally taxable income is independent from adaptation measures. As a subsidy, it might be allowed to deduce adaptation expenditures from taxable income. Examples could be tax deductibility of household expenditures for better isolation of buildings or greening of roofs.

Firms normally can either directly subtract expenditures from revenue or in case of investment goods they lead to a depreciation that reduces future revenues. Hence, adaptation expenditures normally lead to tax reductions. To induce an additional incentive it might be possible to increase deductibility of adaptation cost by a factor. For example expenditures for flood protection could be increased by 50% when taxable profits are calculated.

An alternative form of tax reductions are reductions in goods taxes. For example there might be a reduced VAT for goods which are more resistant to climate change than others. This reduces prices for these goods and thereby makes their production more attractive. This implies that the more resistant good is preferred.

2.1.2.2 Assessment: How can tax reductions and their varieties promote adaptation activities?

1. Applicability

Applicability of the PI to incentivize adaptation

Individuals and firms will compare costs and benefits from adaptation and undertake adaptation measures if benefits exceed costs. Tax reductions to individuals or firms have similar effects as grants: They reduce the direct tax liability and decrease the individual cost of adaptation measures. Due to the direct reduction in adaptation costs this is a very effective way to induce adaptation. However, tax reductions also imply high fiscal costs. In many cases private investment in adaptation measures will occur anyway because private benefits exceed private cost. Only when social benefits exceed the private benefits it is socially optimal to subsidise private adaptation measures.

The reduction in goods taxes directly reduces prices of goods and therefore makes them more competitive. This could compensate higher production costs due to adjustment activities. Hence, reductions in goods taxes might be an instrument to promote the change in production systems. However, like in the case of direct taxes they imply high fiscal costs. These would only be justified if the benefits of adaptation measures are public.

Institutional feasibility

The identification of adaptation activities with positive externalities should be done on the national level. At the regional level the influence of pressure groups asking for unnecessary subsidies should be much higher than on the national level. Therefore, decisions on the regional level are likely to be

too generous and decisions on subsidies should be undertaken at an aggregate level. An advantage of tax reductions is clearly that they imply very little administrative costs since they can be handled within the existing tax collection system. On the other hand there is the problem that the costs of tax reduction are even more intransparent than grants. Benefits are very well visible for those who obtain them. As a consequence there is a tendency for too high subsidies.

Consistency with other policy instruments

Tax reductions can be designed in a way that they are consistent with other policy instruments. In some cases they might promote the use of other policy instruments. An example might be a subsidy to insurance. However, there might also be alternative tax reductions. So instead of reducing taxes that promote adaptation behaviour there might be higher taxes for behaviour which hinders adaptation.

Acceptability to interest groups

Tax reductions lead to reduced revenue. To compensate for this other taxes have to be higher. However, this is very intransparent. As a consequence, there are now special objections to tax reductions. Sometimes they might even be regarded as fair because tax rewards reward warranted behaviour. So there is the danger that there are too little obstacles to tax reductions.

2. Effectiveness for incentivising a desired adaptation outcome

Table 8: Applicability of tax reductions

<u>Policy sector as per White Paper</u>	<u>Applicability</u>	<u>Comment</u>
Production Systems (= Industry)	High	Goods tax reductions have very direct effects on the cost of products. However, it is not clear whether there are public benefits from a change in the production system.
Physical infrastructure (public)	Low	Tax reductions go to private activities
Physical infrastructure (private)	High	Tax reductions have direct effects on the infrastructure cost.
Health policies	Medium	Tax reductions might help to improve working conditions.
Social policies	Low	There are no direct social effects
Agriculture & forests	Medium	Tax reductions might help to change crops and make them more resistant to climate change.
Biodiversity, ecosystems, water	Low	Tax reductions might help to reduce land coverage and to reduce intensity of land use.
Coastal and maritime areas	Low	Mainly public investors

3. Efficiency

What resources does the instrument need to achieve its objective?

If the costs of adaptation measures reduce direct tax liabilities, then the costs of adaptation measures decline. This gives a direct incentive to undertake adaptation measures. However, individuals might have undertaken the same measures without the tax reductions. Since public expenditures could have been saved there might be a large deadweight cost associated with the tax reduction.

In general individuals or firms will undertake adaptation measures if the benefits from these measures exceed the costs. If there are only private costs and benefits and individuals assess these correctly, then any form of public intervention leads to a decline in welfare. However, there might be a problem because the future benefits of adaptation are uncertain. Due to that individuals might underestimate adaptation measure benefits. Then the tax reduction which encourages individuals to undertake adaptation might be welfare improving. However, this implies that the government knows costs and benefits from adaptation measures better than private individuals.

If adaptation measure benefits do not only occur for those individuals who undertake adaptation measures but also for other individuals, then there is a case for public subsidies. The individual decision on adaptation measures only takes private benefits into account. If social benefits exceed private benefits there is too little private investment into adaptation. Then it is socially optimal to reduce individual cost of adaptation measures by subsidizing them.

Positive externalities can mostly be associated with private investment. Examples might be flood protection or investment into the greening of cities. Such investment is normally not fixed to a specific good or production activity. In these cases reductions in direct costs seem to be more appropriate than reductions in goods taxes. A change in the goods produced or in the production structure normally has only private benefits. Hence, there is no case for a subsidy.

4. Equity: What distributional consequences will arise?

Tax reduction implies a transfer from the general tax payer to those individuals obtaining a tax reduction. The return on the investment subsidised by the tax reduction is again private. Hence, subsidies of this type imply redistribution towards the subsidised individuals or firms.

5. Conditions and barriers

There is a general tendency for subsidies to be too high. The reason is that their costs are very opaque. In contrast the benefits are highly visible to those who obtain them. As a consequence there might be interest groups pressing for tax reductions. It is in their interest to overstate potential public benefits and to understate private benefits from adaptation. The opacity of tax reductions is even higher than the intransparency of grants. Hence, if there are large external benefits from adaptation, grants might be the preferred method.

2.1.2.3 Recommendations

Tax reductions have the potential to promote adaptation behaviour. Tax reductions are unnecessary if there are no positive externalities associated with adaptation measures. In this case tax reductions imply a large deadweight cost. Hence, subsidies should only be applied if there are large positive externalities associated with the relevant adaptation measure.

A tax reduction might affect the direct tax liability of individuals or firms. In this case there is only very little difference from a grant. However, a grant is more transparent than a direct tax reduction. Hence, in this regard the grant is the preferred policy instrument. Reductions in goods taxes have a direct effect on the production system and the goods produced. However, adaptations of production systems or goods produced normally imply mainly private and only very little external benefits. Hence, there seems to be no case for a goods tax reduction.

Instead of direct grants, tax reductions probably provide more favourable incentives to engage in activities that increase the resilience of production sites, power utilities and real estate in general, as direct grants tend to be more prone to the generation of windfall gains and lobbying than tax reductions. Besides, tax reductions might be more able to address wider target groups than specifically designed direct grants.

2.2 Taxes

Links between taxes and adaptation to climate change exist where an action has to be considered as mal-adaptation (exhibiting negative externalities) and its taxation aims at reducing the said action. The sealing of soil or building in areas potentially affected by extreme events fall under this description. Thus we look at a specific kind of tax in this subchapter, namely land use taxes aiming at the reduction of soil sealing to improve water-runoff during heavy rainfalls or floods and to decrease the use of (ecologically) valuable land.

2.2.1 Land use taxes and fees

2.2.1.1 Description for the purpose of subsequent assessment

Land use and land management is important for the use of natural resources including water, soil, nutrients, plants and animals. Besides land use has a major impact on the resilience to climate change. This holds on the national as well as on the regional or urban level: On the national level land use affects deforestation and has effects on erosion and thereby on water quality. Retention areas close to rivers prevent flooding of urban areas.

Within urban areas open land is important for recreation and mental health as well as for micro climate regulation. Therefore, the amount of unsealed area is an important determinant of resilience to climate change. Furthermore, unsealed area helps to cope with extreme weather events such as intense rain. It is such a crucial resource that it cannot be ignored. However, particularly in urban areas, soil is being sealed with the increase of housing and infrastructure. In the years between 2000 and 2006 European soil sealing increased by 3.4 %. This was the largest increase in all land use

categories (see EEA, 2010c). Today more than a quarter of EU territory is directly affected by urban land use. And in the next decades urban areas will further expand. By 2020, approximately 80 % of Europeans will be living in urban areas.

Soil sealing affects ecosystem services and the quality of life in a city in many ways. An important aspect is the micro climate. In EEA (2010b) the effect of soil sealing on temperature is shown for Budapest. In green areas with no or very low soil sealing it is much colder than in the highly sealed built up areas. From a European perspective, a low soil sealing per inhabitant in a predefined area is definitely favourable as it reduces the overall ecological footprint. Overall, urban sprawl reduces the proportion of sealed areas. However, high compactness and thus soil sealing of cities will have negative effects on the quality of life within cities. Therefore, cities should avoid soil sealing where possible and use every opportunity to maximize unsealed and green areas as well as further green elements like street trees, green walls and roofs while maintaining their compactness and urban density. - Figure 9 shows the mean soil sealing in European capitals within the Urban Morphological Zone (UMZ) and the average soil sealing in m² per capita. There are large differences in soil sealing among European cities. Mean soil sealing per UMZ ranges from 23 % in Stockholm to 78 % in Bucharest. Overall, in Eastern and Southern cities the soil sealing tends to be higher than in Northern cities. However, when considering the average soil sealing in m² per inhabitant the relative positions could be reversed. Some cities that are highly sealed have a lower average soil sealing per capita like Tirana, Sofia and Athens and lower sealed cities like Brussels, Vaduz and Helsinki have a very high soil sealing per inhabitant. Thus, Helsinki implements more ecosystem services within the city area while Sofia saves space for other uses outside the city boundaries, see EEA (2010b, 2011a, 2011b) for further details.

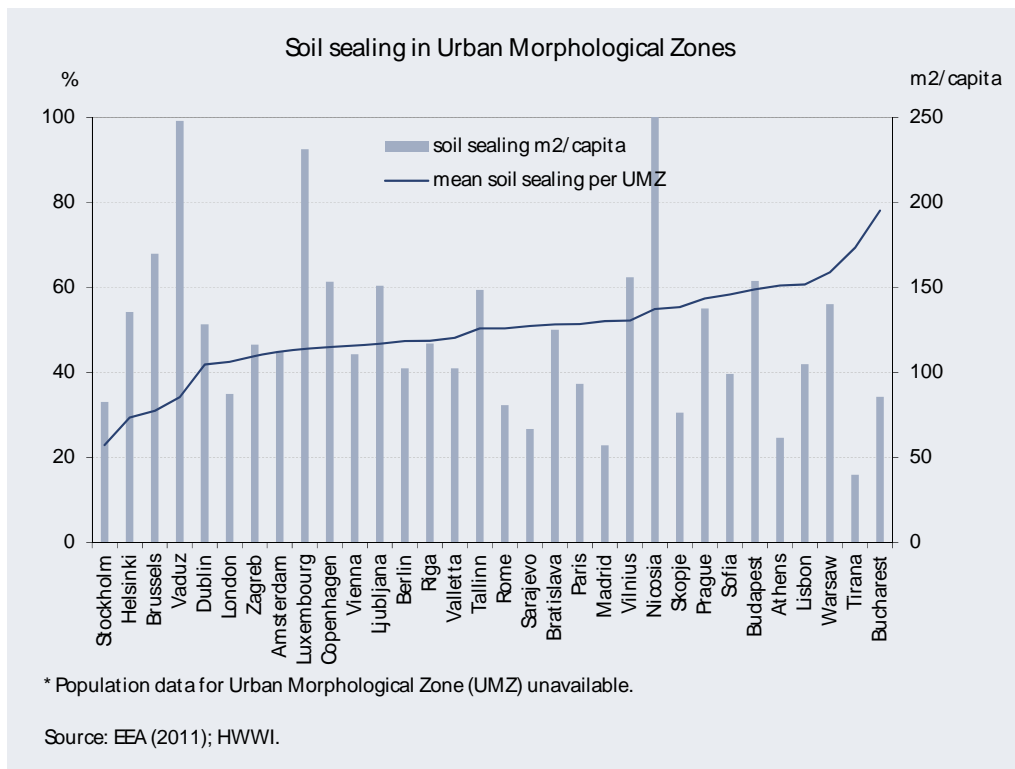


Figure 9: Land use in European cities

2.2.1.2 Assessment: How can land taxes promote adaptation activities?

1. Applicability⁹

Applicability of the PI to incentivize adaptation

Land taxes can be divided in three categories: land sales tax (capital profit tax), purchase (registration) tax and usage (real estate) tax. Taxes on sales or purchases affect the trading of land and might help to avoid price bubbles. However, they will have only very little impact on the use of land and therefore on the environmental quality. A land use tax has the purpose to increase the cost for the use of land. This gives an incentive to economize land use. Hence, land use taxes are an alternative or a complement to traditional land use planning.

There are several forms of land use taxes and the actual design of the tax might be important for the effectiveness and efficiency of the land use tax. A land value tax considers only the value of land not the use. However, the land value is affected by the potential use of land. Land which could be used for buildings or industrial purpose will have a higher price than agricultural land and therefore the tax will be higher. This implies that it is optimal to use the land as intensively as possible. Hence, the tax enforces an intense use. The surface area tax is based on the area of a land property. Here a large area implies higher taxes than a small one. This causes a higher building density and could lower the prices in these high-density areas. Another alternative land use tax is based on the area of soil sealing. This gives an incentive to leave as much land uncovered as possible.

Institutional feasibility

Currently most countries tax land property. These taxes are mostly local and are an important source of local revenue. Between countries there are large differences in the tax base and in tax rates. The property tax is normally levied on land and improvements (e.g. structures, buildings). There are two main taxation approaches: area-based assessment and value-based assessment which can be divided into capital and rental value approaches. Under area-based assessment a charge is levied per square metre of land area, of building or of some combination of the two. Thus, the tax liability is directly based on the size of the land and buildings. The capital value approach on the other hand estimates the market value of individual properties. The rental value assessment is based on the estimated rental value or net rent - see Bird and Slack (2005) for an overview.

The market value is often considered as the better tax base rather than the land size. First, nearby services (like transit systems and parks) are more reflected in the value than in the size of the property. Second, the market value approach accounts for the benefits of the neighbourhood (e.g. a property near a park or near a factory) which are often created by government expenditures and policies. Third, under the area-based approach property taxes are the same for all properties with the same size without considering if they are in a low- or high-income neighbourhood. Arguments for the area-based assessment are that they tend to be less volatile because they do not change when

⁹ Although different kinds of land taxes are already in place in European countries, none has the explicit goal to incentivize adaptive action. Thus no case study or evaluation of existing experiences can be provided.

the property value changes. Furthermore, the area-based approach is easier to understand and cheaper to administer in countries with a less developed real estate market.

To change from either a value based or an area based tax to land use tax requires some shift in the focus, i.e. the shift from a general land value tax to a tax on property surface or the sealed area. Most of the information needed for these taxes should be available in planning institutions.

Consistency with other policy instruments

Since most countries use some kind of land or property tax, there should be no general problem in adopting them.

Land use taxes can be seen as an alternative to payments for ecosystem services (PES). Examples are the services of upstream forests and other natural areas in reducing downstream flood. These services are mostly not compensated in land prices. One way to solve this problem is to provide incentives so that landowners maintain environmental services.

Wunder (2005) describes the principle of payment for ecosystem services. A PES is a voluntary transaction where a well-defined ecosystem service (or a land-use likely to secure that service) is being 'bought' by a (minimum one) buyer from a (minimum one) provider if and only if the provider secures ecosystem service provision (conditionality).

Acceptability to interest groups

A land use tax is mainly borne by the industrial sector and by other space intensive business. If taxes differ between regions (which will normally be the case), taxes change the competitive position of these firms. This will lead to some lobbying against land taxes.

2. Effectiveness for incentivising a desired adaptation outcome

Table 9 summarizes the policy sectors where land use taxes might have an effect.

Table 9: Applicability of land use taxes

<u>Policy sector as per White Paper</u>	<u>Applicability</u>	<u>Comment</u>
Production Systems (= Industry)	Low	There are no effects on industry structure
Physical infrastructure (public)	Low	Tax revenue could be used to improve public infrastructure.
Physical infrastructure (private)	Low	
Health policies	Low	There might be a positive health effect through an improvement of the micro climate.
Social policies	Low	There might be positive effects if the revenue from the land use tax is used

<u>Policy sector as per White Paper</u>	<u>Applicability</u>	<u>Comment</u>
		for social purposes or to reduce other levies
Agriculture & forests	Medium	The land use tax might reduce urban sprawl and leave more space for agriculture and forest
Biodiversity, ecosystems, water	High	Biodiversity in urbanized areas will improve if the covered land area is reduced
Coastal and maritime areas	n.a.	Mainly public investors

Scale: From +++++ for very applicable and relevant to – not applicable/relevant at all

3. Efficiency:

What resources does the instrument need to achieve its objective?

Taxes can be instruments for land use planning. Hence, they are an alternative to planning regulations. In some cases taxes are easier to apply and to adjust than detailed development plans. In this respect taxes have the advantage of being more flexible than planning regulations. Some environmentalists argue that taxes do not guarantee that important spaces remain open for environmental and recreational purposes. However, from the economic perspective it is an advantage that the tax allows alternative use if the use is sufficiently valuable to cover the necessary tax payments. In some cases, this might require very high tax rates. Alternatively taxes should be used within a comprehensive development strategy based on traditional land-use planning.

To further evaluate the usefulness of land prices and taxes as an instrument of environmental policy we look at a few examples. In the Netherlands, there was a huge price gap between agricultural land and land for urban development because of a strong increase of housing prices from 1982 to 2002. In order to solve this problem, different options for land taxation were considered: an open space tax, a development plan change tax and a development tax to encourage building on previously developed land - see Korthals Altes (2009) for a detailed analysis.

The open space tax would have to be paid for construction on an open space in order to compensate for the welfare loss assuming a reduction in the open space. This is efficient if the value of open space to society is not reflected in the market price of the land. However, efficiency of that tax requires the valuation of open space. Since the value depends on the characteristics of the region (i.e. the value of open space in rural areas is different to the one in urban areas) an efficient tax requires an estimate for each region. An alternative is a development plan change tax. The tax is levied on landowners if the development plan changes and they buy a plot of land or start to build on it. The tax is based on the added value when construction is permitted by the government where it was formerly forbidden. This requires estimating the additional land value.

Another tax considered by the Dutch government was a development tax. It would encourage building on previously developed land by taxing green areas and thereby making them more expensive. This gives an incentive for building on previously developed land. But to achieve a significant effect the tax has to be very high. This is also the result of a German research project

conducted in the period 2003-2006, see EEA (2010c). In the project “Circular land-use management” a management game was developed. The aim was to investigate the influence of land taxes on the designation of urban development areas. It was assessed that one driver of land consumption is the preference for planning new developments for the outskirts of cities and not for the inner districts. One explanation can be higher land prices in the inner district of cities. To solve this problem taxes could be introduced to influence the land price.

The management game explores the effects of a changing tax system, i.e. to change the current land tax (based on the value of the land and the value of buildings on it) to a land value tax, surface area tax or land-use tax. The game has shown that price changes are not large enough to cause changes among landowners if the tax revenue remains constant. To achieve a behavioural change of landowners, taxes have to increase by a factor of ten.

What transaction costs will accrue?

The introduction of a land use tax requires information on land use. Most of this information should be readily available. In some countries or regions it might be necessary to collect some additional information. However, these are onetime costs. After the tax is introduced adjustment is only necessary if land use changes. This is rarely the case and transaction costs will be low.

4. Equity: What distributional consequences will arise?

In an environmental context a land tax will be levied on use of land for either industrial purposes, or buildings and soil sealing. Hence the tax is borne by the industrial sector and by other space intensive businesses, such as logistic firms or shopping malls with large parking lots. The land use tax is an additional cost for these firms. To some extent they will be able to pass this cost to their customers. This is a justifiable effect, since it makes other firms with less land intensive strategies more competitive.

5. Conditions and barriers

Land taxes can promote land use that improves adaptation capacities. However, the quantitative effect will be limited unless tax rates are set far above current levels. For political-economic reasons it might therefore be necessary to reduce other taxes as compensation. To select an appropriate compensation tax, the aim of adaptation to climate change as well as the redistribution effects has to be taken into account.

As land use has a different ecological value in different regions, the tax rate should be fixed at the regional level. Regionally different tax rates imply the competitiveness of firms is affected. This is a justifiable effect since adaptation to climate change requires relocation of some economic activities. However there will be distortionary effects if only some regions use land use taxes while others do not. Hence there should be some coordination at least at the national level.

2.2.1.3 Recommendations

Land use taxes help to steer land use. This might improve resilience to climate change. In particular, land use taxes increase density of urban areas and thereby increase open areas with recreation capacities. Within urban areas land use tax can lead to a reduction of sealed areas and thereby improve the resilience to climate change. Given the quantitatively limited power of land use taxes they probably cannot replace land use planning. However they can give important support.

Given these positive effects existing land and property taxes should be adapted to land use taxes. Since land use is of very different values in different regions, tax levels should be set by local authorities. However there should be some coordination - at least at the national level - on the question of whether land use taxes are used as an instrument or not.

Land use taxes beyond those levied today may be introduced in areas highly threatened by climate change impacts. If the tax rate is set appropriately, an optimal amount of land use considering climate change impacts is achieved and the negative externalities of some location decisions are internalized. If the expected damage rises over time, tax rates could also be increased. The tax increase has to be communicated well in advance to allow stakeholders to react to the tax change.

2.3 Licences, permits and variations

2.3.1 Tradable quotas and variations: Adaptation Market Mechanism

2.3.1.1 Description for the purpose of subsequent assessment

The objective of an Adaptation Market Mechanism (AMM) has been described in chapter 2.3.4 above, and we will focus on such a “system of tradable quotas for adaptation” for the basis of evaluation below.

It should, however, be noted that a trading system could also be specified in a way that it limits “risky activities”, and thus would be similar to the trading systems for classical pollutants (Kuch and Gigli 2007). Here, activities that are likely to suffer from climate change impact would be capped. Anyone wanting to engage in such an activity would have to acquire an allowance. The price to be paid for the allowance deters people from engaging in the risky activity. In the assessment below, we highlight particular issues of such a “trading scheme for risky activities”.

2.3.1.2 Assessment: How can tradable quotas promote adaptation activities?

1. Applicability

Applicability of the instruments to incentivize adaptation

As discussed in chapter 3.2, tradable units and an Adaptation Market Mechanism are specifically designed to promote adaptation. The activities that are conducted under an AMM can be manifold and cover various sectors, such as agriculture, protection of private/public infrastructure against

climate change related damage, improving cooling systems in building and improving medical care systems to save health. Hence, a general applicability is given.

Applicability for a trading scheme of risky activities is more limited. A major challenge is to define the meaning of “risky”. This can be assumed as easy for land settlement choices (e.g. risk of storms, flood) but becomes more difficult e.g. with regards to agricultural practices – for example, can agricultural activities be considered “risky” given that there might be droughts in the future? Hence, applicability of a trading scheme for risky activities would be limited to land use for infrastructure.

Institutional feasibility

The introduction of a tradable quota system is possible within a few years. For example, the EU emissions trading system for CO₂ was first discussed at the end of 2000 and started its operation in January 2005. Pilot emission trading systems like the UK system introduced in 2003 only took 1-2 years preparatory time.

A tradable quota scheme needs the following institutional elements: A legal framework is required to specify the target level as well as the allocation of target requirements to specific entities, as well as penalty levels if entities do not comply with their targets. The allocation can be done according to different principles. Given that climate change and thus the adaptation need is caused by emitters of greenhouse gases, the polluter pays principle would call for an allocation of the target which is proportional to emissions. An alternative would be an allocation according to ability to pay. This would mean that the allocation should be linked to profitability of companies. Still another way of allocation would be inversely proportional to vulnerability to ensure that vulnerable companies would face a lower burden than those that are not vulnerable.

A credible trading scheme requires a registry for transactions that needs to be secured against fraudsters. Independent auditors are required to check records of entities and verify that the adaptive benefits estimated ex ante do actually accrue.

Consistency with other policy instruments

Tradable quotas are consistent with the legal system of the EU. They can be introduced on a simple majority and through a Directive. In that respect, a trading scheme is much easier to introduce than a fiscal system that needs unanimity.

A system of tradable quotas needs to be coordinated with other policy instruments to avoid inconsistencies. For example, quotas for risky activities might be in lower demand in case government takes over a significant amount of damage cost. In case grants are provided for certain adaptive activities and the grant level per adaptation unit is higher than the price for the tradable quota, stakeholders will prefer the grant and the supply of tradable quotas will be reduced.

It is also crucial that the government does not bail out stakeholders that have suffered from climate change impacts. In that case, there would not be an incentive to sustain an adaptive activity over time.

Currently, adaptation policies focus on awareness raising and capacity building of stakeholders as well as RFIs for losses actually incurred. The former are a necessary condition to actually embark on adaptation but do not guarantee actual adaptation activity. While the latter do not suffer from uncertainty, under a situation that can provide some insights about the development of future

climate they will always be less efficient than adaptation projects preventing losses, as no rational adaptation project developer will embark on a project that costs as much as the projected loss level.

Acceptability to interest groups

The AMM depends critically on the ability of policymakers to decide on adaptation targets without knowing the actual level of the resulting costs. In a situation with high uncertainty about future climate change, “no regret” policy instruments are preferred by policymakers. RFIs are politically more palatable than risk prevention, especially in countries with a generic short-term political culture, as they allow policymakers to appear proactive and do not affect voters directly. So they gain voter support even if impact prevention would be a better course of action. A successful impact prevention project is politically unattractive because people will take its success for granted if no catastrophes occur that damage property and human health. People easily get used to high levels of safety.

The acceptability of an adaptation market mechanism strongly depends on the allocation method. The allocation of the target for the Adaptation Market Mechanism according to the polluter pays principle will be opposed by the large emitters, who will prefer that adaptation costs are financed from general tax receipts. However, emitter lobbies have accepted emission trading systems where the allowances are auctioned when policymakers were able to convince them that alternative policy instruments would be even more burdensome to the emitters.

A system of tradable quotas for risky activities would be opposed by those who have to date been doing such activities, especially if damages incurred would have been shouldered by the government. With regards to land use risks, political opposition will be higher if not only the prospective use of land is covered, but also existing land users are included in the scheme. They might claim legally that at the time of settlement, one did not yet know about climate change or at least not about the resulting risk for the particular region/site.

2. Effectiveness for incentivising a desired adaptation outcome

The Adaptation Market Mechanism’s contribution to adaptation crucially depends on the policy target set by government. A weak target will only lead to a small amount of adaptation, whereas a strong one will mobilize a high amount, provided the assignment of tradable quotas to adaptation activities can be implemented in an unbiased way. If the enforcement of the adaptation target is seen as credible which means that penalties for non-complying entities are sufficiently high and collected in an equitable manner, the actual level of adaptation should be proportional to the stringency of the target.

The effectiveness in mobilizing adaptive activities will crucially depend on stakeholders’ perception of the stability of the system. If tradable quotas are only issued periodically during the lifetime of the adaptive activity which may be decades, project developers that normally have to finance a high share of the costs of the adaptation activity up-front may not have sufficient trust that the system will continue unchanged. On the other hand, there needs to be an incentive to maintain the adaptation activity over time and thus the trading units should not be assigned in a cumulative ‘bundle’ ex ante. A compromise solution might be best that allocates a significant share of the trading units accruing during the lifetime of the project ex ante, e.g. 30-50% and issues the rest as they accrue.

A trading scheme for risky activities will only reduce them if the allocation of allowances is below the current (and future baseline) level of the risky activity. Otherwise, the scheme is not binding and the allowance price will be zero.

An AMM can in principle apply to all the policy sectors defined in the EU White Paper “Adapting to climate change: towards a European framework for action”. The actual applicability strongly depends on the validation rules. Generally, activities are more likely to be promoted the lower the costs of generating a tradable quota.

Table 10: Applicability of adaptation market mechanism by policy sector

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Medium	Property valuation should be relatively easy.
Physical infrastructure (public)	High	Valuation should be easy.
Physical infrastructure (private)	Medium	Valuation should be relatively easy. However, one might want to exclude purely private goods from the mechanism, see discussion in chapter 5.2
Health policies	High	Separate DALY trading unit provides good incentive. However, eligibility of measures needs to be defined (breakdown of “policies”).
Social policies	n.a.	Such policies are not well targeted to generate tradable quotas; they serve more as a background.
Agriculture & forests	Medium	Only a part of the activities in these sectors directly leads to benefits in forms of tradable quotas.
Biodiversity, ecosystems, water	Medium to low	Unless a separate criterion or adaptation unit in the mechanism awards investment in projects that support/protect biodiversity or ecosystems, there is no incentive to invest in such.
Coastal and maritime areas	Medium	Coastal protection outcomes should be measurable in trading units.

Scale: From high for very applicable and relevant to n.a. not applicable/relevant at all

3. Efficiency

What resources does the instrument need to achieve its objective?

A system of tradable adaptation quotas is theoretically excellent in achieving an efficient outcome. As the market will first mobilize the cheapest adaptation activities, the lowest possible adaptation cost will be achieved, provided

- the allocation of tradable quotas to adaptation activities is not biased
- the criteria to define the accrual of tradable quotas does not lead to maladaptation

Given that it is likely that many adaptation activities have costs that are much lower than the property protected, the trading scheme will reduce costs substantially compared to paying for losses after climate change impacts have occurred. It would be possible to direct funds to certain regions or project types by setting the rules respectively. This could make sure that e.g. all member states host some adaptation activities.

The AMM will generate substantial incentives to develop adaptation projects in a competitive setting. Provided the long-term adaptation targets are seen as credible and regulatory enforcement is assured, specialized adaptation project developers will emerge that will offer their services to covered companies. It is likely that companies would tender out delivery contracts for adaptation units. It is to be expected that competition will drive down the price per unit of SW to a level much lower than unity (1.0) (compare the adaptation cost-benefit ratios in Economics of Climate Adaptation (2009) which frequently reach 0.1 or 0.2).

A trading scheme for risky activities will prevent those who have a revenue/utility that is lower than the quota price from undertaking risky activity. Thus, the lowest added value activities will be prevented, which means that the economic resilience of society will be improved.

Degree of incentive required to mobilize adaptive investment and behaviour

Given that the adaptation target is denominated in monetary units / DALYs, the price of the tradable quota will be high enough to mobilize adaptation activities, but only up to the target level.

Risky activities will be reduced if the tradable quotas for the uptake of risky activities are scarce. The degree of reduction directly depends on the scarcity of the quotas.

What transaction costs will accrue?

Transaction costs related to the design, implementation and operation of an adaptation market mechanism are a relevant issue. The order of magnitude will strongly depend on the design of the scheme. In principle, transaction costs occur for:

- Allocation of adaptation targets to the participants of the scheme;
- Definition of rules and “methodologies” for adaptation activities that generate adaptation units;
- Planning, approving and implementing adaptation activities;
- Monitoring, reporting and verification of adaptation activities and compliance with adaptation targets;
- Compliance and penalty scheme

Transaction costs of overseeing a system of tradable quotas can be kept to a relatively low level. Government administration of emissions trading systems can require as little as 5 staff (Switzerland)

and reach up to 100s for systems with 1000s of installations/projects (Germany, CDM staff at UNFCCC Secretariat). Brokerage fees in mature emissions trading system reach less than 1% of the transaction.

The main transaction costs will accrue for documenting and validating adaptation activities and verifying the amount of tradable units created by them. One can draw on the experience gained in the existing offset schemes such as the Clean Development Mechanism (CDM) and Joint Implementation (JI) as well as existing compliance markets such as the EU Emissions Trading Scheme (EU ETS) – both to estimate order of magnitudes and to identify potential for designing the scheme in a lean way. Experience from project-based emissions offsets shows documentation and validation cost of 50,000 – 150,000 € per project, whereas verification costs reach 15,000-40,000 € per turn. Monitoring and verification of emissions under the EU Emissions Trading Scheme has costs of the same order of magnitude. Most of these costs are of a fixed nature that is independent of the scale of emissions. As this will also apply to adaptation activities, the trading scheme should be limited to large entities. An important driver for transaction costs is the level of scientific certainty and complexity. Examples for reducing complexity are: using proxies/default factors for estimating future climate risk, and allocating adaptation targets on the basis of available data without (m)any special clauses.

A trading scheme for risky activities would have a smaller scope and likely a lower number of participants. This would reduce the absolute transaction costs. At this stage, it is however not possible to judge whether relative transaction costs, i.e. costs compared to adaptive benefits, would be lower as its overall impact may also be lower.

4. Equity: What distributional consequences will arise?

If greenhouse gas emitters have to shoulder the adaptation targets, they will try to pass through the costs of acquiring tradable quotas to their customers. So the incidence will be proportional to the emissions intensity of consumption. As poorer social strata normally have a higher emissions intensity of consumption (see Hassett et al. 2009), there will be a negative distributional consequence. This could be counteracted by defining the wealth saved by an adaptation activity in a way that takes into account the share of wealth saved in the total wealth of households.

5. Conditions and barriers

What design features are essential in order to make it feasible?

A credible Adaptation Market Mechanism requires political decisions on the adaptation units to be traded. Subsequently, a target level needs to be fixed and this target has to be allocated to certain entities. Enforcement of the target through penalties or other deterrents is crucial, as well as independent auditing of adaptation units created through adaptation activities. To generate sufficient liquidity for trading, the number of covered entities needs to be sufficiently large, also to enable the mobilization of a wide array of adaptation activities. In order to harness the cheapest adaptation options, entities that are not directly covered by the target allocation should be allowed to generate tradable quotas through dedicated adaptation activities.

In case of a system of tradable quotas for risky activities, a decision about the “correct” level of risky activities needs to be taken.

Challenges

An Adaptation Market Mechanism requires a reduction of scientific complexity regarding the estimate of climate change impacts as well as the expected development of economic activities in areas to be impacted. The level of uncertainty for those parameters may be seen as too high to determine adaptation units in a way that is seen as sufficiently objective. As projections of climate change are inherently uncertain, this is probably the largest single challenge for an Adaptation Market Mechanism¹⁰. However, this challenge applies for all other adaptation policy instruments alike unless they only want to generate “no-regret” adaptation that is beneficial under a vast range of different types of climate, or they try to optimize societal reaction to minimize secondary economic effects of impacts of extreme weather events (as is the case for RFIs). The latter instruments can be utilized even under full uncertainty whether climate change impacts will ever materialize.

Given that most infrastructure-related adaptation activities do not generate any revenues, and costs accrue fully at the outset, the challenge arises whether the accrual of tradable units over time provides a sufficient financial incentive to trigger investments. If this is not the case, a solution may have to be found that issues tradable units before they would actually accrue. This however has the drawback that in case of under-/non-performance, tradable units have been issued that do not represent real adaptation action.

Hence, a key challenge of the AMM is the third-party validation of the generation of trading units by adaptation activities. Difficulties in evaluation of adaptation activities must not be allowed to lead to an arbitrary assignment of tradable quotas. Prior to the introduction of the AMM a detailed validation manual needs to be provided that provides clear rules that are not biased in favour of certain adaptation activities. To prevent prohibitive transaction costs, heuristics must be integrated that inter alia

- allow assessing the baseline economic development in a way that does not require complex economic modelling
- provide a politically decided level of discount rate
- specify the regional climate model to be used for impact estimates to avoid “model wars”
- use World Health Organization specifications for calculation of DALYs

Furthermore, the characteristics of adaptation as partially public and partially private good can give rise to the criticism that the Adaptation Market Mechanism would only be suitable for the cases

¹⁰ Due to the high uncertainty of climate models and the difficulty of downscaling models to provide climate impacts on a small regional scale, estimating climate impacts may deteriorate into pure guesswork. Literature on the evaluation of adaptation projects such as Eriksen and Kelly (2007) and Hallegatte (2009) stresses the difficulty of defining impact indicators for projects. This is especially relevant if adaptation projects worldwide are eligible to generate adaptation units. Similarly, the assessment of the prevention of climate impacts through a certain technological intervention may be difficult. Gaming by project developers could result who would then get adaptation units for projects that actually do not provide such a level of adaptation benefits. If the loss estimates under the AMM are consistently overestimated, inefficient spending would result. For example a project claiming a cost/ SW ratio of 0.5 but overestimating SW by a factor of 4 would actually have a cost/ SW ratio of 2.0. This project would never have been launched had the true cost/SW ratio been known. As there are incentives on both the sides of the companies that have adaptation commitments and those that develop adaptation projects, the regulator needs to be impartial and uphold “adaptation integrity”.

where adaptation has a public good character. However, given that the adaptation need has arisen due to use of the atmosphere as public good, there is no intrinsic argument that the Adaptation Market Mechanism should not finance adaptive activities of a private good nature, provided that they are not receiving financing through other policy instruments. Also, Niggol Seo (2010, pp. 11 ff.) argues that adaptation is a public good. In case these arguments are politically not palatable, the eligibility criteria for adaptive activities generating adaptation units could be defined in a way to only cover adaptation with characteristics of a club or a public good.

2.3.1.3 Recommendations

An Adaptation Market Mechanism would be a highly innovative mechanism to incentivize adaptation activities across the economy. If the challenges of uncertainty regarding climate change impacts on property and human lives can be overcome, it would allow mobilizing the most cost-effective adaptation options. Many design features of emissions trading systems could be directly applied in the Adaptation Market Mechanism, and hence the EU could substantially benefit from the experience gained from mitigation policies. The mechanism requires the political willingness to set an adaptation target and to allocate it to a sufficiently large group of entities to generate a liquid market. Moreover, non-eligible entities should be allowed to implement adaptation activities that generate tradable quotas.

Another option to introduce tradable quotas would be a political limitation of activities with a high likelihood of being impacted by climate change. Such an activity could then only be done by the owner of a quota. Such a system might be easier to implement in a first step (political acceptability, uncertainty of climate change impacts) with a view to expanding it over time to a fully-fledged AMM.

2.4 Other market based instruments

In this subchapter on other market based instruments we concentrate on two instruments, namely payments for ecosystem services (PES) and water markets (or rather the pricing of water use). Payments for ecosystem service directly address the sector of biodiversity, ecosystems and water. They form a variety of the general category of subsidies, trying to incentivize a desired behaviour by reducing its costs. Water markets also relate to the sector of biodiversity, ecosystems and water. In connection with adaptation to climate change, water markets, i.e. the efficient pricing of water use, are most relevant where current and/or future water scarcity prevails.

Neither instrument has yet been implemented explicitly to address adaptation to climate change. However, due to their vast co-benefits they warrant detailed analysis.

2.4.1 Payments for Ecosystem Services (PES)

2.4.1.1 Description for the purpose of subsequent assessment

Payments for Ecosystem Services (PES) schemes have adaptive effects, or rather co-benefits, in various respects. For example, degradation of land is reduced therefore mitigating effects of some extreme events like landslides or reducing water run-offs. Per definition it conserves ecosystems as well as the related biodiversity, which is according to the EU White Paper seen as adaptation to climate change in its own right.

As described in section 2.4.2 of task 1, PES schemes require a well-defined seller and buyer of the Ecosystem Service (ES), a definition of the ES itself, an agreed and sensible measure of conservation, an incentive-compatible payment system (including conditionality of conservation) and finally an initiator and an administrator of the whole scheme.

The seller of any ES can be assumed to be one or more private persons or some other private entity, as PES otherwise do not make sense. The buyer of the ES has to be differentiated into private and public actors. This is because in the case of a public buyer some public funds would be needed, while in the case of a private buyer only non-financial aid and some regulatory framework might be needed. We do not differentiate any further in looking at intermediate solutions where private and public funds are involved at the same time. This might be an interesting question to be addressed later in connection with the instruments of PPPs. The ES depends solely on the preferences and goals of the buyer, as they are the rationale for the whole PES-scheme. It can be safely assumed that the measure of conservation and the payment-scheme are well-defined and accepted by the seller and the buyer of the ES. The same holds true for the administrator of the scheme. It should be noted though that these features are those causing the largest part of the transaction costs. Finally, the whole PES-scheme is initiated by the buyer, as one of its essential features is to set incentives for the sellers to refrain from using the natural resource in a different way than preserving it.

The details of how PES-schemes can and should be set up are extensively discussed in the literature (see among others Mayrand & Paquin (2004), Wunder (2005), Wunder et al. (2008)) and do not need to be repeated at this point. It is sufficient to state that the development of a PES scheme usually takes four main stages, namely (see ESCAP (2009)):

- Identify the demand, set objectives and determine values
- Assess institutional and technical capacity and feasibility
- Establish institutional and contractual frameworks
- Implementation

The resulting principal PES flow chart then looks as follows (see also see ESCAP (2009, p. 8)):

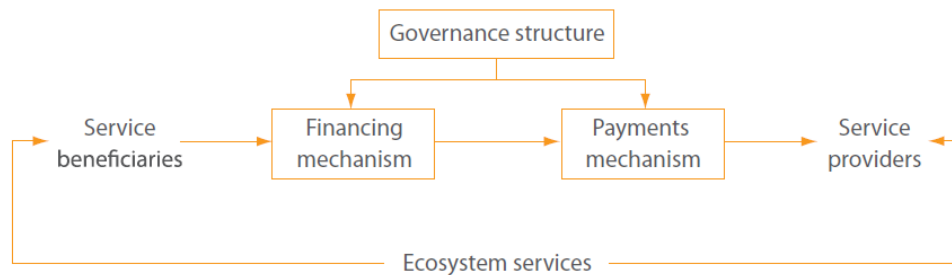


Figure 10: PES flow chart

Up to date, PES are mainly used for

- biodiversity and wildlife protection,
- wetlands,
- carbon sequestration (meaning mainly forest management) and
- watershed protection.

Some examples from Asia are briefly described in Adhikari (2009). An extensive list of world-wide programs can be found in Wunder et al. (2008). Two noteworthy British cases which have not yet been mentioned in chapter section 2.4.2 of task 1 are (see Wunder et al. (2008) and DEFRA (2010)):

- Environmentally Sensitive Area (ESA) & Countryside Stewardship Scheme (CSS), United Kingdom: Buyers in these schemes (ESA: 1986-2003; CSS: 1991-2003) were the UK government together with the EU, while the buyers were farmers in targeted areas. The ES was biodiversity as well as watershed protection and the farmers were paid for benign agricultural practices and agricultural land retirement. The schemes were initiated by the UK government.
- Sustainable Catchment Management Programme (SCaMP), United Kingdom: This scheme was initiated by United Utilities in partnership with a British NGO (RSPB - Royal Society for the Protection of Birds). The PES deals with catchment management in North West England.

Before turning to the assessment of PES in the context of adaptation to climate change two points are worth noting. Firstly, Wunder et al. (2008) note that private (i.e. user-financed) schemes are usually more effective and efficient than state-financed schemes. This can occur because private schemes are more focused on the basic ES while governmental schemes often aim at additional objectives. These commonly belong to social, employment and regional development issues. This can either reflect the attempt to gain support or simple rent-seeking. The avoidance of successful rent-seeking is crucial for the proper and targeted functioning of PES though. Secondly, there are regularly indirect beneficiaries of the preservation of ES. By design they do not pay for the conservation of the ES. This can have several implications. For the buyer of the ES it might be desirable to shift some of the burden of the payment onto these indirect beneficiaries. This can be done by private actors as well as by public actors. Private firms can at least partially include the costs in their pricing policies, if the circumstances allow this and if the bought ES has something to do with their product. Public actors need to finance their engagement anyway which can be done via general taxes and other revenues, in turn shifting at least some of the financial burden onto the indirect beneficiaries. The (additional) indirect benefit might also indicate that the overall value of the ES is set too low and that there are still some positive externalities to be internalized. This would either call for additional

governmental engagement with regard to topping up private schemes or is at least a reminder that especially state-financed schemes should very carefully assess all direct and indirect benefits and beneficiaries of the ES under scrutiny. Finally this argument could mean that combination with other measures in specific sectors – like hydrological services – is worth considering.

2.4.1.2 Assessment: How can PES promote adaptation activities?

1. Applicability

Applicability of the PI to incentivize adaptation

PES schemes are usually not designed to promote adaptation per se. As mentioned before though, the preservation of natural resources has in most cases adaptive co-benefits. Hence, PES mainly sets indirect incentives via these co-benefits. This connection is only dissolved when the measure which conserves the ES can be interpreted as an adaptation measure itself. A typical example would be the non-use or some specified use of agricultural land. Otherwise this instrument merely incentivizes adaptation in the sense of avoiding the further degradation of natural resources.

Institutional feasibility

The institutional feasibility can be considered high. In the case of private PES schemes the only restrictions are general contract laws and – if existent – national or supra-national frameworks for these kinds of instruments. For public schemes the picture is even brighter as the starting point is always an initiative by the potential buyer of an ES. Thus, governmental institutions not only can identify interesting ES but they can also play according to their own rules as long as a seller of the ES can be found. The catch in all this is whether the property rights to the ES – or rather to the area which offers the ES – are well-defined. If this condition does not hold, the institutional feasibility suffers because there would be no clear-cut seller of the ES.

Consistency with other policy instruments

Generally PES competes with a number of other instruments discussed in this report which principally are also able to incentivize adaptation. As long as additionality is avoided, i.e. as long as only one instrument is implemented in order to serve the desired adaptive purpose, no inconsistencies can be expected. While this appraisal is true on the instrumental level, it might not be true on the level of the goals instruments try to realize. Conflicts could arise where the goal and the effect of PES completely counteract other adaptive goals. This could especially be the case for flood protection; some areas could at the same time have a value as an ecosystem, like meadows for example, or they could have a value as a retention area in the case of severe flood events. Thus, if the meadow is part of a PES scheme this might contradict flood protection measures which are taken in other areas. The cost of these (additional) measures might even more than compensate the value of the meadow. This interconnection shows, that integrated – and possibly cross-border – strategies are needed in adaptation and that policy measures on adaptation need to be carefully designed to avoid unwanted or compensating side effects.

Acceptability to interest groups

In general, one can expect acceptability to be high. There seems to be wide agreement that natural resources in the sense of ecosystems are worth protecting. Thus, only a few interest groups would even dare to oppose such instruments. In the case of private schemes, interest groups can be considered largely irrelevant. In the case of public schemes one caveat can be made. As public resources are scarce some shifts in public budgets might be needed in order to further promote PES. This implies financial losses at least to some groups. However, we consider these objections to be minor and they should be easily resolved due to majority considerations. One can also expect that PES is favoured by potential sellers of an ES over instruments like indirect means of financing or command-and-control measures, because they offer direct monetary compensation. Besides, instead of punishing unwanted behaviour, PES rewards desired behaviour and is thus potentially very acceptable.

2. Effectiveness for incentivising a desired adaptation outcome

Table 11: Applicability PES by policy sector

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Low	There is no obvious connection between PES and a higher capacity of production systems to cope with the effects of climate change.
Physical infrastructure (public)	Low	No link.
Physical infrastructure (private)	Low	No link
Health policies	Low	The availability of some ES has positive repercussions on people's health.
Social policies	Low	PES can remotely serve social purposes when specific groups, e.g. owners of small portions of environmentally valuable land, benefit from certain schemes. This aspect is more relevant for poor countries rather than for EU-countries though.
Agriculture & forests	Medium	Obvious benefits would accrue more to forests than to agriculture. Problems could arise, where more resilience in agriculture hampers ES or where flood protection, e.g. by use of agricultural land as retention areas, is also important.
Biodiversity, ecosystems, water	High	The connection is most obvious here. Besides, nearly all implemented or

Policy sector as per White Paper	Applicability	Comment
		planned PES-schemes deal with problems regarding this sector.
Coastal and maritime areas	Medium	Principally, PES can generate good results in this sector but it might also conflict with other aims and areas, most notably flood protection.

3. Efficiency

What resources does the instrument need to achieve its objective?

Three cost components are relevant for PES schemes, namely

- a) the establishment costs,
- b) the management costs and
- c) the ongoing payments to the seller of the ES.

These costs can vary considerably depending e.g. on the level of the PES scheme (local, regional or national), on the number of sellers and on the kind and complexity of the ES. It is generally desirable that the first two categories mentioned above, or rather the overall transaction costs, are kept as low as possible without harming the functioning of the scheme.

The literature is relatively silent on about the costs of existing schemes. A selective overview is given by Wunder et al. (2008, pp. 33), highlighting the fact that they can differ widely. However, the knowledge of the costs of one scheme does not give many valuable insights into the potential costs of another scheme anyway unless the main (local) conditions and parameters are largely the same. Thus, each potential PES schemes calls for a separate evaluation.

From the point of view of the policymaker there is an obvious difference between private and public schemes. While the private scheme (or the whole set of private schemes) only incurs regulatory costs, a public scheme requires constant financing from the public budget. Limited public resources might hinder the sufficient implementation on the one hand, but might set incentives for sensible prioritization of projects under review.

In principle, depending on the underlying contract, the ongoing payments can be adjusted making PES a potentially flexible instrument, allowing the reallocation of resources from time to time. This could be especially interesting with regard to public schemes. Unfortunately, the more flexibly a scheme is designed, the more the incentive to conserve the ES for the seller is reduced. PES schemes should be long-term in nature in order to secure the long-term provision of the service and to avoid political cycles. This in turn increases the requirements for overall financial resources.

Degree of incentive required to mobilize adaptive investment and behaviour

Theoretically the payment to the seller of the ES should make him at least indifferent between conserving (or upgrading) the resource and using it in another (degrading) way. The problem then lies in the valuation of the ES. For potential private buyers it only makes sense to initiate a PES scheme if their benefits outweigh the costs. While this should principally also be true for a public buyer, one can expect that this condition is violated under some circumstances. A public buyer might

also account for indirect benefits of an ES, thus increasing his willingness to pay above the pure direct benefits. Besides, a public buyer might as mentioned above follow additional goals with the PES scheme, also increasing his willingness to pay (and the underlying valuation of the ES). Finally, some ES could be considered too important and valuable to forfeit. In these cases though, other – possibly command-and-control measures – are more advisable compared to PES schemes.

In principle, private schemes do not need additional incentives to mobilize the investment as long as the private entity is aware of the ES and its related benefits. Public institutions could come into play here if some informational deficiencies exist. In these cases, and if the pure information is not sufficient to incentivize the investment into an PES scheme, mixed public and private schemes could solve this problem. However, transaction costs could prove to be an obstacle to wide-spread cooperation between public and private actors in this regard. Generally we conclude that (potential) private schemes mainly need reliable frameworks rather than large financial incentives.

What transaction costs will accrue?

Transaction costs play a crucial role in the potential success of PES schemes. They mainly surface due to informational needs before setting up the scheme, the negotiation process and the enforcement of the scheme in operation. Especially the measurement and the monitoring of the successful conservation of the ES are important in this respect. Nevertheless, Wunder et al. (2008) show, that the start-up costs of many existing schemes are usually much larger than the recurrent costs (in terms of payment for the ES).

All in all transaction costs can become sizeable in PES schemes. Accordingly, Mayrand & Paquin (2004) note that managing transaction costs must be a priority in PES schemes as they determine whether PES are the cost-optimal strategy compared to other instruments.

4. Equity: What distributional consequences will arise?

The distributional consequences are marginal at best. Due to the voluntary nature of the whole idea, any redistribution of financial resources from buyers to sellers of the ES serves the purpose of the instrument.

Some minor caveats exist though. Firstly, in the case of a public scheme those (interest) groups who would have otherwise benefited from the funds now going in PES might protest and deem the idea as distributionally defective. However, this argument would only be valid if their alternative contribution to overall welfare was higher than that of the PES. Secondly, some schemes itself could have distributional consequences among the group of sellers of the ES. This is a question of the design of the scheme though and in principle can be handled.

5. Conditions and barriers

What design features are essential in order to make it feasible?

The success of PES depends on careful planning in setting up the scheme and on the integrity of the scheme once it has been put in place.

According to Mayrand & Paquin (2004), the most important characteristics are:

- a clear definition of the provided ES,
- on-going and open-ended contracts and payments,

- low transaction costs,
- sufficient and sustainable funding,
- monitoring of compliance and
- adequate flexibility to adjust the scheme when conditions change.

Challenges

PES is theoretically a very elegant way to conserve natural resources. In practice, several obstacles arise. Beside of the fact that there are trade-offs between the design characteristics listed above, the most important of them are:

- How can the idea be promoted in the private sector?
- Are property rights well-defined to be able to identify the supplier of the ES?
- What are the community characteristics and how do they fit into a potential PES? Would the organization of a PES be possible at all and how can the potential sellers be convinced of the benefits?
- How far are the legal frameworks developed to allow the establishments of PES?
- Is there enough political willingness to implement such schemes?
- How can the problem of transaction costs be tackled and how can they be kept low especially in public schemes?

2.4.1.3 Recommendations

PES is a very interesting idea to promote the conservation of natural resources. They offer co-benefits also in the context of adaptation to climate change. PES schemes are generally not set up in order to promote adaptive behaviour per se. Besides, some conflicts can arise between protecting ES on the one hand and using other measures in this report to facilitate adaptation in other sectors or with regard to other impacts of climate change not relating to natural resources like biodiversity or water. The most prominent example in this regard is the potential conflict between flood protection and ES conservation.

To solve these potential conflicts it might be advisable to mainstream conservation funds in a way which also accounts for adaptation of climate change. This could either mean that funds have to be rechanneled or topped up to additionally incorporate adaptive benefits of ES. For example the CAP-reform can be shaped accordingly.

Finally one has to realise that there is no blueprint for PES schemes. This either calls for setting targets in ES conservation and aiming at achieving this at minimal costs or for capping funds and trying to maximize the benefits from ES by strict prioritization of potential projects. As the success of PES depends very much on national and regional circumstances, no tailor-made suggestion can be given though. Instead, the public actors on different regional levels (EU, countries, country-states or -regions) as well as private stakeholders should verify whether existing schemes were successful or future schemes appear worthwhile.

2.4.2 Water markets

2.4.2.1 Description for the purpose of subsequent assessment

Water is a cross-cutting issue in adaptation to climate change. It might be related to more frequent and more extreme flood events and it is in the form of oceans, lakes and rivers one of the most important ecosystems for mankind. Furthermore it provides utility to people in the form of drinking water, water for irrigation and water for sanitation. While we have already dealt with flooding and ecosystem services, we will address some challenges regarding ground water and fresh water in this section. In connection with adaptation to climate change this is most relevant where current and/or future water scarcity prevails. This calls for efficient use of water and thus for instruments to incentivize thrifty use. However, these mechanisms are of general validity, because under changing climatic conditions water scarcity might become a common phenomenon in a number of EU-countries. With a changing climate, water demand will probably increase for irrigation, gardening, cooling in the energy sector and – paired with higher incomes – also for recreational activities. On the other hand, water supply will probably decrease and become less foreseeable, especially in Southern Europe. These two developments potentially widen the gap between water demand and supply, unless appropriate measures are undertaken. However, it has to be noted that this is not regionally restricted to the Southern parts of Europe, as also other (Northern) countries could suffer from drier conditions (see EEA, 2007).

The EU Water Framework Directive from 2000 (WFD) was set up to accommodate the increasing demand for cleaner water-related environmental surroundings.¹¹ The WFD addresses topics like water pollution, cross-border river basin management, the coordination of objectives and measures but also the matter of correct water pricing. This last issue is especially important for our purposes, as the right price of a resource reflects its scarcity. If correct (or sufficient) pricing is lacking, current and future scarcity is not factored into private decisions on the use of the resource. Consequently, the ZEW (2010, p. 60) states: “Water markets require some control, ensuring that prices reflect water scarcity and that infrastructures are appropriate to limiting waste and leakage, and efficiently managing water use and distribution.”

We are well aware that there are numerous other challenges regarding the nexus of water and (adaptation to) climate change, like water-planning, water infrastructure, water management in agriculture as well as in urban areas. Nevertheless we consider water markets and the underlying assumption of increasing scarcity to be the most significant when talking about economic instruments and adaptation to climate change.

This section differs somewhat from the other sections where explicitly one instrument was analyzed, because in the following paragraphs we will deal with the question which instruments appear appropriate to economize water use in a market based economy. Thus the focus is whether price signals would be able to incentivize adaptation. These signals can either stem from the establishment of water markets, i.e. pricing water use at all, or from measures where water markets already exist,

¹¹ See the website http://ec.europa.eu/environment/water/water-framework/index_en.html as a starting point.

i.e. taxing water use in times of pronounced scarcity or subsidizing water saving technologies in certain sectors. While we have looked at taxes and grants as policy instruments, the topic of water warrants picking these measures up again in this special context.

Some adaptation options for water supply and demand are listed in Bates et al. (2008, p. 49):

Supply side	Demand side
<ul style="list-style-type: none"> • Prospecting and extraction of groundwater • Increase storing capacity by building reservoirs and dams • Desalination of sea water • Expansion of rain-water storage 	<ul style="list-style-type: none"> • Recycle water • Reduction in water demand for irrigation by changing the crop mix, the irrigation method etc. • Set economic incentives by metering and pricing to encourage efficient use.

To keep things simple, we focus on the demand side of water markets and how demand can be influenced and how demand might react to certain measures, i.e. basically price signals. We are nevertheless aware that the supply of water is highly affected by climate change too, and that there are measures available to increase or stabilize the supply of water, like e.g. desalination. These however are mainly related to technology and much less to behaviour (except for using supply enhancing techniques) and thus only play a minor role in the following considerations.

The demand for water comes from three sectors: households, industry and agriculture. Sometimes the energy sector is named as a fourth one; otherwise it is included in the industry sector. Demand can either be in-stream (no withdrawal from the cycle) or off-stream. In-stream demand relates for example to shipping purposes or hydropower generation. This kind of demand is not further analysed. Off-stream demand can either be consumptive, like irrigation, or non-consumptive, i.e. the water returns into the cycle e.g. via sewers. Off-stream demand is the relevant part for water markets.

Demand differs widely according to sectors and geographical region. Using data for 2001 the EEA gives the following overview:

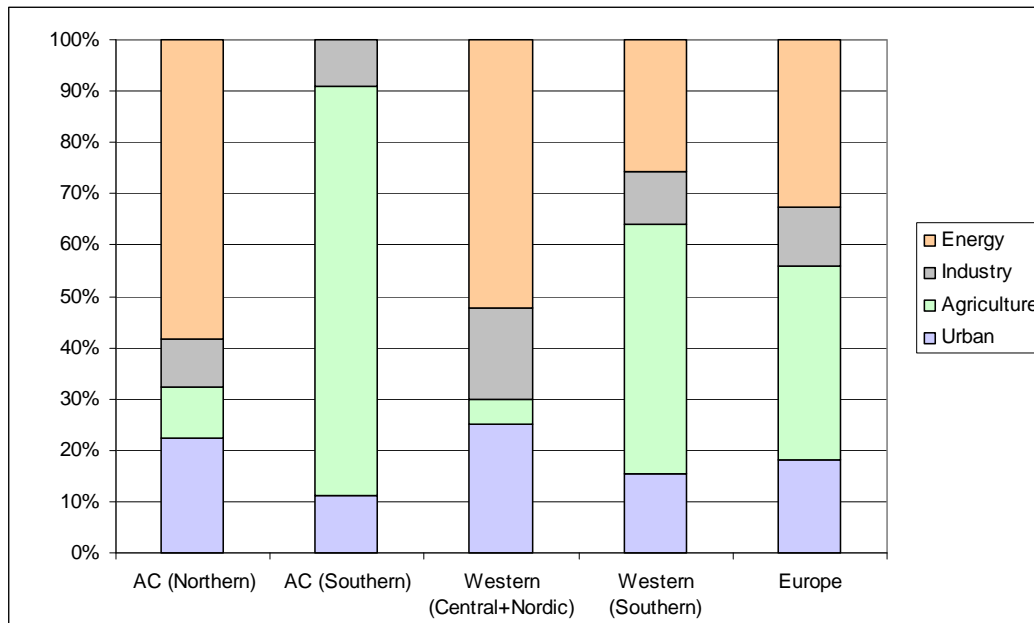


Figure 11: Shares of sectoral water use in five European regions¹²

Hence, the sectors are of very different importance to the abstraction of water. For example, according to CEPS & ZEW (2010b) in Germany water is mainly used by the energy sector (56% before 2005), mining and industry (18%), public water (13%) and only to a minor extent by agriculture (1%). On the contrary, in Italy nearly two thirds of water abstraction is for agriculture. This shows that the challenges can also vary regionally with regard to the sector which has to be primarily addressed by politics. Nevertheless, the EEA (2009a) concludes that the agricultural sector should be of central interest in terms of more efficient irrigation. This assessment is confirmed by the figure above, as in Europe about 40% of water use is connected to agriculture.

Although it is rather difficult to retrieve data on water prices in Europe which reflect the current or at least the recent situation, the following figure gives an impression of the overall variability of water prices in selected European countries. At the end of the 1990s water prices in the Netherlands were high for household and agricultural use, while they were especially high for industrial use in the UK, Turkey and Hungary. In most countries the prices for water in agricultural use were (close to) zero, and by far smaller for household use than in the Netherlands, France and the UK.

¹² The regions are defined as follows:

- AC (Northern): Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, Slovak Republic.
- AC (Southern): Cyprus, Malta, Turkey.
- Western (Central + Nordic): Belgium, Denmark, Germany, Ireland, Luxembourg, Netherlands, Austria, Finland, Sweden, United Kingdom, Iceland, Norway, Switzerland.
- Western (South): Greece, Spain, France, Italy, Portugal.

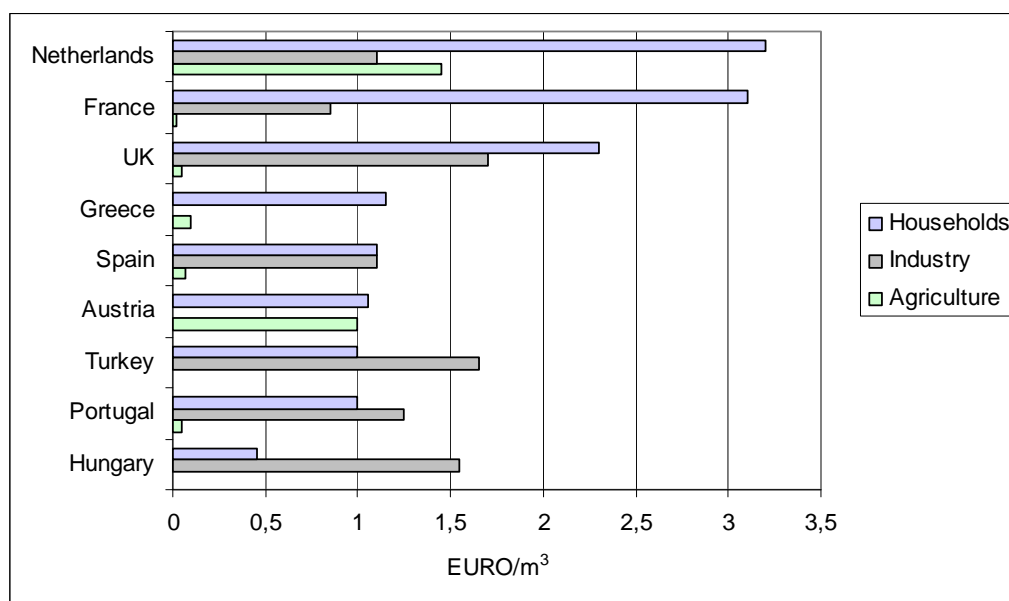


Figure 12: Water prices in selected European countries in the late 1990s¹³

At least to some extent though, prices for household use of water rose in many European countries in the last one or two decades of the twentieth century. Most notably this happened in Hungary, where over a ten year period prices rose by nearly 20% in real terms (see the figure below).

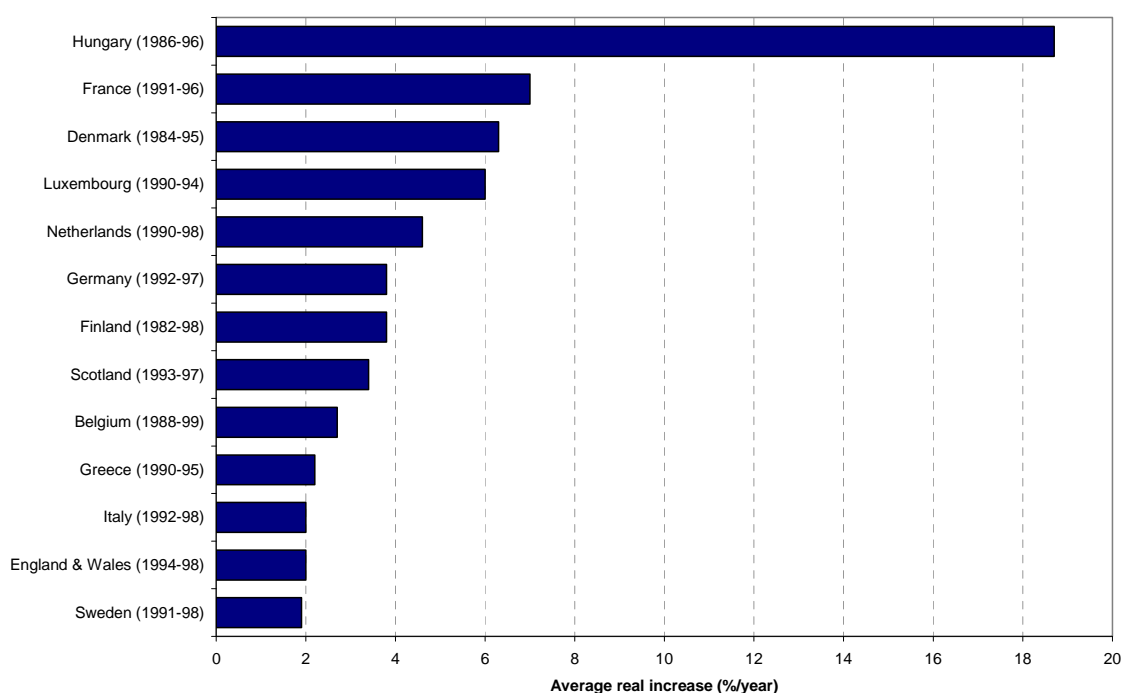


Figure 13: Water price increases in selected European countries in the late 1980s and 1990s¹⁴

¹³ Source: EEA website, <http://www.eea.europa.eu/data-and-maps/indicators/water-prices>.

¹⁴ Source: EEA website, <http://www.eea.europa.eu/data-and-maps/indicators/water-prices>.

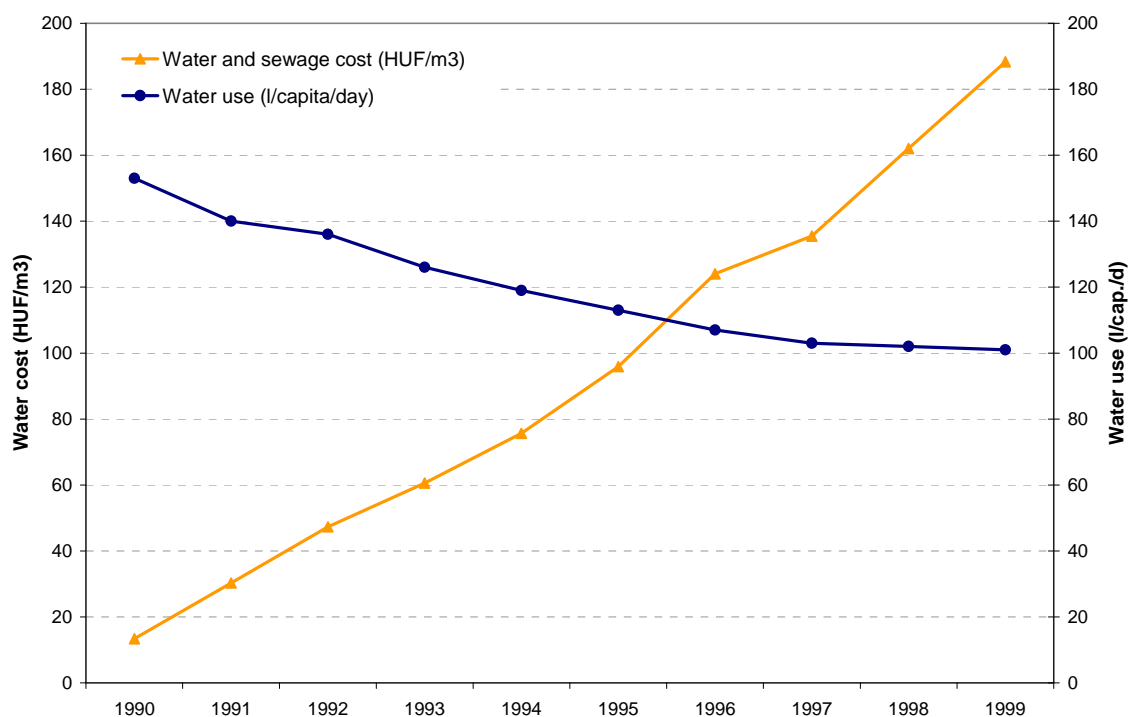


Figure 14: The connection between water price increases and water use in Hungary, 1990-1999¹⁵

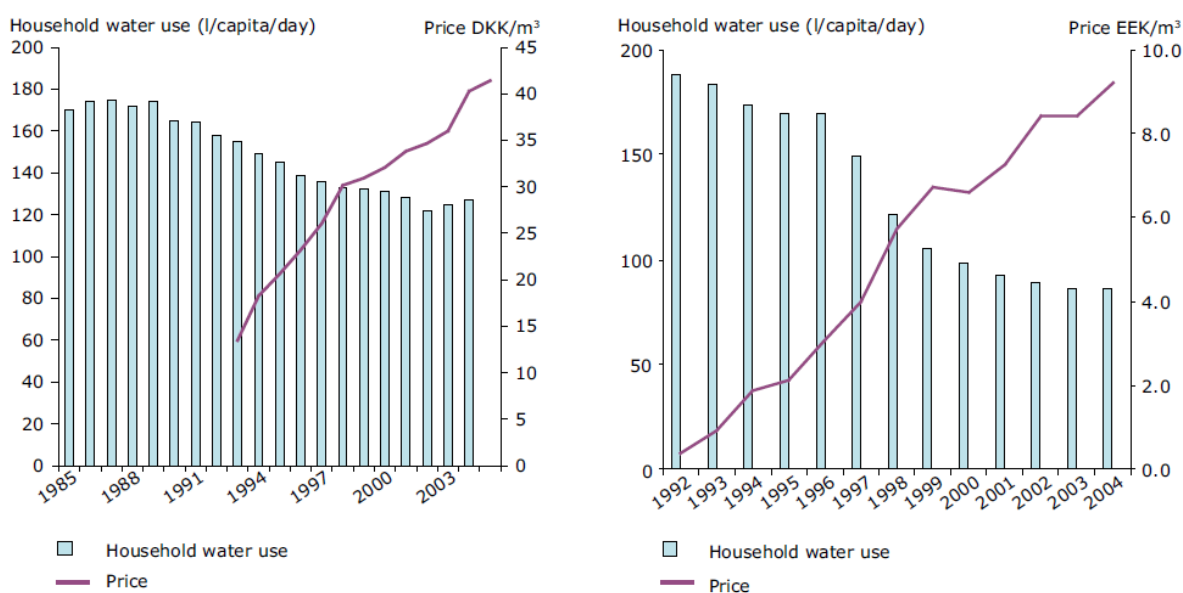


Figure 15: The connection between water price increases and water use in Denmark (1990-2005, left) and in Estonia (1992-2004, right)¹⁶

¹⁵ Source: EEA website, <http://www.eea.europa.eu/data-and-maps/indicators/water-prices>.

¹⁶ Source: EEA (2009, p. 35).

The ultimate – and expected – connection between water prices and the use of water is depicted in the preceding figures. The considerably higher costs for water and sewage set incentives to use much less water. In other words: the price signal in water markets can generally help in a big way to economize the use of water.

Due to the different economic challenges in the demand for water from agriculture and households, we turn our focus on these two.

Municipal water supply to households (and also to industry) is network-based. Thus it is a natural monopoly due to increasing returns to scale. Public provision of this kind of water supply becomes inevitable then. The inherent danger in public provision is that other motives than efficient pricing are dominant or that appropriate water prices are simply not established, because the full costs are not recovered. According to the WFD full cost recovery is essential for efficient use of water. Roth (2001) notes, that full cost recovery requires the inclusion of operational and maintenance costs, of capital costs, of opportunity costs, of resource costs, of social costs, of environmental damage costs and of long run marginal costs. Only then would both the provision of water and sewer networks be priced in, as well as the current and future scarcity of the resource and the external costs of water use. It is seldom that one finds municipal water prices reflect more than the operational, capital and resource costs. Thus, it seems to be still a long way to full cost pricing. However, politics could act here by bringing full cost pricing forward. This can be interpreted as a crucial adaptation measure especially in European areas where heat stress, droughts and urban water scarcity will become relevant even in the immediate future. Enacting this kind of policy has the advantage that it is difficult for households to react to higher water prices other than using the resource more efficiently. Industry could attempt other measures like resorting to additional groundwater extraction, but this could be prevented by monitoring. Fears that higher water prices might have detrimental social effects are usually unwarranted. Even if some low income groups would potentially suffer from high water prices, they could be compensated for this outside the water market, i.e. with other public means. The social protection of some does not justify the wide-spread subsidization of many in the water sector.

Apart from full cost pricing some other features need to be established. Firstly, the evidence shows that it is necessary to set prices according to volume as flat rates set incentives to overuse water. This in turn calls for metering water usage. For more on pricing schemes and its prerequisites refer to Roth (2001), Jones (2003) and EEA (2009a).

Some examples from Southern Europe show that sometimes even informational policies help in economizing the use of water. Campaigns in Greece, Spain and Cyprus led to significant reductions in water use (see EEA, 2009b).

The problem of water pricing becomes more complex if we turn to irrigation in agriculture. This kind of water use is far more difficult to monitor as it is sparingly network-based. Thus, especially groundwater is used. Hanemann (2005) notes in this respect, that the observation that water prices often reflect the (physical) supply costs, not the scarcity of the resource is the reason why e.g. US-farmers pay much less for irrigation than urban dwellers for tap water. Hence, water prices for agricultural use (irrigation) are usually the farthest away from full cost pricing and in turn they are heavily subsidized (see, among others, Jones, 2003 and Agrawala & Fankhauser, 2008). This conforms to the price figures presented above and shows that the WFD is in particular not yet implemented in agriculture.

There is overwhelming evidence that appropriate prices for irrigation water, together with other measures which make coping with the need to adapt easier, reduce the demand for water in agriculture. EEA (2009b) for example states, that a reduction of water abstraction in the Boutonne river basin (France) by 50% would require a doubling of prices whereas the same result would require a price rise by 588% in Cyprus. Some caveats apply though, because if water is only a small cost component in agricultural production, the effects are less pronounced and in addition to this it has to be possible for the farmers to change their behaviour (reduce water use, change crop types) in order to avoid negative social consequences (see EEA, 2009a).

Water trading is based on the idea of tradable permits.¹⁷ Economic agents or entities receive water rights entitling them to (temporarily or constantly) use a specified amount of water over a given time period. These rights can be traded between participants of the system. By creating a market for water rights a price for water use arises. Apart from examples like Australia, South Africa and the US only the Canary Islands in Spain have established water trading in Europe yet. In addition to the common challenges for markets for tradable permits (definition of the rights, monitoring, setting up of the market etc.) Luo et al. (2010) identify water scarcity as a prerequisite for water trading to work (efficiently). In the context of adaptation this would call for local solutions in places water is scarce already or expected to be due to a changing climate as otherwise no prices for water use would surface. In order to promote the development of efficient prices the total amount of water rights has to be carefully set. If the amount, i.e. the overall cap, is set too low, the resulting prices will also be too low. The appropriate cap can only be determined on the local/regional level though and might require a trial-and-error approach.

EEA (2007) provides an extensive list of adaptation measures in the whole water sector in EU countries, while EEA (2009b) concentrates on good practices in this regard. Worth noting of those, besides the ones which were mentioned in the introductory section under task 1, are:

- Cyprus: Subsidies and low interest loans were combined to incentivize the use of improved irrigation systems.
- Spain (Guadalquivir river basin): The replacement of the old open channel networks by on-demand pressurised networks enhanced irrigation efficiency considerably. Besides, EEA (2009a) mentions that the additional implementation of flexible charges on water use led to a 30% reduction in water consumption for even the same crop types. Furthermore, the flexible rate incentivizes the efficient use as in comparison to other Spanish regions with flat rates the consumption was between 25% and 35% lower.
- The Common Agricultural Policy already allows investment support to improve irrigation efficiency.

What can be concluded in the context of adaptation to climate change? It is obvious that the water sector plays a crucial role in adaptation to climate change. Due to the complexity in this area, and the large number of interconnections with different sectors and possible policy instruments and measures, we concentrate on some central messages.

¹⁷ We do not mean pollution rights here, nor do we deal with virtual water trading which essentially tries to identify how much water was used in the production process of goods and services.

The creation of water markets and the efficient pricing of water can be viewed in itself as adaptation to climate change. The WFD from 2000 already called for full cost recovery in water pricing but in many countries of the EU there is still a long way to go on this path. There are nevertheless some lessons one can learn from recent experiences as guiding principles (see among others Roth, 2001, Jones, 2003, EEA, 2009a):

- Full cost pricing should account not only for the pure supply costs of water (mainly operational and capital costs), but also for opportunity, environmental costs and other components. Adaptation comes into play here, because then future scarcity should also be considered.
- At the same time, subsidized water prices are very common, especially in the agricultural sector. These subsidies should be scrapped as soon and as far as possible, while accounting for potential social side-effects on farmers or poor households.
- Prices have considerable effects on behaviour, i.e. water use. These prices should generally be based on the volume consumed. This requires metering of use, which in itself often has dampening effects on water use, because metering makes the actual use more transparent to the consumer.

It is obvious, that the necessary changes are hard to implement – at least on political grounds. Besides, to some extent property rights need to be established and enforced, which might prove difficult in some areas and for some water uses. However, the example of Australia shows that an urgent need to act finally ensures the implementation of measures. Australia already faces severe water scarcity which might be a picture of the future in some European countries, but Australia has also started numerous adaptation measures in the water sector in the last decade (see Bates et al. 2008, p. 92). Hence, the further implementation of water markets also seems to be advisable for the EU.

After this has been achieved to a satisfactory degree, additional measures can be considered. For example CEPS & ZEW (2010a) suggest taxing water in drought areas and reducing taxes on water saving technologies at the same time to ensure budget neutrality. This could also be considered when full cost pricing of water markets is (partially) absent. Then a water tax could take the place of efficient pricing thereby incentivizing efficient water use. Tax reductions on water saving technologies (or other measures like grants) reduce water use via a different route but might have the same effect if appropriately designed. In this regard, the arguments from the related section on these instruments hold.

2.4.2.2 Assessment: How can water markets promote adaptation activities?

1. Applicability

Applicability of the PI to incentivize adaptation

The experience of some countries shows that efficient water pricing is, in principle, possible. As we have shown, a price on the use of water sets incentives to use the resource more efficiently. This can simply consist of using water less while still realizing the same result, either in irrigation or household use. The adaptive behaviour can also be reflected in the installation of water saving technologies. This would be conducted by private entities if the expected benefits of such a measure exceed the costs of the measure.

Hence, price signals set incentives to adapt in the water sector. As stressed before water pricing – including water trading schemes –, the taxation of water or subsidizing water saving technologies is especially relevant in those parts of Europe where general or seasonal water scarcity can be expected or is already prevalent. There is no doubt that water markets can promote adaptation in this regard.

Institutional feasibility

The institutional feasibility of water markets to some extent depends on the specific situation of the region. In this regard it is a matter of governance on the one hand, especially when thinking about appropriate pricing for irrigation and a matter of firm policy on the other hand, when thinking about water prices for households and industry. Nevertheless this also comes down to being a governance problem as water companies are usually state-owned. Governance is even more relevant in water trading, as the setting up of the market, its surveillance etc. is necessary. Thus we conclude that as long as sufficient institutions exist, it is possible to implement efficient prices. The same obviously holds true for water taxes and subsidies for technology.

Consistency with other policy instruments

Water markets have only limited or no effects on a number of sectors defined by the EU White Paper. Accordingly, there are no potential conflicts with all the instruments dealing with these sectors. For the remaining sectors the consistency could very well be high. Much of the necessity to adapt in the agricultural sector stems from changing precipitation and temperature patterns. The sector must adapt to this by changing the overall land-use, the crop mix and the irrigation of existing plants. All these measures have in common that they also relate to the use of water. Incentivizing water use by efficient pricing then complements any other measure aiming at the agricultural sector.

The same holds true for the whole area of ecosystem services (including biodiversity and watershed-protection). Some Payments for Ecosystem Services schemes aim at watershed protection and thereby attempt to stabilize the supply of water and its quality. Possibly, one could combine both instruments to intensify both effects. For example some funds from efficient water pricing could be invested in PES-schemes protecting water-related ecosystems.

Acceptability to interest groups

The acceptability of higher water prices will probably be low, as any consumer is (upfront) opposed to paying more for the good. It is very likely that especially farmers and lobby-groups acting for poor households will contest higher water prices. However, as discussed above these arguments are not valid; poor households could be compensated via different routes and farmers have been notoriously subsidized by underpaying for water use, warranting new incentives.

Water trading might face an additional problem; as shown above it will only work on a local/regional level where water scarcity already exists or potentially looms. On a small geographical level, protests against the introduction of water trading might be more forceful though, making the implementation more difficult. This could require additional marketing or the clear-cut message that alternatives could be even worse for the water users.

2. Effectiveness for incentivising a desired adaptation outcome

Table 12: Applicability of water markets by policy sector

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Low	<p>Water markets or prices might induce more efficient technologies in some production branches.</p> <p>While experience shows that firms strongly react to price signals, this is probably only relevant in those industrial sectors where water as an input plays an important role. Besides, especially firms might find other ways to adapt or have long planning and investment horizons, where water saving technologies only have a small role.</p> <p>Generally though, water markets do not make production systems more resilient, but they incentivize the implementation of specific technical devices.</p>
Physical infrastructure (public)	n.a.	No link exists in this regard.
Physical infrastructure (private)	n.a.	No link exists in this regard.
Health policies	n.a.	No link exists in this regard.
Social policies	n.a.	No link exists in this regard.
Agriculture & forests	High	Applicability is obvious here and is discussed in length in the text.
Biodiversity, ecosystems, water	High	Applicability is obvious here and is discussed in length in the text.
Coastal and maritime areas	Low	Applicability exists to some degree, when the mentioned areas also have a function as an ecosystem or ocean water is supposed to serve as a supplement to other water resources by desalination. This might become less necessary with a more efficient use of other water sources.

Scale: From “High” for very applicable and relevant to “Low” not applicable/relevant at all.

3. Efficiency

What resources does the instrument need to achieve its objective?

In terms of the establishment of efficient pricing, the main costs will accrue as a result of the need to monitor usage by the different consumers. This is much easier for the household and the industrial sector and metering of consumption is wide-spread in some European countries like e.g. Germany. It becomes more difficult (and costly) in agriculture, but metering has also been implemented in some places already. The obstacle in this regard becomes smaller with more metering due to scale effects.

In principle the same holds true for water trading with one additional caveat; for efficient water trading a market structure for the water rights needs to be established and maintained. This requires supplementary resources.

In terms of taxing water use, the same logic applies as in the section on taxes themselves; refined tax systems are in place in all European countries. The only resources required would be those to collect a water tax. This could be compensated by the revenues generated.

In terms of subsidizing water saving technologies, the same logic applies as with all subsidies; they extract money from the general budget, which cannot be used in other places and they need to be financed somehow. Additionally, administration is necessary to issue the subsidies and decisions have to be made on which projects are subsidized and which not. The budgetary consequences of these kinds of subsidies could be reduced by combining them with water taxes, thereby financing the subsidy and possibly the administrative costs.

Degree of incentive required to mobilize adaptive investment and behaviour

The degree of incentive of water prices depends on the possibility of adapting to the new situation of higher prices, i.e. the more elastic demand is the more incentives are set by higher prices. This could also hinge on the original level of prices, i.e. the lower the starting price is, the more higher prices might be felt. In other words, we expect decreasing marginal incentives with higher water prices (or a water tax). These considerations also highly depend on the sector and on the regional circumstances, calling for more detailed analysis of these issues which cannot be done within this report.

What transaction costs will accrue?

The transaction costs largely depend on whether one looks at water pricing itself or the related economic instruments. In the case of more efficient water pricing the transaction costs will probably be low, as the principal administration is already in place. The set-up costs of metering and its monitoring will probably make up the most of additional transaction costs. In the case of the economic instruments the transaction costs will probably be higher, because in addition to the metering and monitoring one will have to implement extra administrative bodies or sections within existing public administrations. These additional costs are only warranted if efficient pricing cannot be achieved in other ways and water trading or water taxes are deemed necessary as a second-best solution.

4. Equity: What distributional consequences will arise?

Those groups with high water consumption and/or with a high share of spending for water would probably lose if water prices rose. However, in the case of poor households, this can be remedied via the social income transfer system instead of generally pricing water too low for all household

consumers. In the case of agricultural consumers higher water prices simply reflect a reduction of unwarranted subsidies on the use of a valuable resource. Thus, the ensuing re-distribution enhances overall welfare by advancing efficiency.

5. Conditions and barriers

What design features are essential in order to make it feasible?

The main features of efficient water pricing have been mentioned in the description. In short full cost pricing and a rate according to volume consumed are necessary, which in turn requires metering of consumption. The same would be true for a water tax, i.e. it would also require metering and volumetric taxing as flat rates do not set sufficient incentives. For water trading an institution would have to administer the water rights and its market as well as the overall cap. Technological subsidies do not require these features, but they need definitions of preferable techniques. Besides it might be necessary to define a minimum saving compared to the technology used before in order to justify the subsidy.

Challenges

There is one great barrier which needs to be overcome and that is the lack of political will to allow efficient water pricing. As water is either delivered by public firms or is a common resource in a country, very much depends on the ability of policy to implement the right measures. As recent experience indicates, water pricing is often used for other objectives than preserving a potentially scarce resource. Often distributional or sectoral goals play a larger role. Only in cases where the strain becomes too obvious – see the example of Australia – can resolute political action be expected. In the European context further information on the challenges in the water sector for politics might prove imperative.

2.4.2.3 Recommendations

The water sector is one of the most challenging in adaptation to climate change. In principle the tools to incentivize adaptation are already in place, because the empirical evidence shows that price signals strongly support the efficient use of water. Water prices according to full costs and volume used would be a step into the right direction, because future scarcity due to a changing climate is part of these full costs. If this kind of pricing is politically out of reach one could consider the introduction of water trading schemes or water taxes as an approximation of these costs. The revenues of a tax, after accounting for administrative costs, could be used to carry out public, or to subsidize private, water saving measures.

Finally, it also has to be mentioned – like in the EU White Paper – that mainstreaming with other measures is generally advisable. This could also be done within the WFD and the Groundwater Directive.

2.5 Financial Instruments: loans and guarantees

Financial instruments have the objective to encourage (further) investments. In this chapter we look at the potential of loans and guarantees in the context of adaptation. Given that the two instruments have very similar effects for the entity that takes the loan/guarantee, it is to be expected that the results are similar. Nevertheless, after some general considerations in this section, we look at the instruments separately in the next two subchapters in order to identify any differences.

As discussed above, the nature of adaptation activities can differ from standard investments done with economic motivations. In the context of adaptation, a fundamental question is: what is/are the major investment barrier(s) for entities that consider investment in adaptation activities? Is it:

- High interest rates and/or risk premiums for default risk?, or
- Accessibility of a loan¹⁸?, or
- The investment itself, given that adaptation-related investments often do not create a financial return but rather serve to avoid an unknown damage in the future?

The answer to this question will depend strongly on the type of investment and the type of investor. In the following, we differentiate between:

- a) investments that bring a financial return such as improved agricultural practices (e.g. special types of seeds) or implementation of highly efficient irrigation systems,
- b) investments that do not result in a financial return but that “only” avoid a potential damage in the future, e.g. storm-proofing houses¹⁹,
- c) private and small-to-medium sized investors with typically lower financial backing (and hence perceived higher default risk), such as private house-owners and farmers,
- d) large corporate investors with a good financial backing (and hence low default risk).

The following table summarises the likely prevailing barriers for adaptation-related investments differentiated by these investor groups and investment types.

¹⁸ This could be due to a) the fact that no bank is willing/able to calculate an appropriate interest rate for an adaptation activity, b) banks are not willing to engage in financing of adaptation activities in general (e.g. due to the fact that projects often do not generate revenues), or c) that the creditworthiness of the investor is insufficient.

¹⁹ There might be indirect revenues such as reduced insurance premiums. However, one can expect that typically the level of premiums saved is too small to be considered as revenue for loan purposes. On the other hand, the availability of insurance funds to repair damage IS a form of revenue.

Table 13: Major investment barriers for adaptation-related activities by investment type and type of investor

Major investment barrier	Small and private investors	Large corporate investors
Investments with financial return	Accessibility of loan	High interest rates (only if return on investment is at the margin of profitability)
Investments without financial return	Investment per se	Investment per se (but potentially higher willingness to invest in cases with clear, predictable damage potential)

It is therefore obvious that loans and guarantees are most appropriate in cases where the investment creates a financial return and where the investor struggles to get a loan (and where the guarantee can facilitate this). In cases where the investment creates a financial return and where the investor in principle has good creditworthiness, the value of a guarantee is less clear and strongly depends on the overall profitability of the investment. For investments that do not generate a financial return it is likely that the investment per se is the major barrier, given that the return of avoided damage is highly uncertain. Hence, one can expect that a public guarantee would not change this situation in a meaningful way.

2.5.1 Loans

2.5.1.1 General description

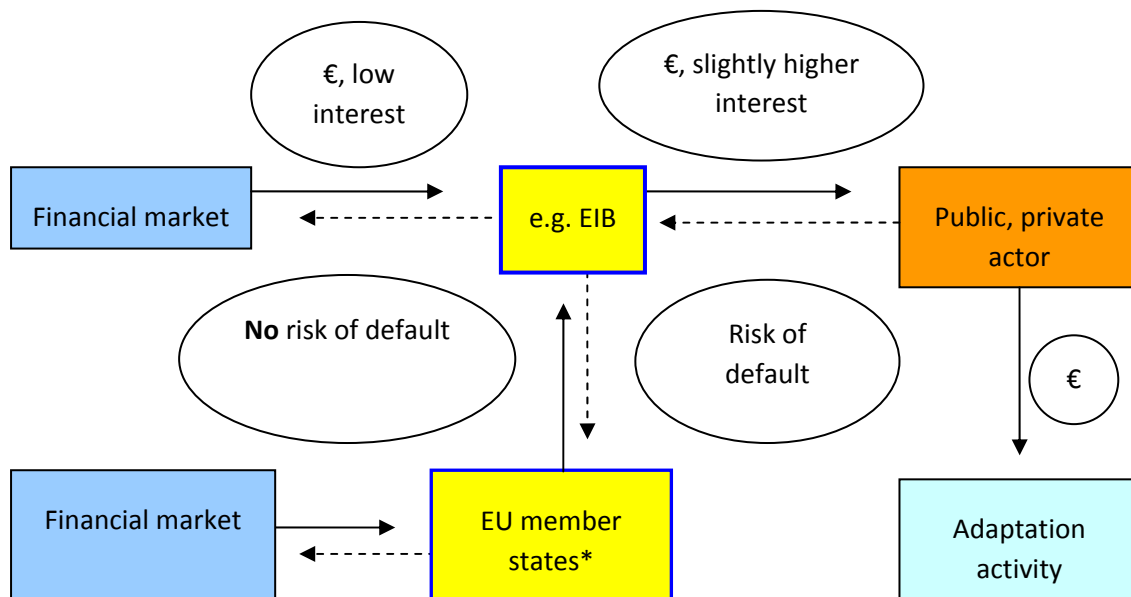
Financial instruments are a form of PPPs as public capital is used to make loans more attractive to debtors, and hence the adaptation activity would be financed by combining public and private funds, even though there is also the option of public to public loans. The economic instrument of loans intends to fund adaptation activities up-front and receive pay-back of the investment from the recipient over time. Loans especially focus on one target group; actors that have identified the need to conduct an activity/programme/measure which prevents climate change damage but who are not able to finance it. Furthermore players for which the adaptation incentive would be too low without the loan might be incentivized through attractive interest rates. For the latter it will usually be difficult to quantify avoided losses through adaptation hence convincing incentives to conduct adaptive activities are hard to achieve. So the demand from especially small private actors like e.g. households is hard to forecast. Providing cheap loans might incentivize some players, however we recommend considering combinations with e.g. grants to increase applicability (see below).

Regarding scarce resources of the public budget, the approach is very attractive as over time no public funds are required directly unless there is an interest rate subsidy below the rates the financing institution has to pay²⁰. A European lending institution like the European Investment Bank (EIB)²¹ could act as intermediary and take over the risk of non-compliance from the recipient to enable low interest rates. So the EIB capital could serve as collateral. However often the adaptation activity does not deliver direct revenues therefore the repayment of loans is not automatically guaranteed and relies on other, external factors. This complicates the required evaluation of the risk potentials of various different adaptation measures. Hence over time, defaults of debtors will generate some funding need. This approach might allow large amounts of financial resources to be provided for adaptation purposes and has been applied in other schemes already (see below). The following hypothetical example outlines how the EU through the lending institution EIB²² could practically apply loans as an economic instrument to promote adaptation. First the EIB informs public or private actors intending to implement adaptation activities to apply for funding. The EU (in this case the EIB) might define eligible adaptation activities ex ante. Experts evaluate the risk of default and the adaptation benefit of the applications. A set of activities is selected and the total required funding is calculated.

²⁰ It is obvious that public money is “blocked” for the loan period; i.e. it is not available for other purposes in that period. However, over time it is neutral for the public budget under the assumption that all loans are properly paid back.

²¹ The EIB is just an initial example for an intermediary. It was selected as it has access to financial market sources with AAA-rating and is experienced in distributing loans on small as well as large scales. However other public financing institution on EU or domestic level might be reasonable as well. Depending on the circumstances it could even be necessary to found a new EU-backed financial vehicle.

²² It is also possible that other public players, such as member states or regional public institutions provide the loan. One should bear in mind though that not all such institutions have access to cheap capital from the financial markets due to their credit ranking.



*) Alternative approach via member states

Figure 16: Schematic functioning of loans (example)

In a second step the EIB asks for the budgeted financial resources from the financial market via bond issuances and selects the ones with the lowest interest rates. Due to the characteristic that the EIB-bonds are backed by EIB's ownership by all EU states the institution is able to receive triple AAA rating, therefore it would be able to raise funds from the capital market on very favourable conditions (see also EIB 2011). During the economic downturn in the years 2009 and 2010, interest rates on short term loans with triple AAA status have been lower than the inflation rate.

A variation of this approach would be that member states directly transfer financial resources to the EU or its intermediaries like EIB. Hence they would be responsible for acquiring the funds and as they usually also use the capital market for attracting new money but not all of them have AAA rating the overall costs could be higher.

A third approach would be that neither the member states nor the financial market deliver the funds but the EU itself provides new budget resources, financed by e.g. free budget or additional taxes. However an agreement on additional earmarking of EU revenues for specific expenditures is usually not allowed and would require unanimous approval by all EU member states. Hence the latter two approaches are dependent on the willingness of member states to agree on additional payments to or an equity increase of the EU, therefore the maximum amount of loans is likely to be lower as with the first approach. Furthermore the described administrative conditions make an agreement unlikely.

Following successful acquisition of funds the EIB channels the money to the applicants and monitors correct implementation and spending of resources. To cover transaction costs and administration as well as some risk, the EU/EIB may choose to provide the financial resources to the public and private

actors at slightly higher interest rates, e.g. 3.5 % instead of 2.9 %²³. However this rate has still to be lower than the one from regular banks to generate additional incentives and adaptation activities. Particularly in the case of micro-finance e.g. for broad application to small adaptation activities, private lenders usually perceive significant risks that might lead to prohibitively high interest rates.

Other important aspects are the duration and structure of the loan. The EU and other public actors might be willing to give loans for a couple of decades to invest in flood prevention on the scale of a once in thirty years flood. Financing forestry with long “return”-times is another example where such long-term commitment can make a difference. The EU and other public players may be willing to wait longer for repayment than private investors.

2.5.1.2 Assessment: How can loans promote adaptation activities?

In the following we evaluate the economic instrument “loans” according to the criteria applicability, effectiveness, efficiency and equity.

1. Applicability

Applicability of the PI to incentivize adaptation

As described the PI is generally applicable to incentivize adaptation by decreasing the costs for entities that want to invest in adaptation activities, but that do not have the financial resources to pay for the investment, or that want/need to take a loan for other reasons. Hence, for this target group, there is at least a basic applicability of the instrument. However this economic instrument has not the same applicability for all groups. In the following we outline relevant conditions and barriers as well as the institutional feasibility for loans designed as described above in order to trigger climate change adaptation.

Institutional feasibility

The institutional implications will depend on the details of implementation, such as the actors to be involved on the public side. In general terms, however, loans are a well-known and tested economic instrument and there is expertise on the relevant public levels (EU and national) that can be drawn upon for setting up a loan scheme. The same applies at the bank level. However expert knowledge for evaluating the risk of default in the adaptation sector has to be built up in the starting-phase of the economic instrument. It should be possible to make use of knowledge that has been generated in other financial sectors. The EU might additionally select certain adaptation measures which alone are eligible. These could be e.g. agricultural activities outside the regular EU agriculture subsidies, funding of small-scale climate proofing of housing or certain municipal activities that are not covered by EU or domestic measures yet. This step would obviously require additional expert knowledge – internally within the EC, the EIB or externally. It would increase transaction costs and requires

²³ Examples from other risk-sharing instruments like the RSFF or structured funds like EPMF or EEE-F show that the EU can be flexible in terms of taking risk and charging for this. In the example of these structured funds, the EU is taking a higher risk than other investors, but does not get paid for it. This way EU funding can be leveraged with private capital.

political agreement on eligible adaptation measures. The latter could be difficult to negotiate as the interests of member states might be diverse.

Consistency with other economic instruments

Loans are generally consistent with several outlined economic instruments providing adaptation incentives; we could not identify serious conflicts. A special focus is recommended for the combination of loans and partial grants. This would increase the incentive for many target-groups and is likely to expand the feasibility significantly. Furthermore attractive combinations might also involve grants for certain ancillary activities, such as institution building, raising awareness and if applicable technical assistance. For instance a farmer would first get a grant to pay an agricultural expert to analyse which adaptation activities are most promising. Based on the expert report, the farmer would be eligible to apply for a loan that finances the suggested activities.

One has to consider whether EU backed financial instruments might lead to crowding out private finance. Therefore the private sector should be reviewed, to see if it offers loans for non-revenue backed adaptation activities at all. Guarantees for private funds that finance adaptation activities might be introduced if the private market starts to retreat from sectors where it had been active before.

Acceptability to interest groups

The acceptability for lobbies from civil society and economy is related to the distributional characteristics of the instrument. Lobbies might try to favour certain target groups by negotiating special eligibility criteria and interest rates while avoiding broad applicability. This would indirectly channel common tax money into the support of specific groups. A balanced mix of different target groups is recommended, while focusing on the most vulnerable and cost-beneficial ones.

Besides, there might be fears that an increase of loans would divert money available for grants, or that funds for loan are relabelled and counted for other obligations, as e.g. has been discussed often in the context of official development assistance (ODA).

2. Effectiveness for incentivising a desired adaptation outcome

The effectiveness is categorized by the sectors as defined in the EU white paper adaptation. We define “effectiveness” as how well the economic instrument is suited to successfully trigger adaptive behaviour, activities, programmes etc. in certain sectors or for specific groups. Private and public actors are separated as they partly face different challenges. The first table describes the impacts of public (lender) -to-private (beneficiary) loans, the second table of public-to-public ones. The evaluation scale reaches from n.a. to High, where High stands for a positive adaptive impact of the PI on the sector and n.a. stands for not applicable/relevant at all. Ranges (e.g. low to medium) are given due partly to differently affected groups within the sector. The justification can be found in the “Comment” section.

Table 14: Assessment: Public-to-private loans

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Low to Medium	<p>Industry is a very diverse sector with areas already affected by climate change, e.g. production close to coastline or heat sensitive electricity generation. Therefore we apply a scale which covers the diverse positions of the industry sector:</p> <p>Medium for investors that have identified the need for adaptation in the short-term and face challenges to get a loan with economical interest rates;</p> <p>Medium for investors that have identified the need for adaptation in the long-term</p> <p>Low for investors that have identified the need for adaptation in the short-term and have access to loans</p>
Physical infrastructure (private)	Low	Positive impact is limited as major financial burden remains with investor, incentive might be too weak to convince private actors
Health and social policies	n.a.	Mainly public actors, which are not covered by a public-to-private loan
Agriculture & forests	Medium to High	<p>The agricultural sector is partly already affected by climate change impacts as precipitation and temperatures change. Especially in Southern Europe significant effects could be identified within the last decade. In particular smaller farmers might face challenges in attracting finance for adaptation, and hence loans might be an effective instrument to provide funds.</p> <p>High for investors that have identified the need for adaptation in the short-term and face challenges to get a loan with economical interest rates;</p> <p>Medium for investors that have identified the need for adaptation in the long-term</p> <p>Medium for investors that have identified the need for adaptation in the short-term and have access to loans</p>
Biodiversity, ecosystems, water	n.a.	Mainly public investors, which are not covered by a public-to-private loan
Coastal and maritime areas	n.a.	Mainly public investors, which are not covered by a public-to-private loan

Table 15: Assessment: Public-to-public loans

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Low to Medium	Most state-owned industries have to compete in the market and have comparable situations to the private ones. Hence no significant difference to private industry.
Physical infrastructure (public)	Low to High	<p>Typical public infrastructure that is affected by climate change is dykes, roads, railways or partly electricity transmission systems. As this infrastructure and also its adaptation are usually financed by budget spending, states might raise funds on the capital market for investments. Here we see significant differences among EU member states in terms of interest rates. Whereas municipalities, regions or countries like Ireland, Greece, Portugal or Romania might pay very high rates, the EU loan interest requirements would be significantly lower. Several states could get incentivized significantly.</p> <p>Low in Member states with high ranking as AAA High in Member states with low ranking (e.g. BB)</p>
Health and social policies	Low to Medium	<p>The implementation of a health policy might require loans and some states might profit from low EU interest rates. The overall effect is expected to be very low.</p> <p>Social policies that could be affected by adaptation loans might be lowering migration impacts due to climate change. However, this strongly depends on the national situation and needs further evaluation.</p>
Agriculture & forests	Low to High	<p>Generally it can be expected that in the agriculture sector public institutions are rarely active. However often forests are managed by the state. Generally the same effects as in the private sector occur.</p> <p>High for investors that have identified the need for adaptation in the short-term and face challenges to get a loan with economical interest rates;</p> <p>Low for investors that have identified the need for adaptation in the long-term</p> <p>Low for investors that have identified the need for adaptation in the short-term and have access to loans</p>
Biodiversity, ecosystems,	Low to High	Borrowing Member States / institutions benefit from

Policy sector as per White Paper	Applicability	Comment
water		lower interest rate
Coastal and maritime areas	Low to High	Borrowing Member States / institutions benefit from lower interest rate

The effectiveness of loans to incentivize adaptation has been proven in different countries and circumstances. For instance the Australian “Climate change adjustment programme” focusing on the agricultural sector combines grants and loans to support farmers that have to face challenges of a changing climate. These instruments have been specifically designed to cope with the impacts of changing climatic characteristics. For further information see the case studies in Annex II (page 278f).

3. Efficiency

What resources does the instrument need to achieve its objective?

The attractive aspect of this economic instrument is that initially no public budget is needed as the EU and the member states can rely on funds from the capital market, derived through the funding institution, e.g. EIB.

In the alternative financing models either the EU budget contributors or the member states have to provide capital. Here we see less availability and stronger resistance by national governments.

If expert evaluation of risks is erroneous and debtors default, the EIB budget (or the budget of the institution issuing the loan) would be needed as collateral. Hence, the risk element is substantial. Even though examples of the use of the EIB budget as collateral for borrowing money from the financial market exist, it is not possible to forecast how national finance ministers will react to this potential liability. A solution might be to agree on a cap for loans which also restricts the collateral demand.

What transaction costs will accrue?

Transaction costs will arise during the evaluation process of beneficiaries’ applications and the management of financial resources. Transaction costs are either subsidized or covered by slightly higher interest rates for the recipients. The model of attracting additional finance on capital markets and channelling it to recipients has been applied by the EU and its intermediaries already. Therefore the administration is expected to be mature and transaction costs are unlikely to be a barrier for implementation. More difficulties are likely for evaluating the applications regarding their risk level. Required capacity has to be either built up or paid for; this could likely increase transaction costs, especially in the starting-phase.

4. Equity: What distributional consequences will arise?

The distributional consequences will depend on the design features of the loan scheme. A major question will be where the money needed for the loans comes from and who is providing collateral for the default risk. The most likely model assumes that EU tax payers take over the risk burden while financial markets earn low profits with virtually no risk.

On the receivers' side, primarily small and medium sized entities appear to be favoured by a loan scheme. They have the possibility to finance adaptation activities with very favourable interest rate conditions. Regarding public receivers, especially institutions/states with lower sovereign credit ranking (=higher risk of default) will benefit from an EU loan scheme.

5. Conditions and barriers

Loans can promote adaptation activities in a well-defined but limited context. They appear most suited for cases where the investor struggles to get access to funding for a project that will create (some) revenues in the future.

However, due to the rather limited quantitative effect of loans to the overall cost structure of an investment, the impact on and benefit for many adaptation activities can only be considered moderate at best.

A notable exception might be public-to-public loans that can help governments of EU Member States with weak credit rankings to lower the costs of procuring money.

A main barrier for all investments that do not generate direct or indirect revenues is that their return (in terms of avoided damage) is highly uncertain. Hence, many actors may hesitate to take action today. This is particularly applicable to retrofit measures (e.g. strengthening the fundament of existing buildings); people are likely more willing to take adaptation-related investments in the case of new-build ("greenfield") projects.

2.5.1.3 Recommendations

The assessment shows that loans need specific design features to be demanded by a broad scale of potential recipients. Feasibility may be achieved by considering that different level of incentives will be necessary to achieve broad application for loans. Some groups will appreciate the availability of loans with low interest rates as they have identified the need for short-term adaptation already. Other groups might need further incentives before investing in e.g. long-term adaptation with insufficient understanding of the benefits.

Given the likely limited quantitative impact of loans for some of the outlined groups, we recommend bundling them with partial grants on the investment; i.e. granting x% of the investment and providing a loan for the remaining part. This would provide actors with a stronger incentive to invest and overcome the "uncertainty-barrier" described above. The size of grants may differ between adaptation activities, e.g. long-term loans could be larger than for short-term activities or adaptation measures that provide revenues for the loan recipient. Broad information campaigns, technical expertise to assist the appliers or institution building (as e.g. in the existing programmes JASPERs or ELENA), or public funding to build up the capacity of financial institutions to assess the risks properly and reduce the transaction costs may be a good option for ancillaryloans in these cases. However, this needs case-by-case analysis and decision.

2.5.2 Guarantees

2.5.2.1 Description for the purpose of subsequent assessment

In the context of this project, one can differentiate between two types of guarantees.

The first one follows the classical definition of guarantees, i.e. cases where a government – be it the government of a Member State or the EU – takes over the default risk of a private debt obligation (“public-to-private guarantee”). This can either be a full takeover or a partial takeover of the default risk. For example, both the EU SME Guarantee Facility and the EU Guarantee Fund for External Action have capped their guarantee values at 50-75% of the project value, depending on project type and programme (EU Commission 2010b)²⁴. The objective of the guarantees is to lower the costs of a loan for a borrower by reducing the default risk premium that the lender typically takes, or to enable loans to borrowers that otherwise would not be considered creditworthy due to a high default risk or that cannot bring in the required securities. This principle is shown in Figure 17:

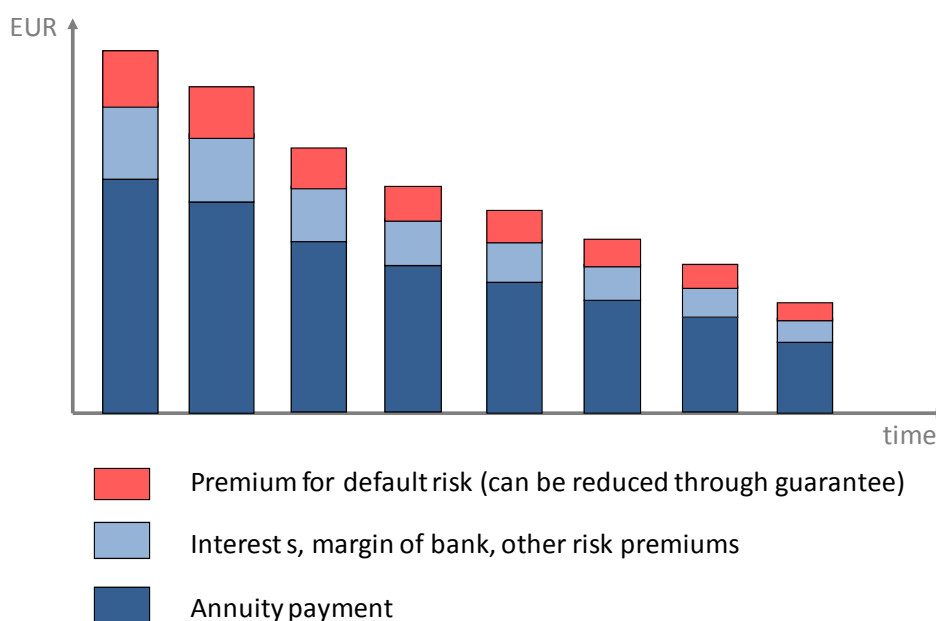


Figure 17: Cost elements of an annuity loan and cost reduction potential through guarantees

The second type of guarantee that is interesting for the purpose of adaptation is a “public-to-public guarantee”, where the EU - or theoretically any country with a good sovereign credit ranking that is

²⁴ A new initiative is the “Europe 2020 Project Bond Initiative” for which a public consultation was started in February 2011. The objective of the Bond Initiative is to provide EU support to project companies issuing bonds to finance large-scale infrastructure projects. The Initiative aims to attract additional private sector financing of individual infrastructure projects by improving the rating of the senior debt of project companies, thereby ensuring that this can be placed as bonds with institutional investors (http://ec.europa.eu/economy_finance/consultation/index_en.htm, accessed 16 June 2011)

willing to do so - would provide guarantees for loans taken by governments of EU Member States and/or national public institutions. This could be useful for financing e.g. adaptation-related public infrastructure projects in EU Member States with a bad sovereign credit rating, since these Member States would face relatively high default risk premiums if they borrowed from the financial markets. While such a type of public-to-public guarantee does not match with the definition of a PPP, we feel that it is an interesting application and include it as a variation in our analysis.

Overall, the nature of guarantees is indirect compared to loans that can be considered as direct support. At the same time, expenditures for the public institution that issues the guarantee are relatively limited.

2.5.2.2 Assessment: How can guarantees and their variants promote adaptation activities?

1. Applicability

Applicability of the PI to incentivize adaptation

Guarantees are an economic instrument that lowers the costs for entities that want to invest in adaptation activities, but that do not have the financial resources to pay for the investment themselves, or that want/need to take a loan for other reasons. Hence, for this target group, there is at least a basic applicability of the instrument.

At the same time, one needs to consider the rather indirect nature of guarantees described above. Looking at the cost components of an annuity loan as visualized Figure 17, it becomes obvious that a guarantee can only affect a relatively minor cost item out of the overall expenditure basket that an investor needs to deal with. This will influence the effectiveness of the economic instrument (see below).

Institutional feasibility

The institutional applicability of the instrument will depend on the details of its implementation, such as the actors to be involved on the public side. One major question in this regard is, which intermediaries will be involved and whether one applies a public-to-private or a public-to-public guarantee scheme. In general terms, however, guarantees are a well-known and tested economic instrument and there is expertise on all relevant public levels (EU and national) that can be drawn upon for setting up a guarantee scheme. The same applies to the bank level.

Consistency with other economic instruments

Guarantees are generally consistent with several outlined economic instruments providing adaptation incentives. It would not make too much sense to introduce loans and guarantees at the same time, as they have a similar effect (although guarantees act more indirectly). However, it can make sense to combine guarantees and partial grants. This would increase the incentive for many target-groups and is likely to expand the feasibility significantly.

Apart from this, the discussion in chapter 2.5.1.2, subchapter “Consistency with other economic instruments”, applies.

Acceptability to interest groups

Same as for loans, see above.

- 2. Effectiveness for incentivising a desired adaptation outcome

The effectiveness of guarantees for incentivizing adaptation is very similar to loans (see chapter 2.5.1.2 above for details). The main difference is that guarantees have a more indirect nature than loans. The effectiveness of money spent for guarantees strongly depends on how accurately the default risk can be evaluated and what types of projects are financed. Hence, it is not possible to provide a general evaluation across sectors and project types.

Looking at the relevant policy sectors as defined in the EU White Paper “Adapting to climate change: towards a European framework for action”, the relevance of guarantees also varies strongly by sector. We summarise our assessment of the applicability of guarantees to the policy sectors. The overarching question was “how well is the instrument suited to affect adaptive behaviour”. In order to operationalise this question, we have looked at the following sub-questions:

- Are the actors of the sector identical with the target group of guarantees?
- To what extent can guarantees support action in the policy sector?
- What is the actual access of actors to loans?

Public-to-private guarantees:

Table 16: Applicability of public-to-private sector guarantees by policy sector

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	Low to Medium	Medium for investors that face challenges to get a loan; Low for investors that easily get a loan (limited financial impact of a guarantee)
Physical infrastructure (public)	n.a.	Public investors, which are not covered by a public-to-private guarantee
Physical infrastructure (private)	Low	Positive impact but limited in scale (major financial burden remains with investor)
Health and social policies	n.a.	Mainly public investors, which are not covered by a public-to-private guarantee
Agriculture & forests	Low to Medium	Medium for investors that face challenges to get a loan; Low for investors that easily get a loan (limited financial impact of a guarantee)
Biodiversity, ecosystems, water	n.a.	Mainly public investors, which are not covered by a public-to-private guarantee
Coastal and maritime areas	n.a.	Mainly public investors, which are not covered by a public-to-private guarantee

Public-to-public guarantees:

Table 17: Applicability of public-to-public sector guarantees by policy sector

Policy sector as per White Paper	Applicability	Comment
Production Systems (= Industry)	n.a.	Private investors, which are not covered by a public-to-public guarantee
Physical infrastructure (public)	Medium	Borrowing Member States / institutions benefit from lower interest rate
Physical infrastructure (private)	n.a.	Private investors, which are not covered by a public-to-public guarantee
Health and social policies	Low	Direct benefit unclear due to policy-nature of "sector"
Agriculture & forests	Medium	Borrowing Member States / institutions benefit from lower interest rate
Biodiversity, ecosystems, water	Medium	Borrowing Member States / institutions benefit from lower interest rate
Coastal and maritime areas	Medium	Borrowing Member States / institutions benefit from lower interest rate

3. Efficiency

What resources does the instrument need to achieve its objective?

In general terms it may be noted that from the perspective of the EU budget there is no significant difference between loans and guarantees. In both cases budget money is given, e.g. to the EIB, which they either lend on or use as collateral for guarantees. Hence, in both cases they need to be financed up-front and the risk exposure for EU budget is limited to the amount given. Guarantees usually offer a higher leverage (project size/public fund), but also impose higher risk for EU taxpayers' money.

To assess what amount of resources will be necessary we looked at existing guarantee schemes of the EU and its Member States. The results are outlined in the following:

Through the "Loan Guarantee instrument for TENs Transport projects" (LGTT) the EU provides guarantees for a maximum of 20 billion € of loans. These guarantees cover up to 10% of the individual loan sum and they are intended to bridge especially repayment problems during the starting phase of infrastructure projects. The collateral amounts up to 1 billion € which is split between the EU Commission and European Investment Bank (EIB) (see also: EIB 2008). If one assumes that the framework conditions of the large infrastructure projects supported by LGTT are

comparable to large infrastructure projects in the adaptation context – such as dikes, harbours, climate proofing of transport systems – one can refer to the above figures to estimate resources needed for adaptation related guarantees, i.e. public funds of 1 billion € for collaterals could then enable investments of around 20 billion €. This gives an input-output ratio of 1:20, or 5%. However, a major difference between the infrastructure systems supported by LGTT and adaptation projects is that the latter typically do not generate revenues whereas the former do e.g. through toll payments for highway / bridge use.

Another example is the UK's Small Firms Loan Guarantee Scheme (SFLG). If the borrower makes use of the loan via one of the selected lenders (regional banks) he must pay a premium of 2% per annum on the outstanding amount of the loan. This premium is received by the state for providing a risk guarantee covering 75% of the loan (compare SFLGfinance.uk). Average default rates are about 13% (see SFLG Annual report, p.5) which are covered by the British tax payers ultimately (see Graham 2004, p. 9). Interestingly, the default rate reached 30 – 35% in the initial stages of the programme. The programme enabled nearly 6,000 loans worth £409 million, with public input of around £60 million (Graham 2004, p. 9). This gives an input-output ratio of 60:409, or 14.7%. The SFLG programme finances primarily smaller projects with investments of up to £ 250,000 – and would therefore be more comparable to SME and private investors' needs in the context of adaptation. However, the limitation regarding the typical lack of revenue generation through adaptation activities discussed above also applies here.

The examples above show that the required resources for setting up a guarantee scheme for adaptation strongly depend on its actual design and target group(s). Besides, a major barrier for applying guarantees in the context of adaptation may become the lack of revenues generated by projects.

What transaction costs will accrue?

As distribution and contact with the loan recipients is usually covered by the lending institution, e.g. a bank, the state does not have to cover the usual administrative overhead (see also SFLG Annual report 2008, p.1). However the guarantee scheme is responsible for the defaulted component of the portfolio which would have to be covered by the EU or its intermediaries at the end of the day. To minimize own costs the EU might require a premium by the borrowers as the UK does with its SFLG. The premium level has to be considered carefully; too high rates will discourage adaptation activities, too low ones might irresponsibly increase costs for the EU.

4. Equity: What distributional consequences will arise?

The distributional consequences and hence, equity considerations, will depend on the specific design features of a guarantee scheme. A major question will be where the money needed for the guarantees comes from. On the receivers' side, primarily small and medium sized entities appear to be favoured by a guarantee scheme.

5. Conditions and barriers

Guarantees can promote adaptation activities in a well-defined but very limited context. They appear most suited for cases where the investor struggles to get access to funding for a project that will create (some) revenues in the future.

However, due to the rather limited quantitative effect of guarantees to the overall cost structure of an investment, the impact on and benefit for many adaptation activities can only be considered moderate at best. A notable exception might be public-to-public guarantees that can help governments of EU Member States to lower the costs of procuring money.

As stated above, a main barrier for all investments that do not generate direct or indirect revenues is that their return (in terms of avoided damage) is highly uncertain. Hence, many actors may hesitate to take action today. This is particularly applicable to retrofit measures (e.g. strengthening the fundament of existing buildings); people are likely more willing to take adaptation-related investments in the case of Greenfield projects.

2.5.2.3 Recommendations

Given the likely limited quantitative impact of guarantees, we recommend bundling guarantees with partial grants on the investment; i.e. granting x% of the investment and providing a guarantee for the remaining loan. This would provide actors with a stronger incentive to invest and overcome the “uncertainty-barrier” described above.

Summary of evaluation of market based instruments to promote adaptation

In the following we present a summary of the evaluation results of MBIs analyzed in Task 2 in a tabular form. The first table describes the outcome of the general evaluation criteria which stay similar or constant for all sectors. They include all evaluation results except the sector specific applicability. The latter is presented in the second table. Regarding the qualitative evaluation results, the expression “High” usually expresses a positive outcome whereas low usually stands for “negative” impact. However there are three exceptions which are noted in the first column.

Table 18: Overview of general evaluation results of market based economic instruments

	Subsidies		Taxes	Licenses, permits	Other MBIs		FIs	
	Grants	Tax reductions	Land use tax/fees	AMM	PES	Water pricing	Loans	Guarantees
General applicability to incentivize adaptation ²⁵	Medium	Medium	Low	High	Low - Medium	Low - Medium	Medium	Low
Institutional feasibility	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium
Consistency with other instruments	High	High	Medium	Medium	Low to medium	High	High	Medium to high
Acceptability to interest groups	High	High	Medium	Medium ¹	High	Low	High	Medium
Little resource requirements (Low = positive)	High	High	Low	Low high ²⁶	High	Low	Medium to low	Low
Transaction costs (Low = positive)	High	High	Medium	Medium to high	High	Medium	Low	Low
Equity (Distributional consequences)	High	High	Medium	Medium to high	High	Medium	High	High
Conditions and barriers (Low = positive)	Medium	Medium	Low	Medium to high	Medium	High	Medium	Medium

Scale: Usually from High for very positive to n.a. not applicable

²⁵ This criterion reflects the broad applicability of the instrument as described in the table 1 above. If the EI is applicable in many sectors it receives a „high“ grade, vice versa a „low“ one.

²⁶ Depends on demand system

Table 19: Sector-specific applicability of economic instruments for adaptation

	Subsidies		Taxes	Licenses, permits	Other MBIs		PPPs		RFIs
	Grants	Tax reductions	Land use taxes and fees	AMM	PES	Water pricing	Loans	Guarantees	RFIs
Production Systems (= Industry)	Medium	High	Low	Medium	Low	Low	Low to medium	n.a. to medium	High
Physical infrastructure (public)	Low	Low	Low	High	Low	n.a.	Low to high	Medium	High
Physical infrastructure (private)	High	High	Low	Medium	Low	Low	Low	Low	High
Health and social policies	Low (social policies) to high (health policies)	Low (social policies) to medium (health policies)	Low	High (health); n.a. (social)	Low	n.a.	Low to medium	Low	Low
Agriculture & forests	Medium	Medium	Medium	Medium	Medium	High	Medium to high	Medium to high	Medium
Biodiversity, ecosystems, water	Medium	Low	High	Low to medium	High	High	Low to high	Low to medium	Low
Coastal and maritime areas	Low	Low	n.a.	Low to medium	Medium	Low	Low to high	Low to medium	Low

Scale: From High for very applicable and relevant to n.a. not applicable/relevant at all

2.6 Risk Financing Instruments

2.6.1 Role in disaster risk management and climate adaptation

Risk financing instruments have been introduced in task 1, and in task 2 we will now provide more detail on these instruments as well as lay out the criteria for undertaking the assessment. Contrary to most other instruments discussed in this report, many RFI for dealing with (current) climate variability have been implemented already in many different varieties, and in task 3 we will focus in more detail on key sectoral applications in different national and institutional contexts (“the real world”) in order to provide evidence and factual insight into how insurance instruments help absorb the increasing loss burdens and may lead to improved adaptation decisions.

Risk financing instruments for absorbing the losses incurred by extreme weather events are part and parcel of disaster management (see Table 20). Disaster management covers a wide array of interventions as shown in the table below, comprising ex ante, risk based interventions (prevention, preparedness and risk financing, which are commonly summarized as disaster risk management (DRM)) as well as ex post interventions (relief and reconstruction). The balance today is tilted heavily to ex post interventions with about 90% of international funds disbursed by donors and international financial institutions for disaster management being allocated to post-disaster emergency response, relief and reconstruction (UN/World Bank, 2010).

In spite of high returns on investments that reduce risks and prevent losses before disasters strike, disasters are sorely under-prevented. As one example, in the US, several studies show that only about 10% of flood-prone households have adopted loss-reduction measures, which Kunreuther et al. (2011) attribute primarily to myopia. The same is generally true for Europe, and the upfront costs of the investment in risk reduction loom large relative to the perceived benefits from the measures over time. In the absence of concrete information on net economic and social benefits and faced with limited budgetary resources, many policy makers are also reluctant to commit significant funds for risk reduction. Instead, they face post-disaster political pressure to provide funds to assist victims and aid the recovery process (Benson and Twigg, 2004). Recently individuals, governments, the insurance sector and the donor community have started to encourage pre-disaster, pro-active disaster investment and planning strongly, to redress this balance and reduce the overall costs of disaster management, which have been rising (Kreimer and Arnold, 2000; Linnerooth-Bayer et al., 2005; Gurenko, 2004). From an insurer’s viewpoint, this is helpful, since it reduces the risk of high losses, and hence the uncertainty in pricing and the need for reinsurance. It can contribute to making insurance more affordable, and it reduces the number of claims that are likely to arise. Yet, although mostly insurers do not see it their core concern to carry out prevention and consider this the clients’ concern, in the UK as one examples, insurers have carried out demonstration projects on flood-proofing, community flood action plans and sustainable drainage.

2.6.2 Overview of risk financing instruments

The important distinction between *risk financing* and *loss financing* is that the former is purchased/organized by the persons or community at risk, whereas the latter is provided by people and the state and thus (usually) funded by current and future taxpayers. Risk financing instruments, however, can also serve as important re-distributive instruments if the premiums for insurance or the interest for capital market securities are cross subsidized by persons within the victim community or subsidized by persons outside. In fact, cross-subsidization and flat premiums are often the case (such as in France, Spain and the US, see also the discussion in task 3 for details), risk financing instruments hold a substantial potential to provide for EU burden sharing arrangements in a warming climate that may lead to increased disaster burdens in some regions, such as for flood hazards in Eastern Europe, and drought and heatwaves in Southern Europe.

Examples of financial mechanisms and arrangements available for managing climate-related risks include formal and informal risk financing mechanisms for agents operating at different scales - farms, households and small/medium enterprises (SMEs) operating at the micro scale, large national and multinational firms, and governments (local, regional and national) - including commercial property and agricultural insurance or public sector national insurance programmes.

The best known risk financing instruments are risk transfer instruments. Risk transfer pools and shares risks before a catastrophe occurs and requires the use of instruments, which are predisaster arrangements in which the client incurs a cost in return for the right to receive a (usually) much larger amount of money after a disaster occurs (Cummins and Mahul, 2008).

Table 20: Options for the management of natural disasters events

Timing	<i>Ex ante</i>			<i>Ex post</i>
Type	Prevention/ Mitigation	Preparedness	Risk financing	Managing the impacts
Effect	Reduces hazard and/or impacts	Reduces impacts	Financial protection for losses provided by pre arranged mechanisms that share	Reduces impacts (relief) and advances recovery (reconstruction)
Key options	Physical and structural mitigation works (e.g. irrigation, embankments) Land-use planning and building codes Economic incentives for proactive risk management	Early warning Contingency planning, networks for emergency response, Shelter facilities, evacuation plans	Insurance and reinsurance for private and public sector assets (Risk transfer) Alternative risk transfer, such as catastrophe bonds, for public assets National and local reserve funds	Providing response, relief and compensating losses Supporting recovery Rebuilding housing and infrastructure

Source: Based on IDB, 2000

In the EU, there is a huge variety of risk financing arrangements, including the roles of the public and private sectors, which is discussed in task 3. The figure below shows the relative percentage of losses (public and private) absorbed by insurance companies, the government and the victims (savings, loans, and other forms of self-insurance) with respect to six major European disasters. In some countries, notably Italy (and also the Netherlands and Denmark), the state has had a proclaimed policy of absorbing up to 100 percent of disaster losses, and almost half of the Umbria earthquake reconstruction in 1997 was financed with public funds. Globally, the insurance industry is a minority payer for catastrophe losses. In the period 2000-09 about 38% of total climate-related disaster losses were insured (see project worksheets).²⁷ The larger part of the losses was borne by the affected parties themselves, federal, state or local governments, and, in highly affected countries with little coping capacity, the international donor community. It is notable that the insured proportion varies greatly depending on the hazard; storms are better insured than floods or droughts.

More recently, many countries are moving towards public-private insurance arrangements much like Spain, which has a national disaster insurance programme backed by its government. Alternatively, as the UK Easter floods of 1998 show, there is widespread private insurance cover in England and little post-disaster government assistance. This cover is voluntary compared with compulsory insurance for some hazards, for instance, in Switzerland, which has nearly 100 percent catastrophe insurance density in some cantons (Huber, 2004; BaFin, 2003) compared for example to Belgium (10 percent) and Italy (5 percent).

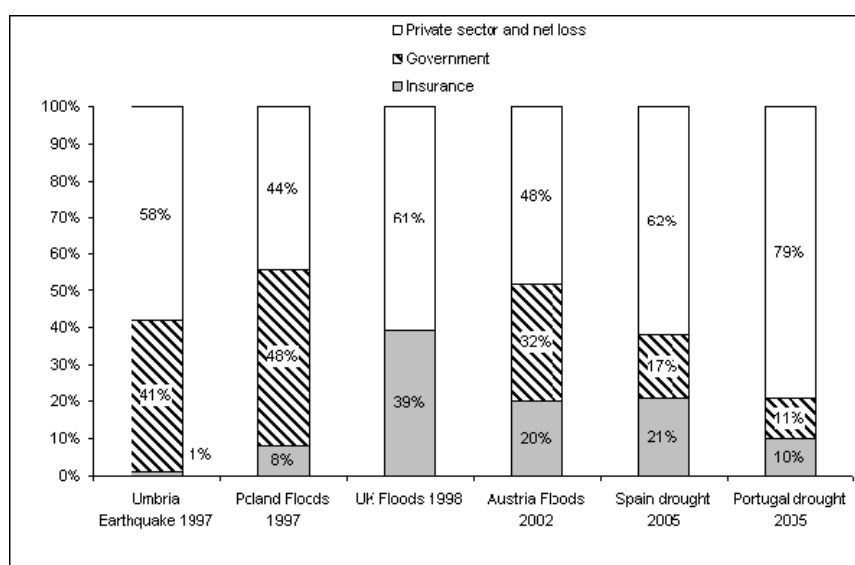


Figure 18: Cross-country sample of financing modalities of disaster losses by insurance, government assistance, and private sector and net loss (as a percentage of direct losses)

Source: Hochrainer et al. 2010

²⁷ These figures only include large natural disasters.

The table below identifies key risk financing instruments for the private sector and farmers and distinguishes this from ex post loss financing and non-market pre disaster arrangement. Governments also rely on diverse financial approaches to repair public infrastructure, assist victims and otherwise meet their post-disaster liabilities: taxes (e.g., Australia enacted a tax following the 2011 floods), diverting funds from other budgeted programs (e.g., Austria in 2002, when it financed flood relief from funds previously targeted to purchasing fighter jets), borrowing money domestically, or taking loans from international financial institutions (e.g., Romania borrowed from the World Bank following the 2009 floods). Conventional financial arrangements can fall short of meeting post-disaster capital needs, and the financial gap may worsen with more intense and frequent climate-related disasters. To close the gap, governments are experimenting with capital market and hedging instruments (insurance related securities), like insurance and catastrophe bonds, among others.

Table 21: Pre- and post-disaster loss and risk financing arrangements

	Mechanism	Households/business: Loss of assets and business interruption	Farmers: Loss of crops and livestock	Governments: Relief and reconstruction expenditure
Post - disaster (ex post) loss financing	Market and non- market	Sale of productive assets, emergency loans; public assistance	Sale of productive assets, emergency loans; public assistance	Taxes, diversions, loans from international financial institutions, aid
Pre- disaster (ex ante) risk financing	Non-market	Kinship and voluntary mutual arrangements, calamity funds	Kinship and voluntary, mutual arrangements, storage, mutual funds	Reserve funds
	Market-based Risk transfer: Risk pooling and sharing	Insurance, catastrophe bonds, weather derivatives	Insurance, weather derivatives	Insurance, regional pools catastrophe bonds

Our focus in the following discussion is on risk transfer instruments, including property and crop insurance, national insurance programmes, regional pools and government or sovereign insurance. We briefly introduce the mechanics in the following section.

Insurance and reinsurance

The mechanism of insurance can be explained as follows. Insurance is an economic institution that allows the transfer of financial risk from an individual to a pooled group of risks by means of a two-party contract (Kunreuther, 1998). The insured party, the policyholder, receives coverage, indemnification, against the loss from an uncertain event from the insurer in exchange for a certain payment, the premium. Usually, full coverage is not supplied; for example deductibles of fixed

amounts or ratios are the standard case. The loss to be reimbursed based on an insurance contract is called a claim (Kunreuther, 1998) or indemnity payment.

Insurance uses the same principle underlying the *Law of large numbers* discussed before in the context of risk pooling for governments. For risk transfer, this law, also known as the insurance principle, states that for a series of independent and identically distributed variables the sample mean over the variables converges to the theoretical population mean of the probability distribution and thus the variance around the mean decreases for large numbers. For insurance, this means that the variance of average claim payments to the insured decreases as the number of policies increases. Premiums become calculable with an increasing degree of confidence (Kunreuther, 1998).

Insurers also purchase insurance in order to reduce their risk exposure. The latter is usually done by means of reinsurance. Figure 19 displays the transactions involved in reinsurance as well as insurance. The insurer is referred to as primary carrier. The underlying principle for reinsurance is the same as for insurance; reinsurance may in fact be called "insurance for insurance companies" (Swiss Re, 1996). The objective of insurance is thus to spread risks as widely as possible to construct a relatively uncorrelated portfolio of risks so that the law of large numbers operates (Kunreuther 1998). Reinsurance is essentially an international risk-sharing agreement that makes it possible to transfer catastrophic risk from the national insurance system to worldwide risk-sharing pools operated by multinational reinsurance companies.

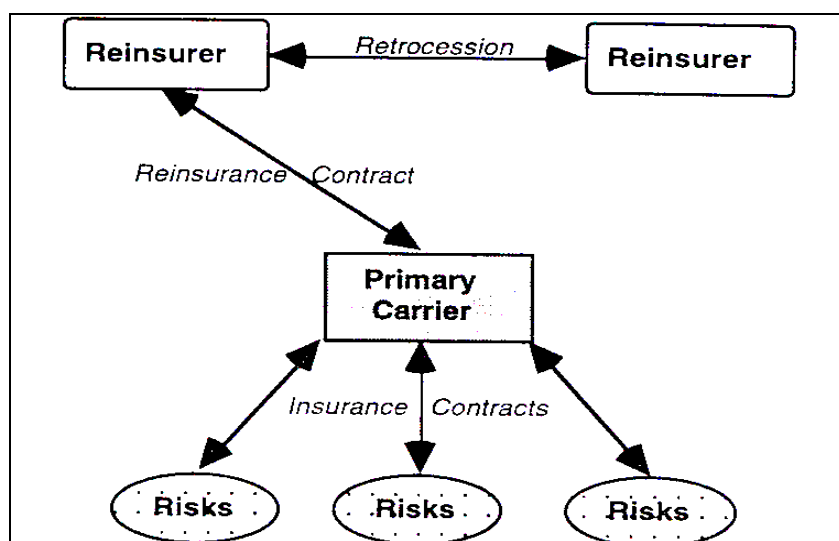


Figure 19: Insurance and reinsurance

Source: McIsaac and Babbel, 1995

There are many different types of insurance depending on the types of risk covered. While health and car insurance is widely available and used for normally distributed "life-cycle events", such as illness or accident, natural disaster insurance is more complicated as it covers low-frequency, high impacts events, i.e. "non-normal" events. There are different modes of delivery, and insurance against natural hazards can be offered as a voluntary extension of property insurance and household contents insurance, or it can be mandatory for clients to participate in insurance schemes such as in Spain and France. For agricultural and sovereign insurance, it is often offered on a voluntary basis.

There are different types of disaster insurance designed for dealing with natural catastrophe risks. These will be described in more detail in the sections below

Index based insurance

Traditionally, insurers have paid claims based on actual losses (indemnity-based insurance), which requires extensive networks of claims adjusters who assess individual losses following an event. It also means investing in marketing to individual clients and controlling moral hazard. Moreover, insurers in low-income countries have far less access to global reinsurance markets than do those in developed countries. The low volume of business and large fixed expenses mean that reinsurers can service these markets only at high cost. Traditional indemnity-based crop insurance programmes are thus costly, which is a reason why many have failed in developing countries (World Bank, 2005).

To avoid the high transaction costs of indemnity-based insurance systems, index-based or parametric schemes make payouts contingent on a physical trigger, such as rainfall measured at a regional weather station, thus circumventing expensive claims settling. In the case of weather derivatives, farmers collect an insurance payment if the index reaches a certain measure or “trigger” regardless of actual losses. These schemes may offer a less costly and thus more viable alternative to traditional indemnity-based crop insurance.

2.6.2.1 Alternative risk transfer instruments

Insurance or reinsurance are traditional mechanisms to shift risk. However, in recent years due to lack of market capacity, new strategies to finance disaster losses through the capital markets have been developed, which are often subsumed under the heading alternative risk transfer (ART). There are many different types, the key ones of interest to this discussion being weather derivatives and catastrophe bonds

Catastrophe bonds

As another novel insurance mechanism, a catastrophe bond is an instrument whereby disaster risks are packaged (securitized) in the financial markets (they are usually parametric). The investor receives an above-market return if a specific catastrophe does not occur in a specified period but sacrifices interest or part of the principal if an event does occur. Disaster risk is thus transferred to international financial markets that have many times the capacity of the reinsurance market. Another advantage accrues to investors. By adding catastrophic risk to their investment portfolios, diversification is increased since natural catastrophes are generally not correlated with stocks and other investments tied to economic performance. Cat bonds have mostly been used by insurers to access additional risk capital outside reinsurance markets. Lately, governments such as Mexico have started using such instruments as well. However, coverage compared to global reinsurance markets with a capacity of about 200 billion USD is still small (see Figure 20).

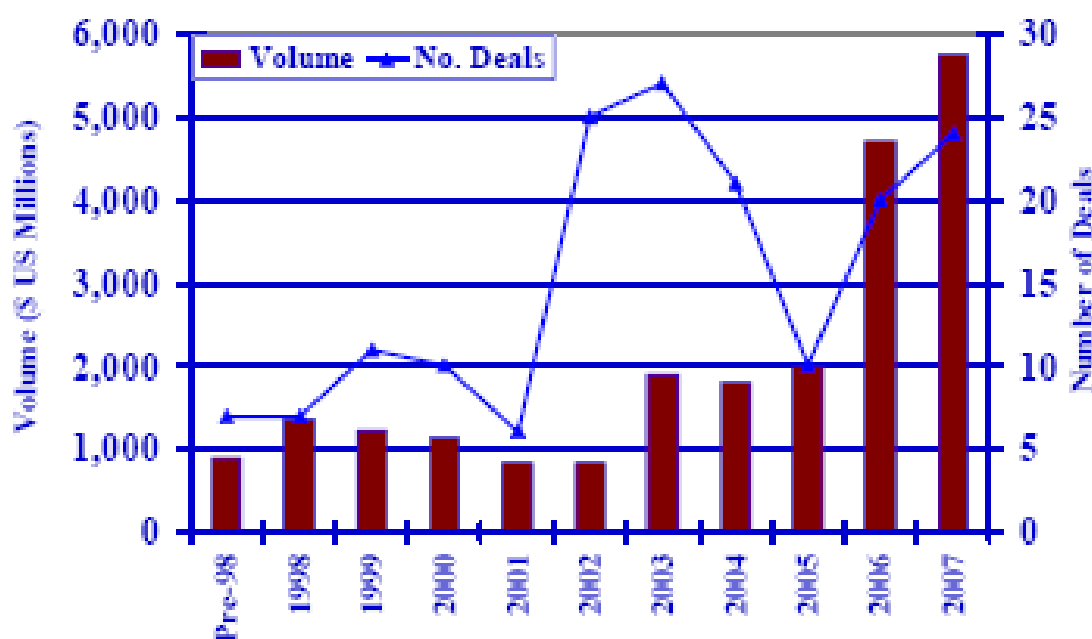


Figure 20: Catastrophe bond transaction and market volume

Source: Cummins and Mahul, 2008

Weather derivatives

Weather derivatives are contracts where payouts are linked to physical triggers, e.g. number of days with temperatures below or above a specified threshold, or rainfall above or below a prespecified level. They are two-party contracts, where given a prespecified trigger, one party provides a payout to the other. Thus they do not pool, but share risks. However, in principle an insurer could build a portfolio of such contracts and thereby construct a pool of risks, which would reduce the variance of the performance. There are many variants of weather derivatives, but mostly they have been used in the energy industry, by snowmobile makers and industry producing air conditioners, as well as the insurance sector. Also, there are novel developments to link it to drought protection in a development assistance context. First deals were done in the late 1990s, and the market grew rapidly, but after ENRON, one of the market makers collapsed in 2001, uncertainty in the market led to smaller volume. Since then the market has however grown and energy utilities, insurers, reinsurers, banks and hedge funds are engaged on both sides of the market. Total volume of traded weather risk contracts in 2010 rose to \$11.8 billion, and growth has been particularly large for rainfall, snow, hurricane and wind risks (Artemis, 2011).

2.6.3 Assessment: criteria to analyze and compare risk-financing instruments

In the following, we conduct an assessment of the RFIs discussed above based on the four key criteria. The four criteria in line with the other criteria used in this task are

- *applicability* for incentivizing adaptation
- *effectiveness* for incentivizing adaptation (risk reduction);
- *efficiency* in terms of benefits and costs; and
- *equity* in providing security to low-income population

We introduce and discuss these criteria here in order to render RFIs comparable to the other PIs under investigation in task 2. Task 2 thus examines the RFIs generally and in a “perfect” world setting, i.e. given idealized conditions and efficient markets. However, as will become clear, much of the assessment depends on the context and the way the RFIs are implemented. This will be the topic of Task 3, where we will assess key RFIs by sector and in a “real world” setting.

In what follows, we discuss these criteria for the whole group of RFIs as there is important overlap.

2.6.4 Assessing Insurance instruments

As insurance instruments generally have very similar characteristic at the generic level, which we consider here, we assess the different types together, namely

- Property and household contents insurance,
- Agricultural insurance for crops,
- Business insurance,
- Sovereign insurance,
- Intergovernmental risk pools

This also helps to identify similarities and differences.

Applicability for incentivizing adaptation

Insurance is generally highly applicable as such mechanisms can incentivize adaptation efforts. In the table below we discuss the applicability of different insurance types to key sectors as identified in the *Adaptation White* paper (with the addition of private property). Property insurance deals with losses to private property. Business property and interruption insurance covers productive systems. Physical infrastructure can be protected by sovereign insurance risk pools. For agriculture agricultural insurance is highly applicable.

There are many adaptation options in these sectors that insurance may incentivize (see also table below for key options), such as

- Flood proofing of buildings and property,
- Retrofitting of houses (e.g. against windstorm),
- Local flood protection measures

- Flood proofing infrastructure
- Building larger scale flood protection schemes
- Switching to more heat and drought resistance cultivars
- Implementation of more efficient irrigation measures

As discussed further below, due to the many barriers, lack of evidence and locale-specific nature of adaptation, it is very difficult to identify key options that can be most strongly incentivized in the different sectors. Providing a more solid database on evidence of incentives i.e. that are actually in place and working in different sectors and countries thus largely remains a an issue for further research. Yet, as a general rule it can be said that actions with a stronger private adaptation component would be more strongly incentivized by insurance. Such options would comprise raising plinths for flood risk in private property and retrofitting homes against windstorms. For options that have a public adaptation component, such as local flood protection measures or developing crop variants with longer growing cycles and Implementation of (additional) irrigation measures for droughts and crop risks, it seems the incentives effect would be smaller

How much insurance mechanisms effectively achieve in terms of incentives is a question we are tackling further in this report.

Table 22: Insurance and adaptation according to key sectors

Policy sector as per White Paper	Sectoral applicability	Type of insurance	Incentivized private adaptation
Private property	+++	Property insurance: private properties are insured against flood and windstorm risks	Risk (flood and windstorm)- based pricing and deductibles can incentivize the following efforts <ul style="list-style-type: none"> • Flood proofing of buildings and property (raising plinth, adapting cellars etc.) • Retrofitting of houses (e.g. against windstorm)
Production Systems and services	+++	Property business insurance: Insurance and other RFI are well used by industry to cope with the financial consequences of disasters, e.g. against flood and windstorm risks. Larger businesses often self-insure by pooling risks across their different operations in different locations or countries	Risk (flood and windstorm)- based pricing and deductibles can incentivize the following efforts <ul style="list-style-type: none"> • Flood proofing of buildings and property • Retrofitting of houses (e.g. against windstorm)

			<ul style="list-style-type: none"> Resilience of supply chains, factories and their inventory etc. Local flood protection measures with private good characteristic
Physical infrastructure (private and public)	++	Sovereign insurance and regional pools for flood and windstorm risk Insurance can be used for infrastructure, but in many developed countries the public sector self-insures via its taxing function	Sovereign insurance contracts via risk based pricing and deductibles can incentivize <ul style="list-style-type: none"> Flood- proofing infrastructure Retrofitting buildings Building larger scale flood protection schemes
Health and social policies	-	Less relevant. However some risks such as heat stress and disease may be covered by life, health or employers' insurance, which are very different from catastrophe insurance	-
Agriculture & forests	+++	Agricultural insurance for drought and heatwave risks. Very relevant for crop insurance, less so for forestry, as most forests are self-insured, often implicitly	Risk (drought and heatwave)- based pricing and deductibles can incentivize the following efforts <ul style="list-style-type: none"> Switching to more heat and drought resistance cultivars Developing crop variants with longer growing cycles Implementation of (additional) irrigation measures
Biodiversity, ecosystems, water	-	These "non-tangibles" are less insurable, so applicability is very limited	-
Coastal and maritime areas	+++	Property insurance: private and business. Generally RFI can be and are used, if the underlying hazard is extreme such as storm surge, but less so for 'inevitable' risks such as sea level rise and coastal erosion. Physical assets located at sea can be handled by RFI's.	<ul style="list-style-type: none"> Flood proofing of buildings and property Retrofitting of houses (e.g. against windstorm) Local flood protection measures

Going beyond sectoral applicability, we turn to institutional feasibility. Financial instruments are not neutral with regard to how they allocate the disaster burden, nor with respect to the social, institutional and political context in which these instruments operate. The social and political contexts are highly diverse across the European Union, and for this reason it cannot be expected that insurance arrangements operating in one country can be smoothly transplanted to another.

Examples can serve to illustrate this. The UK depends almost fully on private market insurance instruments for financing risks from floods and other natural perils. It has a huge investment in the institutional and private capital necessary for an effective market insurance system. Moreover, its political representatives and citizenry have a long commitment to market structures for providing public goods and services. Alternatively, France has a great deal of public backing for its compulsory insurance system, which fits closely with France's history of hierarchical public involvement and less commitment to individual choice. The French recognize that their system of flat premiums distorts market pricing and incentives, and they have consciously chosen to use top-down regulations to compensate for this shortcoming. Moreover, it is not surprising that countries with a long socialist tradition, such as Hungary and Romania, have traditionally relied extensively on public taxpayer funds in sharing the disaster burden. But these countries are facing fiscal constraints that limit the ability of the government to absorb losses in the private sector.

It is not only political and social context that influences the applicability of insurance arrangements from one country to another, but also legal considerations. For example, Spain's public monopoly system is constructed as a public sector guarantee to avoid contravening the EU Council Directive on Indemnity Insurance (92/49/EWG). As another example, there is a debate in many countries as to whether compulsory insurance is consistent with individual rights laid out in their respective national constitutions. Finally, the risk environment is a consideration that limits the general applicability of insurance systems. As discussed, private insurers are reluctant to enter many high-risk markets and this is one reason that flood insurance is not as readily available in the Netherlands as compared to the UK.

Effectiveness for incentivizing adaptation

In the following, we discuss the effectiveness of insurance for incentivizing adaptation more generally, and in task 3, we discuss key insurance arrangements as they are implemented with a focus on how they share risks.

There are three main ways that insurance can lead individuals, businesses and public bodies to take measures that will either prevent or reduce climatic risks (adaptation actions): (i) risk pricing, (ii) reducing vulnerability, and (iii) providing risk-relevant information. Other instruments such as subrogation and liability insurance can also play a role. On the other hand, the incentive effect is in practice often small, and the very purchase of insurance often leads to moral hazard, which describes the disincentive to manage one's risks due to the security provided by insurance.

a) Risk based pricing

Although quantification of extreme event risk remains a difficult task, as better information emerges, risk estimates may be refined and drivers such as climate change, vulnerability and exposure changes factored into the premiums and insurance terms. This would signal to the market and customers an enhanced need for taking adaptive action. It is important to note that insurance pricing is very complex. It is based on an estimate of risk, to which however “loadings” are added, to account for transaction costs, a profit margin as well as the uncertainty of the risk, which requires either reinsurance or a higher level of capital. Also, it is driven by demand and supply under competitive conditions. Risks are pooled in portfolios to make reduce the variability of the risk. In addition different hazards are frequently ‘bundled’ to create products that are more useful to clients and more efficient to administer. All these factors influence the final price of insurance products.

In principle, there should be a unique price for every risk, but this would be impossible to administer, since it would require huge volumes of information, and it would be futile anyway, since the true risk is uncertain. In practice therefore, insurers generally categorise risks into groups based on a number of rating factors, such as location and construction, and use these to construct simplified rating structures. When location is not useful (for some hazards such as hailstorm) vulnerability and exposure can still be used to determine prices e.g. depending on the use of hail nets to protect vehicles.

Finally, as well as setting a price on the risk, insurers can modify the contractual terms and conditions to reflect the degree of risk, and incentivise the client to take preventive action. These include setting deductibles; upper limits on the insured amount; and co-insurance, whereby the client pays a pre-determined share of the losses. These contractual terms can in principle be adapted when risk reduction efforts have been taken, e.g. deductibles could be lowered and upper limits raised.

Barriers

There are several barriers to using price as an incentive.

(i) Risk ambiguity. Insurance premium calculation is plagued with uncertainties, particularly for climatic risks. This means that the price charged is often much higher than the long-run price, to build in a safety margin.

Possible solutions

- Contracts could be set for longer periods, to reduce the variability of the performance.
- Premiums could be adjustable retrospectively (within agreed limits).
- Regulations could permit insurers to carry over surplus premium into the future, to reflect the inherent variability in catastrophe risk (This would also reduce their reliance on a sometimes volatile reinsurance market).
- Better information on hazards through improved access to historical weather data and refined climatic projections (UNEP and SBI, 2011)

- Better information on exposure and vulnerability, through the use of GIS, down to the level of individual drains, buildings and trees, as is happening in the UK (UNFCCC,2008).

(ii) The incentive mechanism is weak; insurers do not reward risk reducing behaviour because of their simplified rating procedures, and the fact that often the client cannot modify the risk greatly without significant capital expenditure.

Possible solutions

- Insurers could develop all-in financial packages that could feature finance for risk improvements and reduced premiums.
- Insurers should maximise the use of IT in order to be more flexible in their pricing structure, including where intermediaries are agents for them.

(iii) Competition. There are strong inertial forces against taking the initiative to introduce a price structure that reflects the individual level of risk (risk discrimination): costly and time-consuming changes to IT systems, resistance from clients and intermediaries, and the threat of losing business (including other profitable classes of insurance) to competitors who can merely delay action for a short time (one year) to attack the active insurer's entire portfolio. In addition, insurance markets tend to go through 'cycles' of surplus supply, and consequently inadequate pricing.

Possible solutions

- Financial regulators and rating agencies should be more prescriptive in ensuring that insurers are setting adequate prices for climatic risks. The *European Insurance and Occupational Pensions Authority* (EIOPA), which is charged with helping to support the stability of the financial system as well as furthering transparent markets and products across member states and sectors could play an important role here, in terms of assessing risks, as well as suggesting improved insurance products for climate-affected risks. As well, the Solvency II requirements including the quantitative solvency test run by EIOPA are likely to reinforce the need for insurers to set transparent and adequate prices for climate related risks.

(iv) Annual contracts. The standard insurance contract length is one year only and insurers may not want to invest effort in analysing a risk in detail, when the client may one year later opt for another insurer.

Possible solutions

- Insurance regulators could encourage the use of multi-year contracts for property risks, and also ensure that insurers are taking adequate notice of climatic hazards

(v) Government Policy. National policymakers may favour solidarity over risk differentiation as a general principle, or there may be circumstances, such as 'legacy' risks that are treated preferentially e.g. where a location that was previously perceived to be low risk, is now rated as high risk.

Possible solutions

- Where general policy prevents price differentiation, alternative incentives must be used (see later).
- 'Rope off' exposures which have arisen before climate change risk was appreciated, and handle them in a different way from new exposures, where the risk is properly assessed. This could be by setting up a national, industry-wide system for such risks. It could be formal, with every insurer having a share, and a mechanism for upgrading or removing these risks over time. Elements of this can be seen in USA 'Fair Plans' for high risk drivers, and in the US National Flood Insurance Program. Alternatively, these arrangements could be voluntary, without pooling, as was done in UK for geological slippage on the Isle of Wight, and for inner city business, after rioting in the 1980's.

b) Risk reduction requirements

The insurance process could be utilised to reduce vulnerability in two main ways. The first is to require specific building standards, local infrastructure or risk management measures as a prerequisite for insurance coverage. In the UK, insurers require the authorities to provide flood defences adequate to prevent a 1-in-75 year flood, as a prerequisite for flood insurance. The second is to insist that after damage has occurred, restoration should be in compliance with climate resilient standards (or in the ultimate, relocation to a safer site, as with the US NFIP).

Barriers

As with risk pricing, there are several barriers to incorporating risk reduction into insurance.

(i) Uncertain benefit. The benefit of the adaptation in terms of reduction of risk has to be quantified, not just in theory but in practice. Also, it may require active participation by the client during the extreme event e.g. to mount temporary defences, or continued action by a third party e.g. maintenance of flood defences.

Possible solutions

- Insurers can introduce these measures in a progressive way, testing the benefit for small numbers of clients.
- Insurers can involve clients in active risk management through supporting community action groups (Climatewise, 2010).

(ii) Non-competitive terms. Reducing vulnerability may entail more expensive premiums, or additional actions by the client. For example, 'upgrading' products need to include the cost of the prospective upgrade in the premium, whereas conventional 'indemnity' or reinstatement products simply replace the assets as they were before the loss, without any adaptive improvements.

Possible solutions

- Regulators could mandate that repairs must be meet climate-resilient standards, or that high-risk sites must be vacated.
- The insurance industry could promote the use of recommended climate-resilient standards by underwriters and intermediaries.

(iii). **Capital cost to client.** To install adaptive measures and amortise the costs may take more than a year, the term of an insurance contract, but often consumerist pressures frown on long-term contracts (contractual fairness) since they limit the consumer's freedom of choice in later years.

Possible solutions

- Market practice should shift to favour the use of multi-year contracts for high-hazard locations.
- Insurers could be permitted to arrange concessionary terms for risk management capital expenditure by clients as part of the insurance contract.

c) Providing risk-relevant information

Insurers often provide information to their clients on how to alleviate risks e.g. how to prevent flooding ,and deal with the aftermath if it is unavoidable (Dlugolecki and Lafeld, 2005; Crichton,2009) The availability of information on climatic risks can incentivise insurance users towards adaptation. At the same time, users need to be informed about the available risk prevention measures and their associated costs. This enables them to take appropriate decisions on risk prevention measures or insurance cover or a combination of both. From the insurer's viewpoint there are advantages also; increased risks might lead to insurability problems which would negatively affect insurance business. So risk prevention measures alleviate that problem. Also, risk prevention leads to lower claims payments, and potentially more profit. Finally, assisting the user helps to build client loyalty.

Barriers

There are two main impediments to the successful use of client education as a tool.

(i) Cost. Generating and distributing information is expensive, particularly if it is customised to individuals.

Possible solutions

- Insurance regulators could encourage the use of multi-year contracts for property risks, which would spread the cost of information delivery
- Insurers can collaborate with each other, or with other parties like the emergency services, to produce generic advice packages which spreads the cost. There are many examples of this by national insurance industry associations.

(ii) Myopia. Lay people do not easily grasp the concept of rare, extreme events. This means they do not give appropriate attention to adaptation i.e. risk management of climate-related risks.

Possible solutions

- Insurers can involve clients in active risk management through supporting community action groups (Climatewise, 2010).
- Revision of the Insurance Intermediation directive could partially address this issue by ensuring that it contains provisions requiring insurance brokers and agents to provide their customers with information on climatic risks and possible risk prevention options.

- Regulators could introduce mandatory natural hazard clauses to standard property insurance products
- Lenders could insist that assets purchased on credit are covered against natural hazards.

d) Subrogation

Subrogation can be a useful, albeit complex tool for insurers to enforce risk management discipline. This concerns the fact that insurers acquire the rights of those whom they compensate. If insured weather damage has been exacerbated by the negligence or breach of duty of any organisations (or individuals), the insurers have the right to sue them , in order to recover the cost of the damages. In France some weather damages are not covered by the public insurance pool, and insurers have used subrogation successfully. Underlying this is the legal requirement for risk prevention planning, which imposes a duty on infrastructure managers. (*e.g. eg the Fontaine de Vaucluse Floods 1993, against municipalities which issued illegal construction permits and the Rhône River floods in Arles 2003, where a railway levee was expected to operate as a flood defence, but failed*).

Barriers and solutions

(i) **Cost and complexity.** It is never an easy or quick matter to prove negligence or breach of duty in court.

Possible solutions

Regulators could simplify the procedures concerning how to prove breach of duty/negligence, and introduce penalties for tardy conduct in the legal process.

(ii) **Freedom from prosecution/unclear responsibilities.** Public policy may put some agencies ‘above the law’ in that they cannot be prosecuted e.g. public weather forecasters, or may not clearly assign duties e.g. for proper maintenance of drainage in England.

Possible solutions

Regulators should re-assess the status of prosecution-immune agencies, and clarify responsibilities for risk management (as has been done in England now for drainage).

Liability Insurance. Liability insurers always review in detail the processes that their business clients have for managing their operations and assets. This means that risky activities are well-managed, and therefore insurable. A specific type is directors’ and Officers’ (D&O), which places responsibility at the top of organisations. This has been used extensively in USA, not so much in EU.

Barriers

(i) **Optional purchase.** In general, liability insurance is non-mandatory. This is because it would be difficult to enforce, and might prevent SME’s from operating because it would be expensive.

Possible solutions

Regulators could make liability insurance (products, public, D&O) mandatory for large firms.

(ii) **Cost and complexity.** It is never easy to prove negligence or breach of duty.

Possible solutions

Regulators could simplify the procedures concerning how to prove breach of duty/negligence, and introduce penalties for tardy conduct in the legal process.

In general, experience shows that **partnership or collaborative relationships between insurance operators (insurers, reinsurers, intermediaries, risk consultants), government authorities (regulators and public service providers) and clients** are crucial for encouraging adaptation in the public and private sectors. For example, the Swiss canton public insurers as well as the US NFIP work closely with public officials on options for reducing risk. In Hungary, a permitting system is in place for assuring that homes and businesses take up preventive measures. Insurers can also contribute to setting new climate resilient standards as they are well informed about the performance of infrastructure in extreme events, so it is important that they are involved in the discussions with building regulators and infrastructure developers. In the UK this is performed by the Property Committee of the Association of British Insurers, and there are similar arrangements in other countries.

Efficiency in terms of benefits and costs

How effective or efficient are RFI instruments in improving social well-being and promoting adaptation in relation to their costs? How can the social costs and benefits of risk-sharing instruments be estimated, taking into account their propensity to reduce risks? These questions are both simple and complicated to address. Consider the most simplified form of risk sharing through a mutual insurance arrangement described in Box 1.

Box 1: A simple mutual insurance arrangement

Two farmers (A and B) live in adjacent valleys, each exposed to a similar risk of flooding (say, a 50 year event). Suppose the risks are uncorrelated meaning if there is a flood in one valley it does not change the risk of flooding in the other valley. A 50-year flood would destroy crops, leaving the affected farmer destitute. Since each farmer feels that destitution must be avoided at practically any cost (the farmers are highly risk averse), they strike a deal. Each will provide an agreed amount of food to the other if he or she experiences the crop-destroying flood.

The costs of this arrangement are small and the benefits large. Since farmer A has the same expectation of receiving food as paying out food, the net expected cost is zero. To strike this deal, however, farmer A and B have to travel some distance to meet and discuss (and perhaps sign a mutual agreement), and to certify if the other has indeed suffered losses. The cost of this mutual insurance arrangement thus includes these transaction costs. The benefits are difficult to measure, but would depend on how averse the farmers are to destitution, which in this example is assumed to be large. Without “risk aversion” persons would not purchase insurance unless required; however, most people are averse to very large losses.

In sum, the benefit-cost calculation is straightforward:

- The social benefits are the benefits of avoiding destitution of the farmers;

- The social costs are costs above expected losses (actuarial or fair premium), which in this simple case are the transaction costs

Insurers make these kinds of deals by amalgamating the premiums of large numbers of exposed agents (ideally including non-correlated risks or diversification) into a financial pool (pooling risks).

The social benefit of insurance is the satisfaction (in economic jargon, the “utility”) gained by risk-averse agents in avoiding high losses. At a minimum, this can be calculated as the aggregate willingness to pay (above expected losses) of persons purchasing insurance. Note that even risk averse agents will not, however, purchase insurance if they have less costly alternatives, which would include sufficient savings to cover catastrophic losses, or if they anticipate that the government will cover these losses. This is not the whole story since there are important “spin off” social benefits and costs that go beyond providing security against the loss of crops and assets, particularly as they spur economic development and set incentives for prevention. Alternatively, if insurance results in incentives for increasing risks (moral hazard) this will increase social losses and thus reduce the net social gain of insurance. If, however, insurers reduce moral hazard with deductibles and reward loss-reduction behaviour, for example, lowering premiums for homes that take flood- or wind-proofing measures, these measures reduce expected losses and increase the net social gain of insurance.

It must also be stressed that the benefits are paid for in high associated costs. Unlike other types of insurance (e.g., life or health), catastrophes affect whole regions or countries at the same time (co-variant risk), and the cost of providing this type of coverage is much greater. As shown in Figure 21, premiums for catastrophe cover are inflated above the annual expected loss by an expense load, which reflects the costs of doing business, and a contingency load, which includes the cost of holding capital, of assuming uncertain contracts and frictional costs (World Bank, Cummins and Mahul, 2008). Frictional costs include costs resulting from informational asymmetries between capital markets and the insurer’s management.

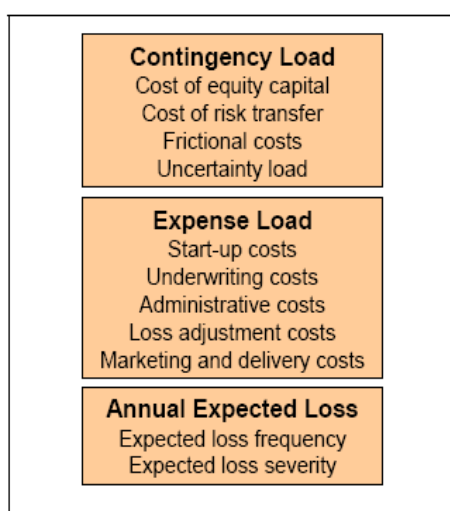


Figure 21: Costs contributing to catastrophe insurance premium

Source: Cummins and Mahul, 2008

On account of the high capital requirements for insuring co-variant risks, the contingency load is far higher with catastrophe insurance than insurance for health, life, motor vehicle and other non-

covariant risks, and for this reason catastrophe insurance costs clients more (sometimes significantly more) than their expected losses. This is hugely important when comparing insurance with non-insurance instruments, like post-disaster assistance. There is evidence that the expense load is appreciably less for publicly administered systems and public-private partnerships, like in Spain and the US, than for commercial insurance (see Box 2 below). However, this finding should be viewed with some caution, since often public insurance systems ‘piggy-back’ on private insurers for the basic administration and distribution, and have simple or nil risk selection procedures.

Index based insurance, weather derivatives and catastrophe bonds were designed partly to reduce the expense load by reducing the transaction costs associated with claims settling, so in theory they would have high scores. However, catastrophe bonds incur high transactional costs because they are usually one-off highly complex contracts involving a large number of independent investors. In practice this has often negated the price advantage between catastrophe bonds and reinsurance.

Box 2 Evidence on the transaction costs of private and public insurance systems

A study by von Unger-Sternberg (2003) shows that insurance premiums are substantially lower for public programmes offering hazard insurance (e.g. in France, Spain and Switzerland) than for private market systems with competition (e.g. in Britain and Germany). This is due mainly to savings on the part of state monopolies in terms of sales and administrative costs. Sales representatives typically receive between 15% and 20% of annual premium income, and in-house administrative and advertising costs add up to a similar amount. Moreover, public systems do not have problems of adverse selection, and they generally do not set premiums to reflect risk which reduces administrative costs.

Equity in providing security to low-income population

Humanitarian assistance to victims of natural perils has a long tradition throughout Europe, a tradition embedded in the ‘Solidarity Clause’, or Article 222 in the Treaty on the Functioning of the European Union. This provision directs EU members to act jointly and to assist one another in the face of disasters, emergencies, and crises. The word ‘solidarity’ has been invoked to justify support for countries facing debt crises, terrorist attacks, pandemics, cross-border infrastructure failures, as well as natural catastrophes. In the aftermath of disasters, national governments tend to proclaim the importance of enhancing cooperation to protect the safety and security of citizens. Solidarity with member states is the stated purpose of the European Union Solidarity Fund (EUSF), created in 2002 in response to massive flooding throughout Central and Eastern Europe, which grants post-disaster financial aid if losses exceed the capacity of governments to respond (Commission Report 2005).

According to Myrdal and Rhinard (2010), however, solidarity means different things to different people (and governments).

For some, solidarity is measured by how much support flows to a country in need.

For others, solidarity means everyone doing their own ‘homework’ to avoid the need for assistance in the first place. Still others believe that solidarity against today’s risks and threats is best pursued outside of EU frameworks.

In our consideration of equity, we take into account the extent to which RFIs directly support the most needy or vulnerable, and also the “unfairness” of persons having reduced their risks to

contribute to those who have not. We will examine Myrdal and Rhinard's second meaning of equity, "everyone doing their own homework", in later sections where we suggest that the EU with its Solidarity Fund partially reorient the fund to provide for incentives for risk reduction. As well, a more radical suggestion, which is probably politically not feasible, might involve partially or completely turning the fund around from post-event support to assisting governments insure themselves.

At the national scale, the most common form of solidarity is post-disaster assistance provided by the government to victims of natural perils. Most western countries have a strong tradition of providing disaster relief and compensating private sector victims for their losses. It may be surprising that even in the US, the average annual expenditure by the federal government for disaster assistance greatly exceeds the average annual loss borne by reinsurers on U.S. catastrophe coverage. In Europe, the picture is even more pronounced with some countries, notably the Netherlands, Austria and (in the past) Italy, providing up to 100% post-disaster compensation to disaster victims. Cross-subsidized insurance, resulting in flat premiums, has also been a mainstay in some countries, notably the U.K., where an implicit agreement not to segregate prices led to high penetration rates even among the poor living in high-risk areas. With recently perceived increases in risk, this implicit agreement is currently being examined in the UK. Other countries, most notably France, provide tax-payer support through government guarantees to private sector insurers.

For all the instruments, one could argue that equity is low-medium as responsibility for the losses is shifted to the affected, and thus there is reduced solidarity compared to a case, where taxes are fully used to absorb the losses.

2.6.5 Weather derivatives

1. Applicability for incentivising adaptation

Weather derivatives can be used by industry and business (services) instead of regular insurance. For other sectors they are not currently applicable except as a novel tool in humanitarian assistance, such as to help leverage additional financing for drought exposed farmers in developing countries, though pilot schemes are being carried out for that sector.

Table 23: Weather derivatives and adaptation according to key sectors

Policy sector as per White Paper	Applicability	Adaptation links (exemplary)
Private property	-	-
Production Systems and services	Energy industry, snowmobile makers and industry producing air conditioners, as well as the insurance sector	Limited, energy industry may invest in additional cooling water installations
Physical infrastructure (private and public)	-	-
Health and social policies	-	-

Policy sector as per White Paper	Applicability	Adaptation links (exemplary)
Agriculture & forests	Experiments with poor farmers	Access to loans for more costly, but better, seeds
Biodiversity, ecosystems, water	-	-
Coastal and maritime areas	-	-

2. Effectiveness for incentivizing adaptation (risk reduction)

The effectiveness for adaptation seems limited as snowmobile makers, air conditioner producers and the insurance sector are intent to hedge their market based losses using this instrument. Only energy utilities may consider measures such as installing additional cooling water capacity for dealing with droughts and heat-waves a substitute for this instrument

3. Efficiency in terms of benefits and costs.

Just like for insurance, the efficiency in terms of costs and benefits depends a lot on market conditions.

4. Equity in providing security to low-income population

Equity is not an issue as the private sector is making use of this instrument.

2.6.6 Catastrophe bonds

1. Applicability for incentivising adaptation

Catastrophe bonds are applicable, but only for the insurance sector buying protection in the financial markets as well as governments issuing catastrophe bonds.

Table 24: Catastrophe bonds and adaptation according to key sectors

Policy sector as per White Paper	Applicability	Adaptation links (exemplary)
Private property	-	-
Production Systems and services	Insurance sector buying protection in the financial markets	no
Physical infrastructure (private and public)	Government cat bond	<ul style="list-style-type: none"> Flood proofing infrastructure Retrofitting buildings Building larger scale flood protection schemes
Health and social	-	-

Policy sector as per White Paper	Applicability	Adaptation links (exemplary)
policies		
Agriculture & forests	-	-
Biodiversity, ecosystems, water	-	-
Coastal and maritime areas	-	-

2. Effectiveness for incentivizing adaptation (risk reduction);

The incentive effect of catastrophe bonds is rather small, but it can be argued that in the longer term there is a trade-off for governments; whether to issue a catastrophe bond or to undertake physical risk reduction.

3. Efficiency in terms of benefits and costs

Just like for insurance, the efficiency in terms of costs and benefits depends a lot on market conditions. Catastrophe bonds are generally associated with high transaction costs, but may overall achieve a lower “risk premium” in terms of the annual interest to be paid to investors.

4. Equity in providing security to low-income population

Equity is not an issue as the business sector uses this instrument, and if governments use it, the question is how the funds collected when issuing the bond are distributed, which is a general public finance deliberation.

2.6.7 Summary scores

Overall, our summary scores look as follows, and again to a large extent the scoring depends on how systems are organized and implemented in practice, which is discussed in task 3.

Table 25: Assessment for the RFI categories

Instrument	Applicability	Effectiveness for incentivising physical adaptation	Efficiency	Equity
Property and household contents insurance	High	Medium- High	Medium - High	Low-medium
Agricultural insurance	High	Medium-high	Medium-High	Low-medium
Sovereign insurance	High	Medium	Medium-High	na
Sovereign risk pools	High	Medium	Medium-High	Na
Weather derivatives	High	Low	Medium-High	na
Catastrophe bonds	High	Low	Medium-High	na

Task 3: Analysis of risk financing instruments for coping with extreme climate-related risks

1 Introduction

Based on the discussion in task 1 and 2, task 3 now focuses in more detail on the role of economic instruments and in particular of risk financing instruments (RFI) for sharing the risks of climate-related disasters. We proceed as follows.

- We discuss all the economic instruments under examination for the project in terms of the characteristics of risk sharing and financing.
- We present gaps and obstacles to demand and supply for risk financing instruments.
- We estimate **climate related disaster risk** over Europe and the **portion of risks insured or securely covered by other means**. This analysis serves to identify **hotspots** in terms of climate related risks and, where insurance coverage seems low, may serve to identify regions and countries where additional action may be desirable.
- We provide an overview of selected risk financing instruments with a focus on insurance as they are employed throughout Europe at multiple scales, and including selected arrangements outside Europe.
- We focus primarily on insurance that covers property and agricultural losses. Importantly, we examine current experience with an eye to how financial instruments can provide incentives for reducing risks but also how they can be explicitly designed to reduce risk and thus promote adaptation. Since risk reduction (adaptation) is not the sole criterion for assessing risk-sharing systems, we examine the applicability of insurance instruments in different social and cultural contexts, their efficiency in sharing risks and their equity in providing post-disaster support to vulnerable households and businesses. We also examine cases where insurance promotes maladaptation, a problem that plagues many European risk financing systems. Finally, we explore the role of the European Union Solidarity Fund in sharing risks across Europe.
- We end with **suggestions for the improved application of existing instruments as well as novel mechanisms for sharing risks** and their **potential for linking to risk reduction**. The focus is on climate related events (droughts, floods, windstorms) under stresses imposed by climate change.

2 Assessing economic instruments in terms of risk financing

Risk financing instruments are distinct from loss financing instruments. As discussed above, we define risk financing instruments by three characteristics, which may be all met simultaneously (e.g. insurance, catastrophe bonds), or individually (e.g. weather derivatives price and share risks, but do not pool).

- They put a price on risks
- They pool risk;
- They share risks;

In order to provide a common ground for the assessment, we now assess all the economic instruments under examination in the project in terms of the characteristics of risk financing. as shown in the table below.

- Grants
- Tax reductions
- Land use taxes and fees
- Adaptation Market Mechanism
- Water markets
- Payments for Ecosystem Services
- Financial Instrument: concessional loans
- Financial Instrument: guarantees
- Insurance
- Weather derivatives,
- Catastrophe bonds.

Unsurprisingly, the other economic instruments analyzed in this study generally do not provide for the risk financing functions. None of the non-RFIs sets a price on risk, and only taxes pool risk implicitly, as taxpayers are responsible for compensating the diverse portfolio of public assets and infrastructure that they “own”. This is the reason that governments are sometimes called “insurers of last resort.” We will discuss the implications of this closely in the remainder of this section. On top of that, taxes share losses after the fact (from existing or novel taxes). Payment for ecosystems and water pricing instruments can be used to share losses post-event, but not pre event as they are not arranged to cope with extreme events, but to raise revenue for the operation of water services and ecosystem services. So, overall the risk financing functions are not important for the other economic instruments.

What is interesting, however, is that in many instances subsidies can be and are used to lower insurance premiums and make those affordable. Taxes could be used to reward insurance uptake (but often are not used in practice). In fact often insurance premiums are taxed, which is a disincentive. Finally, regulation, as a cross-cutting consideration for all instruments under discussion in this report, is very important. This may entail governments acting as insurers, setting up mandatory insurance systems or implementing no bail-out clauses. This will be a main focus of the following discussion.

Table 26: Assessing the instruments in terms of characteristics of risk financing instruments

Instrument	Pricing risk	Pooling risk	Sharing risks	Role in conjunction with RFIs	Evidence
Subsidies	No	No	No	Premiums can be subsidized	Premiums frequently subsidized, particularly for crop insurance
Taxes and fees	No	Yes	Taxes are used to share losses	Could be used to reward insurance uptake	No evidence
Licences and permits	No	No	Can be used to share market and political	-	-

Instrument	Pricing risk	Pooling risk	Sharing risks	Role in conjunction with RFIs	Evidence
			risks, not climate related risks		
Payment for ecosystems	No	No	PES can be used to share losses	-	-
Water markets	No	No	Water prices can be used to share losses	-	-
Habitat banking	No	No	No	-	-
Public Private Partnerships	No	No	Can be used to share market and political risks, not climate related risks	-	-
Regulation*				Governments acting as insurers, mandatory insurance, no bail out clauses	Mandatory insurance and governments as insurers are common over Europe
Insurance (Property, agricultural, business,, sovereign, risk pools)	Yes	Yes	Yes	-	
Catastrophe bonds	Yes	Yes	Yes	-	
Weather derivatives	Yes	No	Yes	-	

*Regulation is a cross-cutting consideration for all instruments

As a next step, we now turn to the “real world” review of insurance as the dominant RFI and assess gaps and obstacles of insurance-related instruments, and how different actual insurance schemes perform according to the criteria discussed before. As insurance markets are nationally delimited, the specific implementation matters importantly, and our real world provides important practical detail of the issues under consideration and tradeoffs encountered when devising and regulating RFI systems. Weather derivatives and catastrophe bonds operate mostly European wide, and thus are not discussed in more detail.

3 Gaps and obstacles to demand and supply for risk financing instruments

As already touched upon, there are a number of gaps and obstacles to be taken into account when considering risk financing arrangements for physical and financial adaptation. Around 60 % of weather disaster costs are uninsured globally. For 2000-2006 in Europe, the insured % of climate-related disasters was 22%. This is because much of the damage in that period was due to flood and drought, which are not well-covered, whereas storm losses are 50% insured UNFCCC (2007). Commercial insurers are reluctant to provide cover for high consequence climate events, particularly if little historical data exist. Other common causes of (re-)insurance market failure are lack of demand and non-affordability of premiums (administration including marketing costs can be 30% or

more of the premium, or the risk may be so severe that it is a virtual certainty i.e. uninsurable). The public sector often intervenes to promote viability or establish (re-)insurance arrangements so that some sort of cover is provided for households, insurers or reinsurers. There are a number of gaps and obstacles that explain why such markets are less than perfect. We discuss the key ones in the following in order to set the stage for the future assessment of the available insurance arrangements. We break issues down into supply and demand-side gaps and obstacles.

4 Supply-side gaps and obstacles

In general the main barriers to the private market lie in the function of risk financing for disaster risk. The main problems are as follows.

Covariate risk

Floods, windstorms and drought often impact entire regions and thus will affect all policyholders in one region; there is covariate risk. For insurance companies underwriting a large number of claims in one region, this means that their risk portfolio is highly correlated and the variance of the portfolio of losses is close to the variance of individual losses if all policies are affected by the same event (Kunreuther, 1998). This may question the economic feasibility of national or regional insurance arrangements (Swiss Re, 1999). The covariate risk issue applies as well to informal insurance arrangements that play a major role in developing countries. These also tend to collapse in the presence of covariate risk (Hoogeveen, 2000).

Ambiguity of risk

The uncertainty associated with a risk and its measurement influences the premium considerably. The higher the uncertainty the higher the premium that will be charged by actuaries and underwriters. As natural disasters are rare events, data to base calculations on are scarce and there is considerable uncertainty in measuring probabilities and losses. Poor data means the uncertainty is much higher, and the private market will be less able to participate in risk-bearing. However, in the last few years research has made great advances in predicting and simulating disasters and calculating the potential impacts.

Adverse selection

Adverse selection denotes the fact that mainly those at risk or at highest risk ("poor risks") will choose to insure themselves. This is problematic as the premiums charged are calculated for the whole population and the risk bearing group may be too small to guarantee profitability for the insurers if those less at risk choose to stay uninsured (Swiss Re, 1999). This is often the case for natural disasters.

Ability to make a satisfactory return on capital/ investment

The fundamental element for any insurance operation is capital, to ensure that it is able to acquire resources, accept risks and pay losses. The capital mainly comes from private investors, who expect to receive a return on investment, in the range of 10 – 20%. They prefer a low volatility to permit steady payments of dividends, and because erratic profits depress the share value. For that reason,

insurers make heavy use of reinsurance. Alternatives like equalisation reserves²⁸ are in principle equivalent, but may require special accounting and taxation treatment, because the modern accounting practice is to avoid financial transfers between years. With the public sector, it may be possible to negotiate longer term contracts.

Freedom to manage the underwriting process

A balance is needed between regulatory control of the market (to protect consumers and workers), and flexibility of operating management (to respond to changing circumstances). The insurance industry is susceptible to underwriting cycles (arising from uneven loss occurrence or capital market influences) which can distort pricing. Consumers need continuity (insurance policies often terminate after one year), but investors and underwriters need to be able to respond to changing circumstances. In order to compete, companies need scope for differentiation (e.g. to underwrite more skilfully, design innovative products, distribute more efficiently). Geographical information systems (GIS) are increasingly used for locational underwriting of natural hazards. Overly rigid insurance regulations in local markets will deter private operators or result in a less optimal solution.

Scale of operation

Since capital and management time are limited, the market potential versus other opportunities is key. Currently 62% of worldwide economic losses caused by weather catastrophes are not insured. If methods can be found to make these risks insurable, then the market potential is high. In some developing markets there are limitations to the proportion of equity capital that foreign shareholders can hold, which may limit the scale of coverage due to the small capital base of the domestic partners.

Financial exclusion

Even in developed countries, this is a major problem. For example in UK, though 80% of households have property insurance, this falls to under half for the poorest decile. The situation may be worsening with the decline of old distribution channels, (local branch network, home service agents) and the spread of direct debit and the internet, (New York Times, 2006). On the supply side, the problems in insuring this sector are administrative expense (a high minimum premium is necessary to reflect fixed costs per case, and also to avoid underinsurance) and anti-selection, e.g., often there is a high crime risk in poorer areas.

Synergy with other operations

Private market operators can gain significant economies of administration if they have a parallel operation that provides other products e.g. fire or auto insurance, or can provide economies of scale from existing skill sets in other countries e.g. modelling capability, policy administration systems. This is particularly important for claim-handling, as capacity can be redirected from non-catastrophe work to assist in emergencies.

²⁸ Money is put into and out of an equalisation reserve when the actual claims are below or above expected levels, to give a better measure of the long-term performance of a portfolio that is subject to erratic losses.

5 Demand side barriers

There are various demand-side barriers some of which the private sector may be able to overcome on its own, while others may need public sector intervention.

Moral hazard

Moral hazard is the risk that an insured decreases his risk-minimizing efforts after having bought insurance coverage. Absent additional rewards from insurers for reducing risk, the insurance policy may create adverse incentives to the one exposed to risk once risk has been ceded to another risk bearer. This problem can be dealt with by measures such as using deductibles in insurance policies (Swiss Re, 1999). In highly regulated markets, where insurers are limited in their ability to introduce appropriate risk-related variations in terms e.g. deductibles on catastrophe insurance coverage offered to consumers, insurance can lead to a less risk-aware culture. It is therefore vital that public control of the risk management framework (land development, building design, construction standards etc) is maintained and that regulators set a reasonable standard of care from policyholders to avoid such "moral hazard". The private sector can be a partner in this: the UK insurance industry actively engages with policymakers on flood defence funding, land zoning and construction standards; in USA insurers help to fund the technical training of publicly paid building inspectors; and Australian insurers helped Fiji to set standards for cyclone-resistant buildings. A way to avoid anti-selection is to make the catastrophe cover compulsory or bundle it with other services e.g. loans or fire insurance.

Biased risk perception

There are several possible factors explaining low insurance demand. One is that those exposed to risk often exhibit myopic behaviour: While immediately after an event, risk minimizing activities like purchasing insurance are undertaken, these efforts are decreased if no events materialize. A rational explanation for myopia found in economic theory is that there is higher time preference for the present than for the future. Myopia can also partly be explained by a misperception of probabilities of natural disaster events which are low probability high consequence events. Often the worst disasters have a return period of hundred years that is beyond an individual's time horizon.

Low insurance uptake is also influenced by the availability of disaster assistance granted by the governments (Kunreuther, 1996). If the perception of being bailed out after an event by the state or government prevails, it is not rational to pay a premium before an event to be indemnified by an insurer. Often consumers have low risk awareness, particularly regarding low frequency-high impact events. The private market can play a useful role in awareness-raising, since it has a profit motive to increase market penetration. Consumers do not usually willingly purchase insurance. This reluctance reduces the market size substantially. Therefore measures which increase the volume, such as compulsory purchase for classes of consumer, are generally incentives for the private sector to enter.

Price

When premiums are high, consumers will not insure. This may be a signal from the private market that the risk is very high (unsustainable), or that there is great uncertainty, or that the scale of operations is too small, or that basic risk management is needed.

Fairness

If consumers believe that others will benefit unduly from the system, or that they are paying more than their "fair share" to the insurance fund, they will not insure willingly. The private market will seek to segment customers, so eliminating cross-subsidies. However, this may be contrary to public policy in terms of solidarity.

Relevance

The insurance must cover the risks that matter to the customer. Here again the private sector seeks to meet customer needs in order to maximise penetration.

Many of the general gaps and obstacles presented here will be of key relevance for the assessment of the insurance schemes in 3d, and we will pick up the discussion started here and contextualize it by specific country applications. The table below summarises how the key gaps and barriers affect the different assessment criteria

Table 27: Insurance barriers and assessment criterias

Key Barrier	Effectiveness for incentivising physical adaptation	Effectiveness for financial adaptation	Efficiency	Equity
Supply side				
Covariate risk and adverse selection			X	X
Demand side				
Moral hazard	X			
Biased risk perception	X	X		
Affordability			x	x

6 Analysis of exposure, risk and coverage of insurance-related instruments

This task focuses on assessing the assets exposed to natural hazards and associated flood, drought and windstorm risks, as well as the coverage of these risks including gaps by the aforementioned instruments for the EU25²⁹. We estimate - to the extent possible – European exposure and asset risk due to climate related events today as well as for future periods. We assess the extent to which the exposed assets (the value at risk) are covered by insurance and other pre-disaster risk financing instruments. As much as possible, this value will be disaggregated in line with the breakdown used for the exposure and risk analysis. We estimate the density of insurance and other risk financing instruments with the risks mapped and compiled. Pricing information for disaster insurance is used as much as possible. Climate change today is generally not priced into insurance products, but the industry has started to consider this driver of losses in line with other uncertainties and ambiguities, and we document relevant considerations. We gauge insurance density for the key hazards assessed droughts, flood and windstorms, and thus provide an estimate of the risks that are not covered by formal financial mechanisms.

Climate change and extreme events

Climate change is projected to change the intensities and frequencies of hazards and potential losses (risks). Indeed it is already doing so in the case of temperature almost everywhere, and precipitation in some places. Even without climate change, the current level of climate related extreme event risk is unclear, due to the inherent variability of the climate. In addition, the socio-economic determinants of risk are dynamic; the key drivers of climatic risks today are exposure and vulnerability, not climate change.

In Europe, far-reaching impacts of current changes in climate extremes have been documented regarding sudden-onset events such as floods and storms, as well as slower-onset disasters such as droughts and heat waves. Among others, the 2002 large-scale flooding over central Europe and the 2003 heat wave of unprecedented magnitude resulting in 70,000 deaths, placed risk management and adaptation at the top of the agenda (EC, 2007b). Agricultural practices are climate (especially heat and rainfall) dependent and the agricultural sector has been particularly exposed to changes in climatic mean values and inter-annual variability with about 3/4 of drought and heatwave losses reported in Europe over the last 30 years accruing in agriculture (EC 2007b). Increases in temperature, as already observed and simulated by climate models, are expected to have a great impact on agriculture. The summer heat wave of 2003 accompanied by precipitation deficits (Schär *et al.* 2004) led to agricultural losses exceeding €13 billion and a 30 per cent reduction in gross primary production of terrestrial ecosystems (Parry *et al.*, 2007).

Yet, knowledge of disaster impacts and risks is limited and heterogeneous. The IPCC Fourth Assessment Report and the EU's Green Paper on Adaptation advocate further refinement to risk management methods and tools (see Carter *et al.*, 2007). A reasonable amount of knowledge exists on the direct risks (exposure, vulnerability, and impacts) from sudden and slow-onset disasters linked

²⁹ For Malta and Cyprus no estimates are available.

to extreme weather. The reinsurance industry, consulting firms and multi-lateral financial institutions have worked together with the academic research community to estimate risks from such extreme events across the globe. A number of previously completed EU research projects (MICE, ESPON, MARS, ENSEMBLES, PESETA, ADAM) have focussed on weather-related hazards and risks in Europe. A recent national-level pan-European study conducted by Feyen, Barredo and Dankers (2009) for the PESETA project fills an important gap by conducting a European-wide assessment of current and future flood risks up to 2100. PESETA estimated average annual values, and at the same time, the ADAM project (see Mechler et al., 2010), on which we mostly base our estimates, similarly assessed flood and drought risk at a European scale identifying monetary economic losses, but estimated full probability distributions at different aggregation scales. There are also national-level assessments of current and future weather risks, mostly on flood risk in England and Wales (DEFRA, 2001), Germany (Apel et al., 2004, and Merz and Thielen, 2004) and the United States (Scawthorn et al., 2006a, 2006b). Hall, Sayers and Dawson (2005) projected risks up to 2100 for England and Wales.

7 Methodology for estimating risks

The analysis of weather extremes and adaptation to their impacts is complicated by the inherent aleatoric, or 'chance' uncertainty of these phenomena. Although specific weather extremes are unpredictable in a deterministic sense beyond a few days in the future, they can be estimated in probabilistic terms: for example the 100-year flood (an event with an average return period of 100 years, or an annual probability of 1 per cent). Natural disaster risk is commonly defined as the product of probability multiplied by the potential impacts affecting people, assets or the environment. Framing the analysis in terms of probability is useful since risk management strategies can be based on the entire range of extreme event scenarios, which would not be possible with the use of average values only. Also, the notion of probability entails addressing *potential* impacts before they occur, rather than coping with *actual* impacts after the fact, thus signifying a shift from reacting to impacts to anticipating and managing risks.

The risk based methodology builds on combining hazard, vulnerability and exposure analyses to an estimate of risk. As much as possible, we build our analysis on work conducted in European and other projects such as ADAM and PESETA. Hazard analysis entails determining the types of hazards affecting a given region, including their intensity and recurrence, as well as possible changes therein due to climate change. Assessing exposure involves analysing population and assets exposed to hazards in a particular region. Vulnerability is a multidimensional concept comprising a multitude of factors, but we focus here on physical vulnerability. Figure 22 illustrates the flood risk analysis, which integrates relevant information on the hazard (flood depth and extent, as well as probability in terms of return period and recurrence), exposure (land use categories) and vulnerability (considered with regard to physical susceptibility of exposed land use classes to flood depth and hazard). The end product consists of probabilistic estimates of losses in monetary terms, summarised by means of risk maps at different aggregation levels.

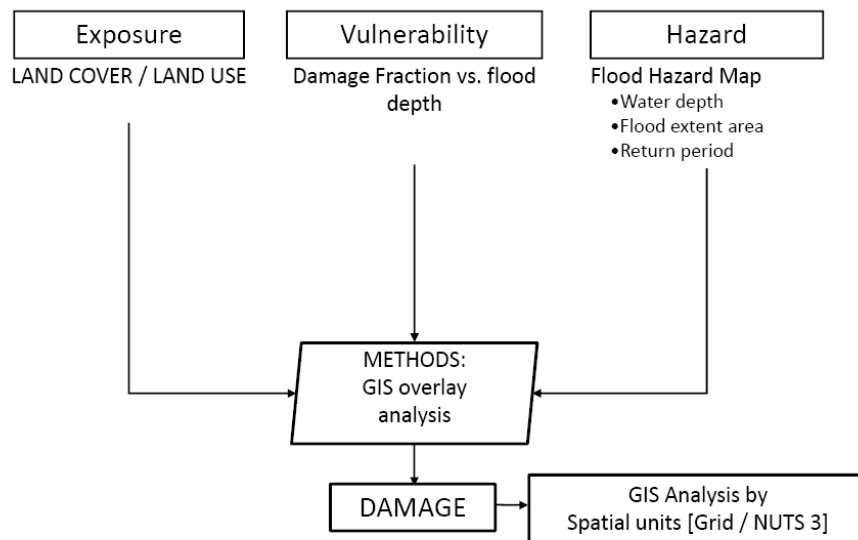


Figure 22: Operational framework for modelling flood risk as a function of hazard, exposure and vulnerability.

Source: Luger et al, 2009.

7.1 Hazard

Hazard analysis entails determining the types of hazards affecting a given region, including their intensity and recurrence, as well as possible changes therein due to climate change. We assess flood hazard, lack of water and heat-waves leading to droughts as well as windstorm hazard for today and the future.

Climate projections using multi-model approaches indicate increases in globally averaged mean water vapour and precipitation over the twenty-first century. Yet, precipitation scenarios show strong seasonal and regional differences in Europe. There is a marked contrast between future winter and summer precipitation change. Wetter winters are predicted for the entire continent; in many regions there will be less snow and much more rain. In summer an apparent difference in precipitation change between wetter conditions in Northern Europe and drier conditions in Southern Europe is predicted. Generally, the behaviour of changing precipitation extremes is projected to be notably different from changes in mean precipitation over much of Europe. The highest quartiles of daily precipitation amounts and annual maximum daily precipitation are anticipated to increase over many areas, including some areas where the mean precipitation is projected to decrease. However, climate models remain limited in their reproduction of local weather extremes due, *inter alia*, to inadequate (coarse) resolution (Christensen and Christensen, 2002; Kundzewicz, Radziejewski and Pińskwar, 2006). Projections of changes in future extreme weather events remain highly uncertain and, as one example, hinder us from robustly predicting future flood risk. On the other hand, drought and heatwave stress operate as slower onset phenomena and are more strongly characterised by mean climate conditions for which there is greater confidence in model projections. Projections of windstorm are presented with less confidence, but recent research is tending towards the view that the future European climate may be stormier.

7.2 Vulnerability

Vulnerability is a multidimensional concept comprising a multitude of factors. Our study focuses on physical vulnerability in terms of exposure o hazard-exposed actors to loss. For this purpose, generally vulnerability curves can be used. Such curves relate the intensity of the hazard with the damages it will cause to specific structures. Usually such damage curves are difficult to assess and therefore proxies are often used for different house classes or landcover areas (Lugeri et al, 2009).

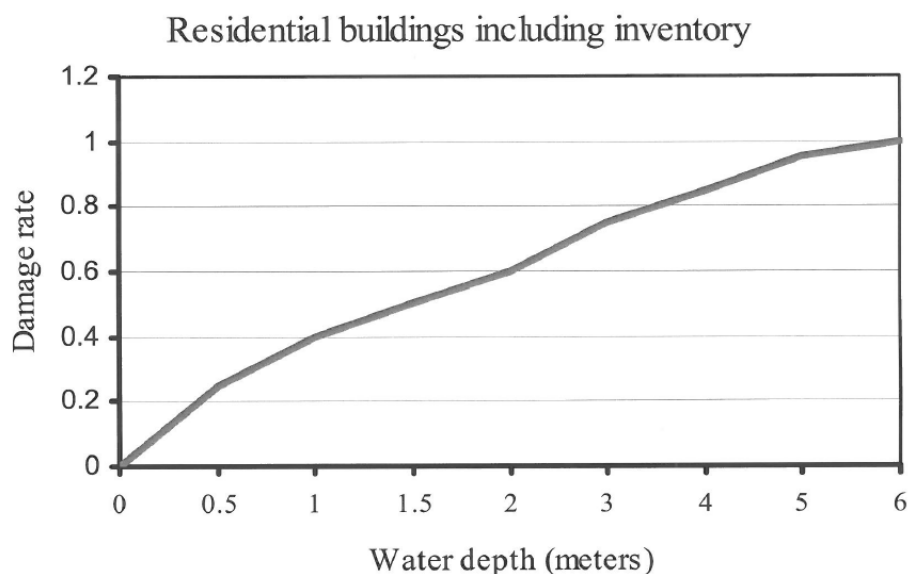


Figure 23: Depth-damage function for a residential building.

Source: Rusmini, 2009.

Our estimates based on work in the ADAM project, takes account of more than 30 depth damage functions for most relevant CORINE landcover classes with the damage expressed in Euros Purchasing Power Parities per square meter and combined via a mapping approach (Lugeri et al. 2010).

7.3 Exposure

Assessing exposure involves analysing assets exposed to hazards in a particular region and country. Based on prior work in European and other projects we estimated European exposure and asset risk in terms of capital stock due to climate related events today as well as for future periods (2030, 2050, 2070 and 2100) given climate and global change (see Table A.1. in the ANNEX). The definition of capital stock used here includes physical assets such as residential houses, industry (business buildings, fabric, construction sites) and infrastructure (roads, airports, port areas, rail networks, public assets). As one can see in Table A.1, there are considerable fluctuations between the different estimates and the most reliable ones were taken (in terms of consistency over the projections as well as most state-of-the-art approaches) and shown in the table below.

Table 28: Capital stock estimates for the year 2011 (in billion Euro).

Country	Capital Stock 2011 (billion Euro)
Austria	1025
Belgium	982
Bulgaria	396
Czech Republic	758
Germany	8840
Denmark	763
Estonia	85
Spain	1932
Finland	1131
France	6374
Greece	482
Hungary	697
Ireland	380
Italy	3,590
Lithuania	223
Luxembourg	130
Latvia	69
Netherlands	1,247
Poland	1,327
Portugal	401
Romania	998
Sweden	1,418
Slovenia	103
Slovakia	363
United Kingdom	4,418

Sources: Based on Nehru and Dhareshwar, 1993; Duffy and Papageorgiou, 2000; Miketa 2004; Sanderson and Striessnig, 2009; O'Mahony and Timmer, 2009; Derbyshire et al., 2010; Luger et al, 2010; EU Annual macro-economic database, 2011.

Estimating exposure changes due to global change in the future is difficult and has to be based on various assumptions. To arrive at capital stock estimates for the future we use GDP growth rate estimates of the SRES scenarios A2 and B1 (which represent the extreme ranges of different growth patterns) and use them for estimating the exposure changes for the respective years. Tables A.2 and

A.3 in the ANNEX show the results for different time periods for the A2 and B1 SRES Scenario, and Figure 24 summarizes the estimates for today and 2100 for the two scenarios A2 and B1.

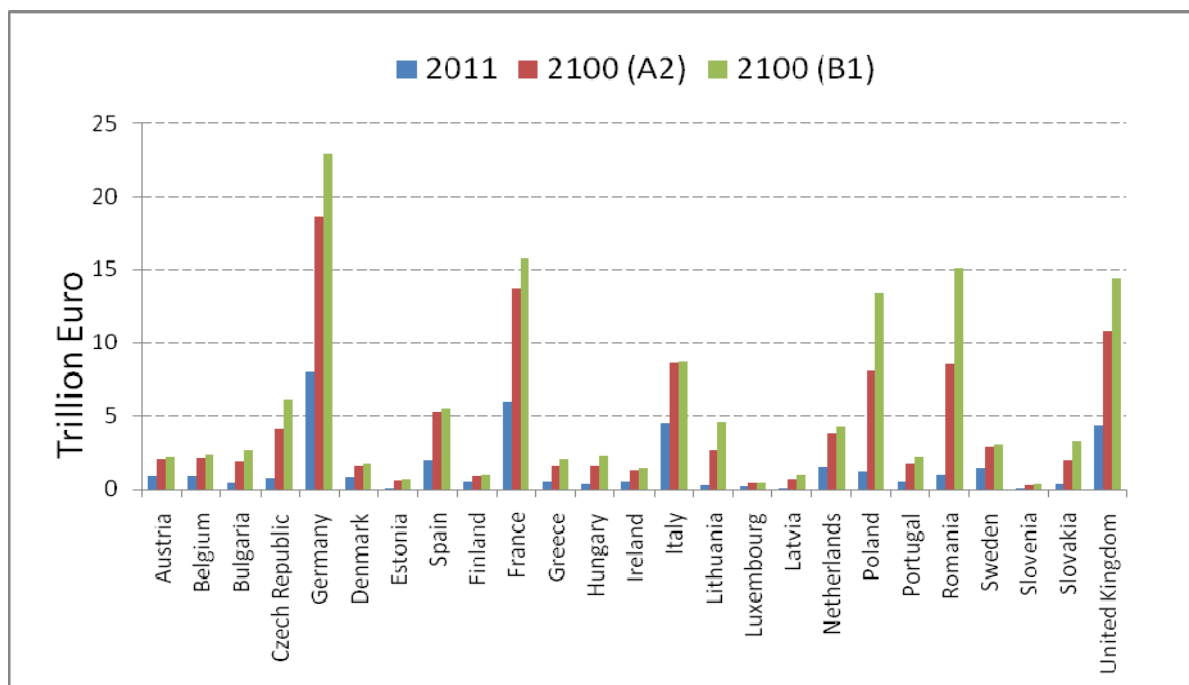


Figure 24: Current and future capital stock estimates for European countries.

Source: 2011 based on ANNEX I, 2100 own calculations as detailed in the main text.

It should be noted that total capital stock is not the same as exposure as not all stock is usually exposed to a given natural hazards. Where possible, estimates for each hazard are used to determine the loss range in terms of total capital stock at risk.

8 Risk estimates

We now turn to describing our estimates of risk for flooding, drought and windstorm. The numbers are based on the referenced sources and transformed to current 2011 Euros where needed. The methodologies used to estimate these risks are similar as depicted in Figure 25, i.e. risk is modelled as a function of the hazard, the exposure as well as the physical vulnerability.

8.1 Flooding

For river flood risk, estimates in terms of probability and corresponding losses are available from Hochrainer and Mechler (2009), Kundzewicz et al. (2009) and Luger et al (2010) based on risk maps developed in the ADAM project as shown in Figure 25. These are the only fully risk based estimates, including the fat tails/low probability events, which are available for all EU member countries.

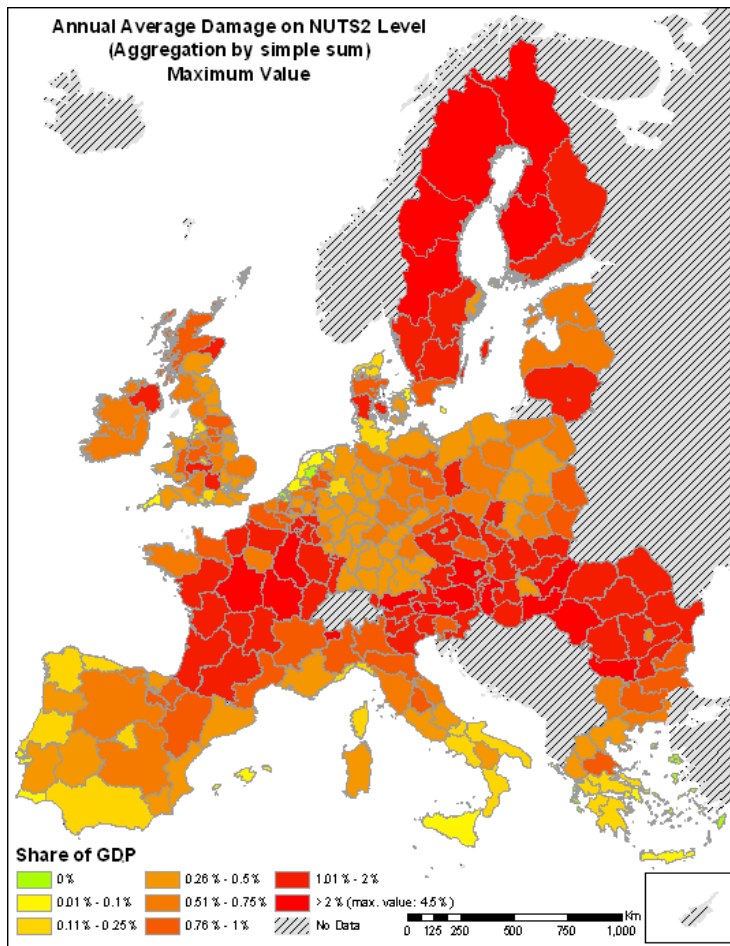


Figure 25: Maximum annual average flood damage for European provinces and regions (NUTS 2 level) as a percentage of GDP for today's climate regime

Source: Luger et al., 2009

As indicated, total exposure to a hazard will only be a fraction of total capital stock. To calculate the exposure of total capital stock due to flooding we use here the highest possible loss event, i.e. the estimated worst inundation scenario, (approximately equal to the whole exposed assets, taken from Luger et al. 2009) and compare it with the total capital stock (see Table 29).

Table 29: Exposure to flooding in terms of total capital stock (in billion 2011 Euro)

	Total Capital Stock (billion Euro)	Maximum Loss Exposure (billion Euro)	Percentage of flood exposure to total capital stock
Austria	1025	349	34
Belgium	982	329	34
Bulgaria	396	55	14
Czech Republic	758	147	19
Germany	8840	1691	19
Denmark	763	46	6
Estonia	85	17	20
Spain	1932	283	15
Finland	1131	276	24
France	6374	1491	23
Greece	482	52	11
Hungary	697	208	30
Ireland	380	75	20
Italy	3590	875	24
Lithuania	223	58	26
Luxembourg	130	47	36
Latvia	69	24	34
Netherlands	1247	243	20
Poland	1327	267	20
Portugal	401	22	6
Romania	998	273	27
Sweden	1418	300	21
Slovenia	103	39	38
Slovakia	363	121	33
United Kingdom	4418	190	4

Source: Own calculations based on Luger et al. 2009 and Appendix A.1.

The table below now shows the losses for different return periods (50, 100, 250, 500) for the 25 EU member countries. Loss distributions can be summarized by the expectation, which here is called annual average losses (AAL). The average annual loss can be calculated via integration of the area above the loss distributions. We indicate AAL in absolute terms and as a fraction of capital stock as

well as GDP. For the UK, robust estimates were not available for the return periods, but for the average annual loss only.

Table 30: Distribution of flood losses over the EU 25

(bn 2011 Euro)	Return Period				
Country	50	100	250	500	AAL (million Euro)
Austria	3.27	4.55	6.79	8.42	140
Belgium	2.25	3.12	5.07	9.13	108
Bulgaria	0.44	0.59	1.18	2.56	26
Czech Republic	1.18	1.49	4.95	6.73	80
Germany	4.51	5.74	8.64	16.72	206
Denmark	2.76	3.18	3.56	3.80	93
Estonia	0.18	0.23	0.33	0.58	8
Spain	2.22	2.74	3.59	4.05	82
Finland	2.24	2.89	3.39	6.69	119
France	8.45	9.65	13.34	20.30	335
Greece	0.66	0.80	1.16	1.75	28
Hungary	1.48	1.85	2.38	4.17	60
Ireland	0.98	1.27	1.73	2.07	40
Italy	7.15	8.69	9.95	11.34	288
Lithuania	0.48	0.57	0.67	0.78	17
Luxembourg	0.92	1.25	2.96	9.17	83
Latvia	0.23	0.32	0.51	0.69	11
Netherlands	2.99	4.07	6.21	15.06	178
Poland	1.63	1.98	2.59	5.06	70
Portugal	0.28	0.35	0.53	0.77	14
Romania	1.71	1.94	2.46	3.28	67
Sweden	2.21	2.57	3.26	16.81	127
Slovenia	0.48	0.69	1.24	2.44	37
Slovakia	1.51	2.06	2.88	4.08	65
United Kingdom	2.8	n.a.	n.a.	n.a.	1099

Source: Hochrainer and Mechler, 2009; Luger et al. 2009, Swiss Re 2008.

There is considerable uncertainty associated with these estimates due to modelling uncertainty as well as parameter uncertainty. Modelling uncertainty (especially within the hazard component) was

incorporated via maximum and minimum water depth and corresponding loss values. Furthermore, up scaling of the losses (see Luger et al., 2010) is dependent on the assumptions of the probability of first loss, i.e. the year event where for the first time a loss will occur. To reflect these uncertainties Table A.4 in the Appendix shows the minimum and maximum loss values for all return periods (over all possible scenarios considered for the maximum and minimum case.). The figure below displays the best estimate for the AAL as well as minimum and maximum values (see also tables A.4 in ANNEX I).

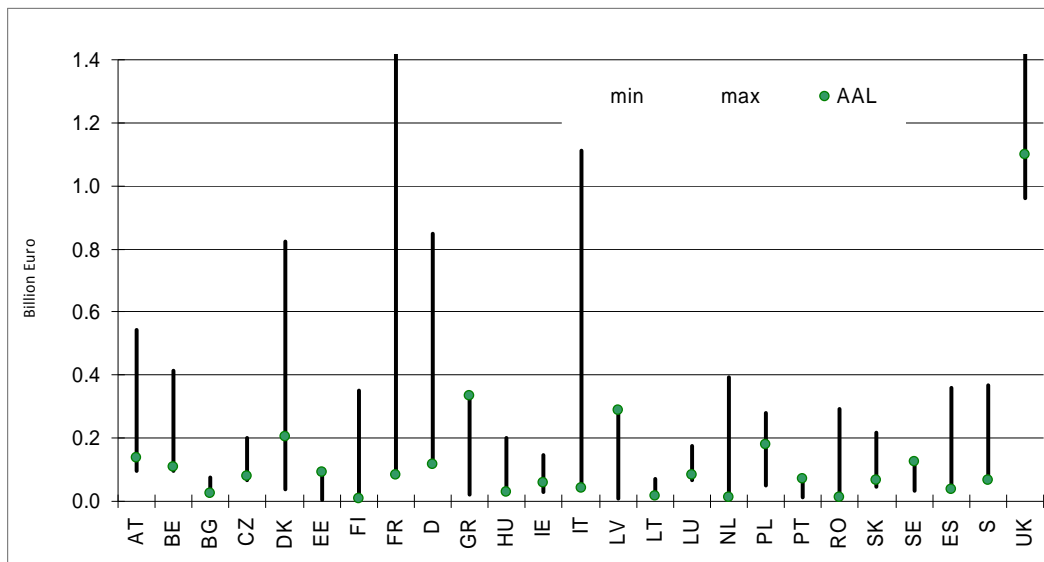


Figure 26: Annual average losses including confidence bounds for minimum and maximum estimates.
Source: Based on Hochrainer and Mechler, 2009 and Luger et al. 2010

According to *Solvency II* (especially the “Pillar 1” of the Solvency II regime which consists of the quantitative requirements) the value at risk (Solvency Capital Requirement) should be estimated at the 99.5% level, i.e. the 200 year event loss has to be calculated. Table 31 shows results for the 200 year return period in terms of percentage of losses to total capital stock and exposed capital.

Table 31: Value at risk estimates for riverine flooding (current situation).

	Capital Stock (bn Euros)	200 year loss event (bn Euros)	Value at risk in terms of total capital stock (%)	Value at risk in terms of exposed capital (%)
Austria	1025	5.30	0.52	1.52
Belgium	982	3.77	0.38	1.14
Bulgaria	396	0.78	0.20	1.42
Czech R	758	2.64	0.35	1.80
Germany	8840	6.71	0.08	0.40
Denmark	763	3.31	0.43	7.16
Estonia	85	0.26	0.31	1.53
Spain	1932	3.02	0.16	1.07
Finland	1131	3.06	0.27	1.11
France	6374	10.88	0.17	0.73
Greece	482	0.92	0.19	1.76
Hungary	697	2.02	0.29	0.97
Ireland	380	1.42	0.37	1.90
Italy	3590	9.11	0.25	1.04
Lithuania	223	0.60	0.27	1.05
Luxembourg	130	1.82	1.39	3.86
Latvia	69	0.38	0.56	1.63
Netherlands	1247	4.78	0.38	1.97
Poland	1327	2.18	0.16	0.82
Portugal	401	0.41	0.10	1.85
Romania	998	2.11	0.21	0.78
Sweden	1418	2.80	0.20	0.93
Slovenia	103	0.87	0.85	2.23
Slovakia	363	2.33	0.64	1.92
United Kingdom	4418	n.a.	n.a.	n.a.

Source: Based on Hochrainer and Mechler, 2009 and Luger et al. 2010 and Appendix A.1

Comparison of results

The results can be compared to other modelling exercises. For example, Feyen, Barredo and Dankers (2009) also give average annual loss estimates due to flooding. As the table below indicates,

the losses from Luger et al, (2009) are lower and sometimes (7 times in total, e.g. Czech R., Hungary and Poland they are higher, for Denmark, Ireland, Luxembourg and the U.K. significantly lower) even outside the uncertainty bounds already discussed above.

Table 32: Comparison of average annual losses due to flooding (current situation).

AAL (million Euro)	Dankers et al.(2009)	Our study based on Luger et al, (2009)		
		Min	Max	Best estimate
Austria	240	95	544	140
Belgium	160	98	415	108
Bulgaria	57	20	76	26
Czech R.	270	66	200	80
Germany	680	171	848	206
Denmark	12	39	822	93
Estonia	8	6	28	8
Spain	280	53	360	82
Finland	300	94	353	119
France	1000	222	1526	335
Greece	49	21	97	28
Hungary	350	48	202	60
Ireland	23	28	148	40
Italy	890	199	1111	288
Lithuania	26	12	73	17
Luxembourg	11	65	176	83
Latvia	28	8	40	11
Netherlands	360	149	392	178
Poland	430	49	279	70
Portugal	25	11	40	14
Romania	220	46	292	67
Sweden	130	100	367	127
Slovenia	48	33	73	37
Slovakia	140	48	216	65
United Kingdom	780	962	3279	1099

Also estimates of loss associated with return periods for Germany and Austria based on a study for CEA (2010) can be compared to our estimates.

Table 33: Comparison of average annual losses due to flooding (current situation)

Flooding	Loss return period (bn Euro)	50	100	250	500
Austria	CEA, 2010	2.07	2.76	3.87	4.92
	Our study (based on Luger et al. 2010)	3.27	4.55	6.79	8.42
Germany	CEA, 2007	4.05	6.62	10.91	14.76
	Our study (based on Luger et al. 2010)	4.51	5.74	8.64	16.72
	Swiss Re, 2008	2.10	-	-	-
Czech R.	Luger et al. 2010	1.18	1.49	4.95	6.73
	Our study (based on Luger et al. 2010)	0.7	1.6	-	-

Values from Luger et al (2010) show here a mixed picture if compared with other estimates from the literature. While for Austria losses are projected much higher, for Germany they seem to be in range. Again if one takes a look at the uncertainty ranges (see ANNEX) one can observe large differences between maximum and minimum estimates, indicating problems within the methodology.

Identifying "Hotspots"

Based on the discussed results, "hotspot" countries at high risk may be identified and Table 34 sorts risks for member states in descending order for the 200 year event

Table 34: Member states and relative flood risk sorted in descending order

	Average Annual Loss		200 year loss event	
	% GDP	% Capital	% GDP	% Capital
Luxembourg	0.205	0.065	4.484	1.410
Slovakia	0.097	0.019	3.452	0.675
Slovenia	0.102	0.036	2.387	0.852
Lithuania	0.063	0.007	2.192	0.250
Bulgaria	0.073	0.007	2.186	0.211
Hungary	0.061	0.019	2.057	0.650
Latvia	0.057	0.013	2.043	0.461
Austria	0.049	0.015	1.862	0.577
Czech Republic	0.054	0.011	1.805	0.361
Romania	0.057	0.007	1.783	0.224
Estonia	0.052	0.008	1.742	0.264
Finland	0.065	0.026	1.684	0.680

	Average Annual Loss		200 year loss event	
Denmark	0.040	0.012	1.430	0.431
Ireland	0.024	0.008	0.855	0.301
Belgium	0.023	0.012	0.817	0.424
Netherlands	0.030	0.012	0.809	0.311
Sweden	0.036	0.009	0.793	0.198
Poland	0.019	0.006	0.601	0.185
Italy	0.018	0.006	0.585	0.202
France	0.017	0.006	0.555	0.182
Greece	0.013	0.006	0.423	0.202
Spain	0.008	0.004	0.285	0.154
Germany	0.008	0.003	0.264	0.084
Portugal	0.008	0.003	0.245	0.090
United Kingdom	0.070	0.025	-	-

Future Losses

There are very large uncertainties associated with projecting risks to the future, particularly for flooding, and many sources would consider estimates not very robust (see Kundzewicz et al. 2010; Mechler et al., 2010; Feyen and Watkiss, 2011). Yet, under some strong assumptions projections for certain SRES storylines are available. Based on Kundzewicz et al. (2010) we use projections of changes within the 100 year flood event under the A1B scenario to compare future and current losses in terms of annual average losses (AAL). Note, that changes of the exposure as well as vulnerability are kept constant. There are also estimates for the A2 SRES storyline from Dankers et al. 2009 with which we compare our results.

Table 35: Average Annual flood losses (minimum and maximum) today (Lugeri et al. 2009) and in 2100 (Kundzewicz et al. 2010, A1B scenario) and Feyen et al., 2010 (A2 scenario).

AAL (million Euro)	Lugeri et al. 2010 (current)				Dankers et al. 2009	
	Kundzewicz et al. 2010 (future)					
Country	today-min	today-max	2100-min	2100-max	Current	2100
Austria	95	544	1,918	2,172	240	410
Belgium	98	415	225	389	160	270
Bulgaria	20	76	304	432	57	130
Czech Republic	66	200	2,514	3,153	270	940
Denmark	39	822	303	313	12	93
Estonia	6	28	132	163	8.3	6.4
Finland	94	353	480	642	300	45
France	222	1526	312	373	1000	4000
Germany	171	848	339	494	680	1400

AAL (million Euro)	Lugeri et al. 2010 (current)				Dankers et al. 2009	
	Kundzewicz et al. 2010 (future)					
Greece	21	97	125	166	49	230
Hungary	48	202	2,237	2,726	350	770
Ireland	28	148	467	526	23	54
Italy	199	1111	256	282	890	2500
Latvia	8	40	127	166	28	39
Lithuania	12	73	405	517	26	120
Luxembourg	65	176	188	258	11	39
Netherlands	149	392	329	396	360	990
Poland	49	279	763	863	430	1100
Portugal	11	40	116	147	25	9.9
Romania	46	292	2,751	3,660	220	160
Slovakia	48	216	1,266	1,690	140	250
Slovenia	33	73	328	368	130	250
Spain	53	360	86	95	48	40
Sweden	100	367	887	1,079	280	580
United Kingdom	962	3279		na	780	3600

One important disadvantage of such approaches is the non-consideration of socio-economic changes over the future which is only tackled recently. Feyen and Watkiss (2011) for example reported recently on future flood losses using the A1B scenario in combination with some vulnerability reduction/ or adaptation assumptions as well as exposure changes for all EU countries.

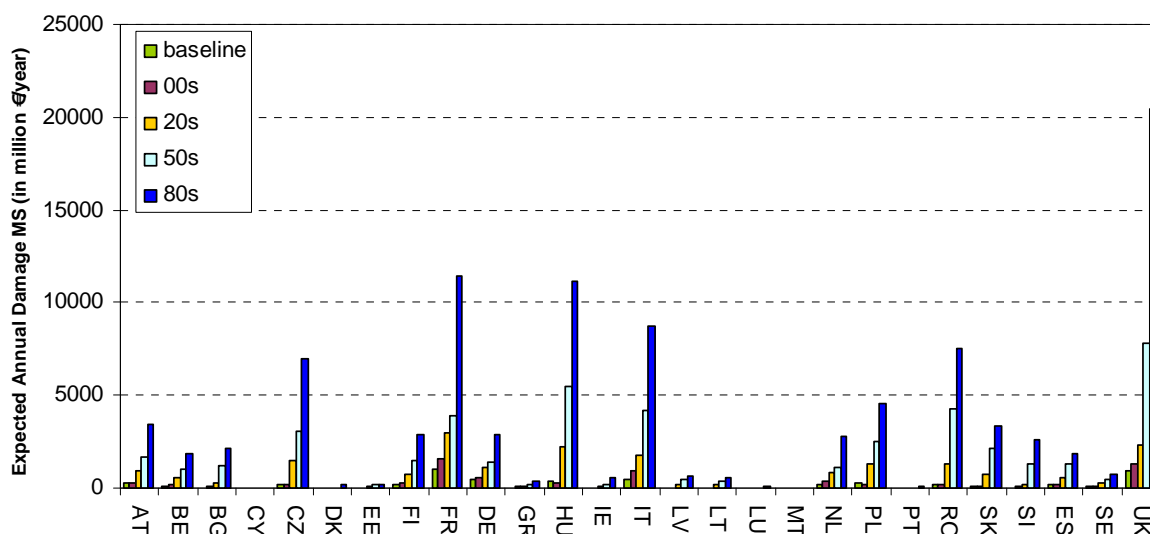


Figure 27: AAL in million € for baseline period (1961-1990), 2000s (1981-2010), 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100) for the A1B scenario (all numbers in constant prices of 2006). Values shown are for combined effects of climate and socio-economic change.

Source: Feyen and Watkiss, 2011.

Feyen and Watkiss (2011) found the strongest increases for the UK, Ireland, Italy, Slovenia, Belgium and the Netherlands, mainly due to a strong increase in the frequency of currently high return period floods (e.g., current 100-year flood may occur every 10 or 20 years by the end of this century). However, considerable uncertainties remain also in this large scale analysis. It is thus important that estimates of future extreme event risk in Europe, and almost everywhere else, are currently associated with massive uncertainties and thus cannot be considered an entirely robust basis for taking key decisions.

8.2 Drought

Our assessment builds on work done in the ADAM project (see Bindi and Moriondo, 2010), where drought losses due to heat and water shortage for today and a future warming climate for spring wheat, winter wheat, soybeans, and sunflowers were calculated for the SRES A2 scenario. It should be noted that at variety of impacts due drought events can be expected, e.g. for the energy sector as well as tourism etc., some of them insurable some of them not (see for a comprehensive summary the ADAM DIGITAL COMPENDIUM, 2010). We focus here on agriculture drought effects to crops. For example, for spring wheat³⁰, we compute the combined drought and heat stress risk calculations for

³⁰ Similar analyses were done for winter wheat, soybean and sunflower.

today and for the change in such risk for the period of 2030-2060 compared to today, with and without adaptation interventions.

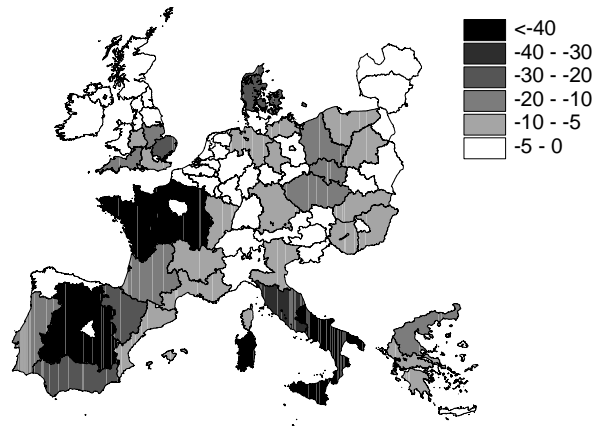


Figure 28: Annualised monetary risk due to combined heatwave and drought stress for spring wheat calculated for the present period (1975-2005) on a NUTS 1 level (losses in € millions). Source: Mechler et al., 2009.

As expected, Southern Europe and parts of France, are today particularly exposed to drought and heat stress and this trend is expected to worsen in the future. In a future climate scenario with a strong north-south precipitation gradient, the Mediterranean basin and central Europe are projected to be more strongly affected by combined heat and drought stress when adaptation is not considered (Figure 29: panel A). When considering the two simple adaptation strategies, however, many regions in Europe would actually be able to benefit from a warming climate (on an annualised basis). Northern Europe in particular would exploit the advantage of higher precipitation by using crop varieties with a longer growing cycle: when water is not the limiting factor, a longer time for biomass accumulation results in an increased yield.

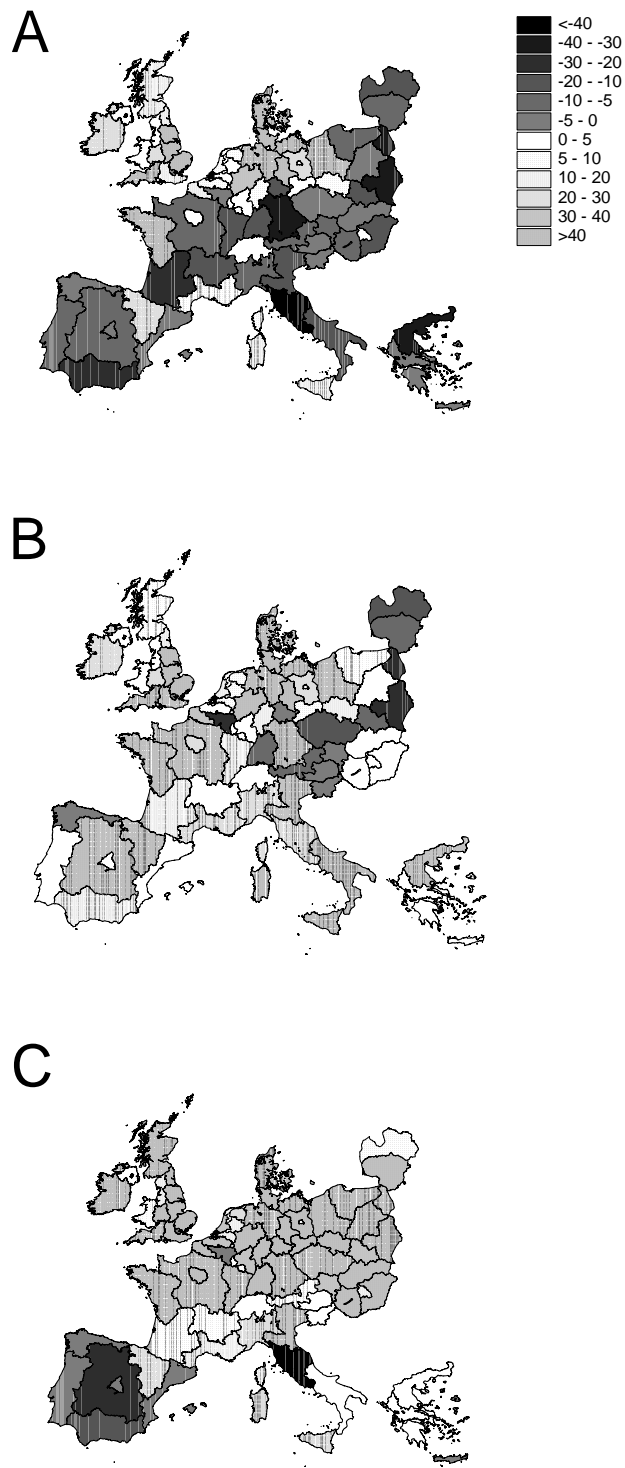


Figure 29: Changes in annualised drought and heat-wave risks to spring wheat over a future period in 2030-2060 compared to today, without adaptation (A) and with adaptation in terms of advanced sowing (B) and longer cycle variety (C) (in € millions). Source: Mechler et al., 2009.

In contrast, in Southern Europe the same adaptation options would result in a negative impact on yield, since crop development shifts towards summer when longer dry spells and heat waves may significantly affect crop growth. Winter crops, such as barley and durum wheat, are generally not affected by water stress; in contrast to summer crops, their growth cycle is generally advanced to the autumn-winter period which is not affected by drought or heat stress either in the present or the future. These estimates can be aggregated to a national level resolution and Table 36 documents average annual losses for the 2 degree future (roughly the 2030-2060 period in the A2 scenario) without and with adaptation.

Table 36: Changes in average yield for spring wheat for the 2030-2060 period (about +2° with respect to preindustrial level) without and with adaptation measures (in million Euro) due to heat stress and water stress.

Losses in million Euros	Current	No adaptation	Advanced sowing	Longer cycles
Austria	-29.0	-19.7	-12.8	47.0
Belgium	0.0	5.7	-22.6	32.3
Bulgaria	-22.6			
Czech R	-68.2	-2.8	-14.2	201.6
Germany	-63.6	265.8	569.0	1795.1
Denmark	-	170.3	188.9	445.0
Estonia	-	-	-	-
Spain	-133.6	-11.7	199.1	-13.3
Finland	-	-	-	-
France	-172.4	77.1	531.8	1348.2
Greece	-48.3	-36.6	40.7	3.0
Hungary	-	-25.5	11.0	151.5
Ireland	-	-	-	-
Italy	-145.0	-86.3	303.2	45.1
Lithuania	-21.9	-9.3	-7.6	81.7
Luxembourg	-	0.3	0.8	4.1
Latvia	-	-16.4	-16.0	9.5
Netherlands	-	23.5	31.9	95.4
Poland	-38.8	8.3	43.4	653.6
Portugal	-70.8	-5.4	2.9	-4.4
Romania	-66.1	-	-	-
Sweden	-39.2	-	-	-
Slovenia	-40.3	-4.4	-3.9	0.1
Slovakia	-64.1	-4.0	2.2	71.6
United Kingdom	-55.5	337.7	418.8	1166.6

Source: Mechler et al. 2009

As one can see, not only negative impacts due to climate change are possible but there may also be very positive ones due to climate change, even without adaptation (see also IPCC 2007). However, there can be large differences between the effects of climate change on agriculture within country regions, such as Spain where large losses are expected in the south and gains in the north. For sunflower and soybean only some loss estimates for the current situation are available and combined with the other crop losses shown in Figure 30.

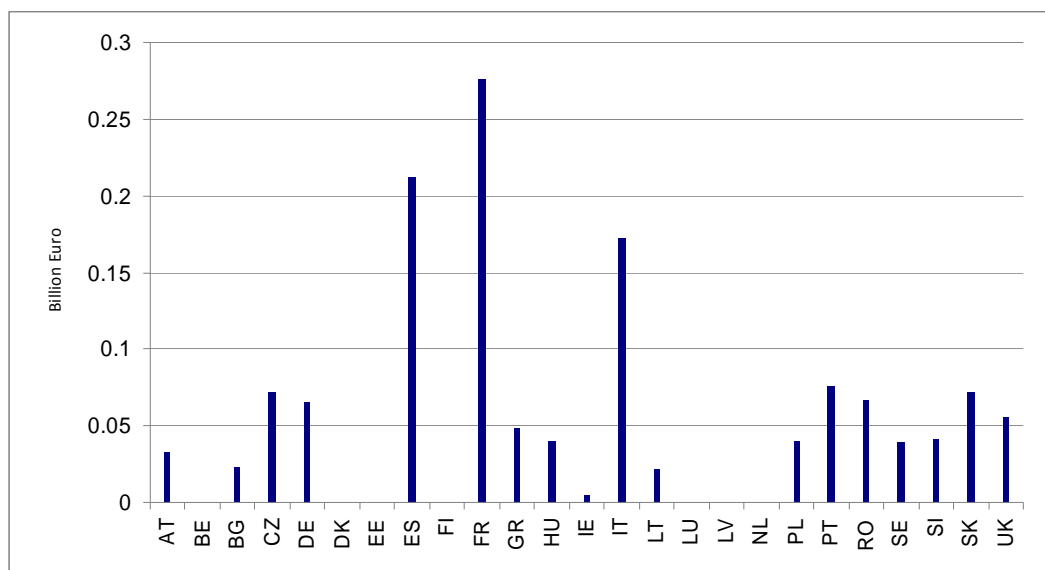


Figure 30: Annual average drought losses in agriculture

Note: Crop losses comprise losses to spring wheat, sunflower and soybean, and estimates do not account for uncertainties

Source: Based on Luger et al. 2009, and Mechler, 2009.

Identifying "Hotspots"

Relating losses to GDP, we can identify hotspots as follows.

Table 37: Member states exposed to drought and relative drought risk sorted in descending order

Country	% GDP
Slovakia	0.0107%
Lithuania	0.0079%
Bulgaria	0.0063%
Romania	0.0056%
Czech Republic	0.0049%
Portugal	0.0045%
Hungary	0.0041%
Greece	0.0022%

Country	% GDP
Spain	0.0020%
France	0.0014%
Austria	0.0012%
Poland	0.0011%
Sweden	0.0011%
Italy	0.0011%
United Kingdom	0.0004%
Ireland	0.0003%
Germany	0.0003%
Netherlands	0.0000002%

8.3 Windstorms

Windstorm risk relates mostly to winterstorms. We do not model these ourselves and had to rely on available estimates from various sources for the 1 in 200 year event for European countries.

Table 38: Losses in billion Euro for selected EU countries for 200 year loss windstorm event for today

2011	Losses (billion Euro)					Max. Loss to GDP (%)
Country	PERILS	Model I	Model II	Model III	AON Model	
Austria	-	-	-	-	0.6	0.21
Belgium	2.4	2.3	1.9	2.8	-	0.61
Denmark	2.8	3	3	4.2	-	1.82
France	14.5	9.4	13.6	16	-	0.82
Germany	9.8	6.2	6	7.9	6.3	0.39
Ireland	1.5	1.8	1.6	2.9	-	1.75
Luxembourg	0.2	0.2	0.2	0.1	-	0.49
Netherlands	5.2	4.4	6.1	5.3	-	1.03
United Kingdom	14.2	8	13.2	17.8	-	1.14

Source: PERILS (2011); Guy Carpenter (2011), CEA (2010).

Climate change impacts on windstorm are analysed in the literature (see Swiss Re 2009 or Schwierz et al. 2010 for example). However, there are large controversies about the relevance of exposure-driven or event-driven increases in future storm loss. This issue will be further looked at in the future. As Figure 36 indicates windstorm risk can also quite dramatic however, less intense than for the flood case.

Table 39: Key member states exposed to windstorm and relative windstorm risk sorted in descending order

Country	% GDP
Denmark	1.82
Ireland	1.75
United Kingdom	1.14
Netherlands	1.03
France	0.82
Belgium	0.61
Luxembourg	0.49
Germany	0.39
Austria	0.21

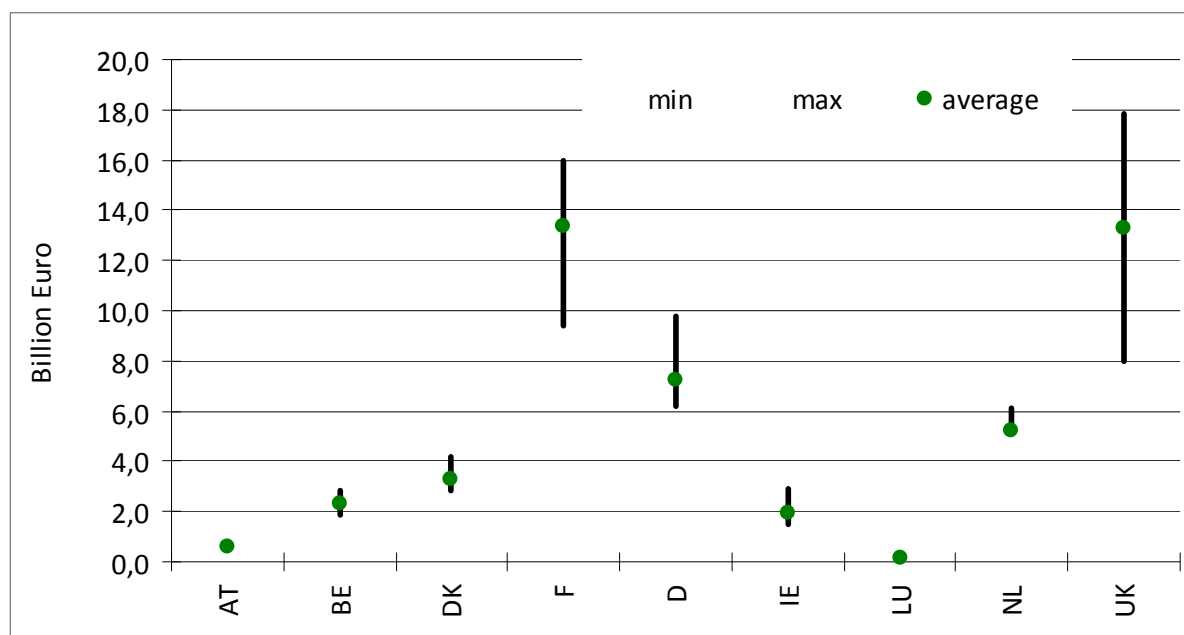


Figure 31: 200 year event windstorm risk in absolute terms (insured and uninsured).

Note: Estimates were available only for exposed countries and for the 200 year event. Source: Based on PERILS (2011); Guy Carpenter (2011), CEA (2010) and Word Bank (2010).

8.4 Assessing insurance coverage

European-wide insurance penetration data is difficult to obtain, and we base our assessment on a systematic review of insurance penetration by CEA published in 2005 as indicated in the table below, supplemented with information from the EMDAT loss database, Swiss Re 'Sigma' reports and expert knowledge.

Table 40: Insurance penetration rates for flood risk³¹

Country	Flooding	Windstorm	Drought
Austria	Flooding	Windstorm	Drought
Belgium	13,75%	88,33%	17,50%
Bulgaria	5,00%	90,00%	0,00%
Czech Republic	90,00%	90,00%	50,00%
Denmark	67,50%	75,00%	5,00%
Estonia	0,00%	90,00%	0,00%
Finland	25,00%	50,00%	0,00%
France	17,50%	90,00%	0,00%
Germany	93,50%	93,50%	90,00%
Greece	15,50%	82,33%	0,00%
Hungary	5,00%	5,00%	0,00%
Ireland	25,00%	50,00%	0,00%
Italy	90,00%	90,00%	90,00%
Latvia	17,50%	0,00%	0,00%
Lithuania	25,00%	50,00%	0,00%
Luxembourg	25,00%	50,00%	0,00%
Netherlands	25,00%	50,00%	0,00%
Poland	0,00%	94,50%	0,00%
Portugal	32,50%	90,00%	0,00%
Romania	50,00%	50,00%	50,00%
Slovakia	20,00%	50,00%	0,00%
Slovenia	32,50%	50,00%	25,00%
Spain	16,25%	90,00%	17,50%
Sweden	50,00%	50,00%	5,00%
United Kingdom	93,50%	93,50%	90,00%

Source: CEA, 2005 as well as expert judgment.

It should be noted that even in cases where high insurance densities are found, that the coverage levels are insufficient for extreme events. Furthermore, public sector assets are usually not insured and therefore even in cases of close to full insurance in the private sector, the non-insured assets from the public sector could cause problems in financing the losses (see Hochrainer and Mechler, 2009). Due to limited data on private and public assets, we work with a general ratio of 30% of risks being public infrastructure and assets (buildings, cars in public hands etc.) (see Mechler et al., 2006). Combining risk with insurance density, we can assess the distribution of flood risk over Europe in absolute terms as well as the uninsured portion (see Figures below). Insurance penetration is highest for windstorm with only about 1/3 of the risk uninsured according to our calculations, yet, as the risk is substantial (we had to rely on the 200 year event), there is a sizeable uninsured risk, which

³¹ Insurance rates per CEA, 2005 are given in terms of ranges, which were translated into discrete numbers as follows: 10 – 25 %: 17.5%; <10%: 5%; > 75%:90%; 25 – 75%: 50%

remains, also owing to the fact that public assets are generally not insured. For flood and drought risks similarly about 2/3 of the private and public asset risk is uninsured.

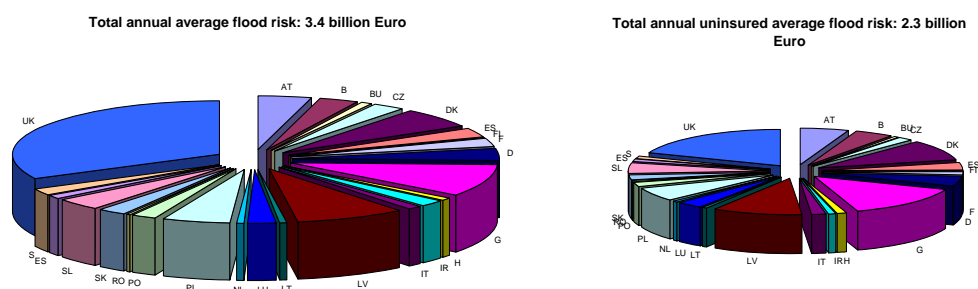


Figure 32: Distribution of flood risk including the uninsured risk over Europe

Note: the uninsured risk comprises private and public assets, and the latter are generally uninsured

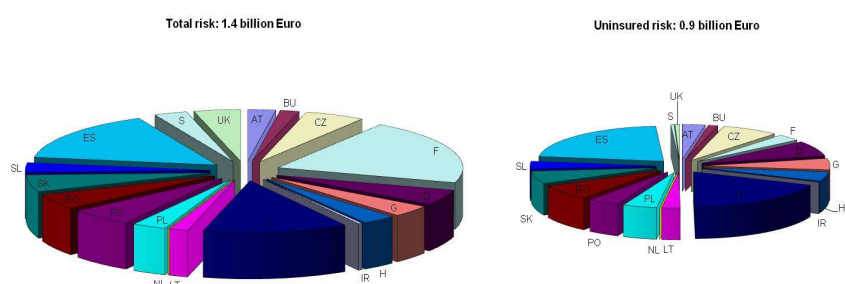


Figure 33: Distribution of drought risk including the uninsured risk over Europe

Note: the uninsured risk comprises private and public assets, and the latter are generally uninsured

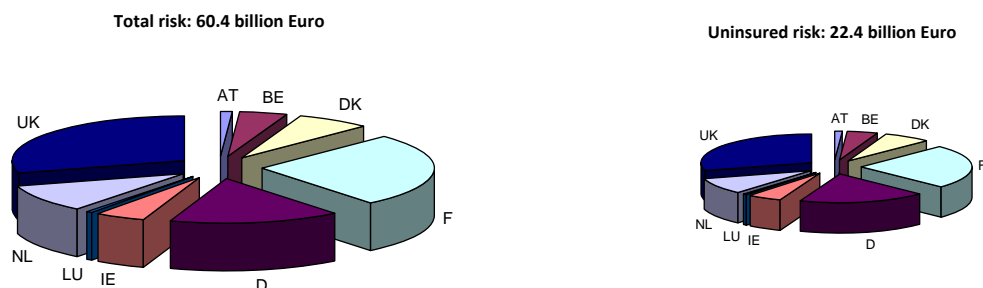


Figure 34: Distribution of windstorm risk for the 200 year event including the uninsured risk over Europe

Note: the uninsured risk comprises private and public assets, and the latter are generally uninsured

8.4 Relation to and implications for Solvency II

The Solvency II directive is the follow up of Solvency I as the set of regulations for (re)insurance firms operating in Europe scheduled to become national law in early 2013. Solvency II demands a more risk based approach to asset and liability accounting. In order to test and assess the European industry's solvency in line with the requirements of the Solvency II directive, so called Quantitative Impact Studies are undertaken by EIOPA (formerly CEIOPS) based on requests by the EC (EIOPA, 2011). Recently, the insurance industry has devoted great efforts to calibrate the capital required to deal with natural disasters in accordance with the Solvency II capital requirements (see CEIOPS 2010a). One important key parameter for such an estimation is the 1 in 200 year gross loss damage ratio for EU member states (CEIOPS 2010b), i.e. country factors representing the cost of a 1 in 200 year loss to the industry as a whole, expressed as a percentage of sum insured (see table below).

Table 41: Comparison of our risk estimates with CEIOPS: 200 year event loss for windstorm and flood

	Flood		Windstorm	
	PCC (% assets)	CEIOPS (% Sums Insured)	PCC (%assets)	CEIOPS (% Sums Insured)
Austria	.573	.15	.065	.08
Belgium	.425	.10	.316	.16
Bulgaria	.210	.15	-	-
Czech Rep	.365	.40	n.a.	.03
Denmark	.430	-	.547	.25
Estonia	.267	-	-	-
Finland	.677	-	-	-
France	.189	.10	.277	.12
Germany	.092	.20	.134	.09
Greece	.199	-	-	-
Hungary	.646	.40	-	-
Ireland	.293	-	.599	.20
Italy	.198	.10	-	-

Latvia	.464	-	-	-
Lithuania	.248	-	-	-
Luxembourg	1.417	-	.154	.10
Netherlands	.317	-	.405	.18
Poland	.188	.30	n.a.	.04
Portugal	.091	-	-	-
Romania	.221	.40	-	-
Slovakia	.677	.45	-	-
Slovenia	.847	.30	-	-
Spain	.148	-	n.a.	.03
Sweden	.198	-	n.a.	.09
United Kingdom	n.a.	.10	.406	.17

Source: CEIOPS 2010a

It is important to note that these estimates not only take account of the intensity of the hazard but also the vulnerability of the building stock and concentrations of exposure at risk. The methodology for the calibration of key parameters for the Solvency II capital requirements can be found in CEIOPS (2010b). However, the full details and the shapes of the loss function are not available, and there are differences of definition (e.g. relating to storm surge) which makes it hard to compare those estimates with others. For flood, there are significant differences between CEIOPS and our estimates. In general our estimates are much higher, but for four countries (Czech Republic, Germany, Poland, Romania) the position is reversed. Further research is needed to establish the reason(s), though clearly the different treatment of storm surge is an important factor. For storm, our estimates are again generally much higher (apart from Austria), despite the inclusion of storm surge in the CEIOPS definition of storm, but the ranking of countries is quite similar in terms of sensitivity to storm, which suggest the underlying hazard models may be similar. Again, further research is required to explain the differences.

In terms of implications of our risk estimates, we suggest there is no need for revising the methodology at this stage (e.g., by suggesting a climate mark up to current risks), as risk estimates and drivers, part. the contribution of future climate change, are very uncertain, and insurance anyway operates with short, mostly 1 year time scales. In fact the focus of QIS5 on the 200 year event as “extreme loss” is well in line with the disaster risk calculus, which often takes this event as the probable maximum loss. Instead, we suggest, as is done by insurers, reinsurers and risk modellers that risks are continually monitored and any major changes accounted for in solvency and premium calculations, overall suggesting and adaptive management approach.

9 Analysis of insurance instruments for climate risk financing

After the general discussion in task 2, and assessing the situation as to flood, drought and windstorm risk in the EU, we now pick up on the discussion of RFI in an idealized world setting and assess key insurance systems in a “real world” context. In this task, we focus on insurance as the dominant risk financing tool and provide a detailed overview of selected insurance arrangements instruments as they are employed throughout Europe at multiple scales, and including selected arrangements outside Europe, like micro-insurance and regional pools that may be relevant to the policy discussion within Europe. We focus primarily on insurance that covers property and agricultural losses. Importantly, we examine current experience with an eye to how RFIs can be explicitly designed to reduce risk and thus promote adaptation. Since risk reduction (adaptation) is not the sole criteria for assessing risk-sharing systems, we examine the capacity of national insurance arrangements for covering catastrophic losses, their applicability in different social and cultural contexts, their efficiency in sharing risks and their equity in providing post-disaster support to vulnerable households, businesses and governments.

In addition to the four criteria used in task 2, an additional key criterion for assess the instruments is the ability to provide reliable and wide comprehensive financial protection for losses from natural disasters. We term this criterion

- *Capacity for providing a reliable and comprehensive safety net*

The following paragraphs describe the criteria, subcriteria and indicators for evaluation.

Applicability

- Risk environment and particularities of the social and political context
- Individual and public affordability of the arrangements
- Institutional feasibility

Effectiveness for incentivising adaptation

- Allocation of liability appropriate for private and collective investments
- Extent of segregated risk-based pricing (and analogously, the extent of “free” government compensation);
- Extent of reductions in premiums to reward risk-reducing location/ behaviour /investments
- Extent of “must do” clauses
- Extent of deductibles, co-insurance
- Evidence of risk reducing activities resulting from insurance
- Evidence of mal-adaptation resulting from insurance

Efficiency in terms of benefits and costs

- Benefits: consumer demand or willingness to pay for insurance (above expected losses)
- Costs:
 - Contingency load
 - Expense load
 - For equivalent hazard probabilities, the “rate on line” reflects differences in these loads.

Equity in providing security to low-income population

- Who pays, who benefits?
- “Flatness” of premium
- Subsidies to low-income clients
- Compensation through non-insurance instruments
- Government reinsurance and other forms of support making private insurance affordable

Capacity for providing a reliable safety net

- Portion of risks covered by RFIs (public and private insurance)
- Portion covered by other secure forms of compensation
- Penetration and type of insurance
 - Voluntary or compulsory
 - Bundled or single hazard
 - Limits and deductibles
- Public compensation (How financed? How affordable?)
- Reliability of post-event payments
- Evidence: increased incomes and welfare of insured

Before proceeding, it is important to note that risk financing instruments are part of a wider portfolio of arrangements that are available to the private sector. As shown in Table 42, RFIs compete with post-disaster arrangements, most importantly, public assistance and emergency loans, which can be less costly, as well as less reliable, than insurance and other pre-disaster arrangements. There are also non-market instruments (which do not involve a premium, share or pool risks) that can be put into place before disasters. These include personal or corporate savings and informal agreements for mutual help with family or neighbours (in developing countries, for instance, families often place members in other countries, who send remittances in the case of disasters).

Table 42: Pre- and post-disaster loss and risk financing arrangements for the private sector

	Mechanism	Households/business: Loss of assets and business interruption
Post -disaster (ex post) loss financing	Market and non- market	Public assistance, emergency loans; sale of productive assets
Pre-disaster (ex ante) risk financing	Non-market	Savings, kinship and voluntary mutual arrangements, calamity funds
	Risk transfer: Risk pooling and sharing	Insurance, catastrophe bonds, weather derivatives

10 Insuring households and businesses

We begin by focusing on climate-related catastrophe insurance arrangements for households and businesses as they manifest across nine countries: the Netherlands, Austria, Spain, Switzerland, France, Germany, the UK, Hungary and (outside Europe) the US. We choose these countries because they represent institutional arrangements that span the main characteristics of insurance systems across the EU, and the US flood insurance program provides a useful comparative example. They differentially include common hazards, such as storms, hail, floods, earthquake, and also landslides or subsidence. Sometimes these risks are covered separately and sometimes bundled with a fire policy or an “all hazards” policy. They differ on the extent of cover offered, as well as indemnity limits, and whether the policies are compulsory, bundled or voluntary. Importantly, they differ institutionally with regard to the involvement of the public authorities and private insurers. We pay particular attention to characteristics that influence risk-reducing behaviour, such as how the policies are priced to reflect risk, whether they have deductibles, and whether the contract is conditional on location, risk-reducing investments or behaviour.

Keeping in mind that insurance systems cannot easily be transplanted from one country to another, our purpose is to gain insights on what works best for reducing risk and advancing adaptation. This will steer our discussion to how the European Commission can tailor its advice, directives and other policies to make use of insurance instruments for its climate adaptation agenda.

We proceed by: (1) providing a roadmap across the eight countries according to “who pays” differentiated by private versus public liability; (2) briefly describing arrangements for disaster insurance in the selected nine countries; (3) discussing criteria for evaluating the national arrangements; and (4) summarizing subjective assessment of the arrangements along the criteria. Note that a more extensive discussion of these systems with details on the subjective rankings can be found in the Annex.

10.1 A roadmap across national systems

As a roadmap, in Figure 35 we group the nine country specific insurance systems according to how they allocate liability and responsibility for disaster losses across individual households, businesses (private liability) and taxpayers (public liability). We choose this grouping because attribution of responsibility is crucial for linking insurance systems with adaptation. Any transfer of liability from at-risk individuals to taxpayers (or others not in the risk pool) reduces incentives for private investment in preventive measures. Yet, as shown in Figure 35 most countries (the single exception being the U.K.) include these transfers usually for reasons of social solidarity in the face of natural perils. At the same time, and what is often lost sight of, any transfer of liability from the government to individual households reduces incentives for the government to take on investments in collective protective measures.

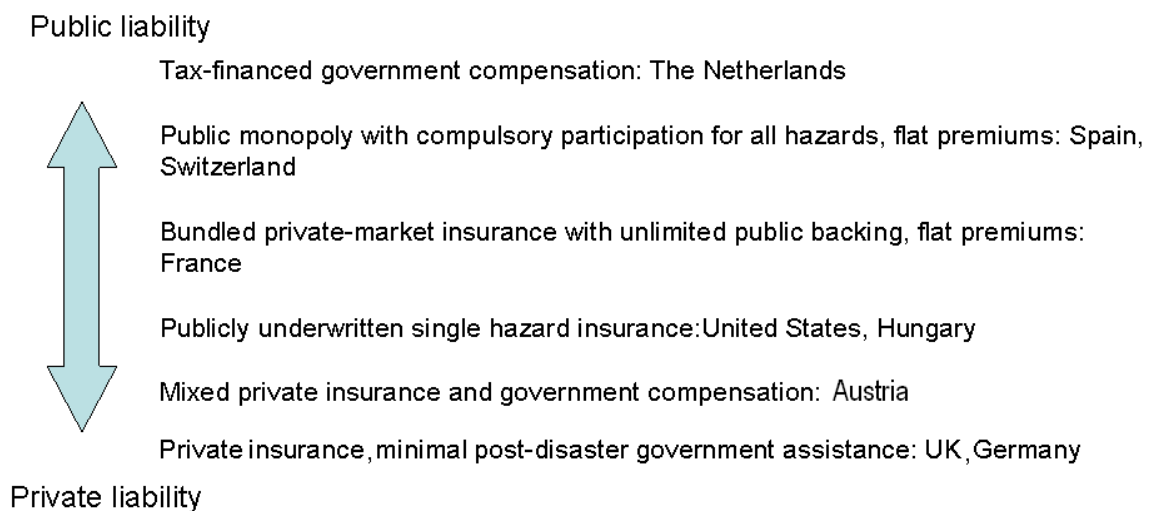


Figure 35: Country Models for Flood Insurance as they reflect private and public liability

At one end of the continuum are models where the state absorbs a large part of the financial burden or liability. In the Netherlands the government typically compensates victims following major flood and other types of “uninsurable” disasters. At the other end of the spectrum is the UK, which has extensive private insurance penetration, and the government typically does not provide post-disaster financial support to private persons. In between is a range of public-private partnership arrangements that differentially allocate the disaster burden. We briefly describe these systems below.

10.2 The Netherlands: tax-financed government compensation

The Dutch government generously compensates losses from uninsurable disaster losses that cause considerable disruption in accordance with the 1998 Calamities and Compensation Act (WTS). The limit on compensation is €450 million per year (Paklina, 2003). There is voluntary private hazard insurance covering mainly storm and hail risks, and also business interruption. A government disaster fund (separate from the WTS) provides compensation for major natural and man-made disasters, and this fund has historically compensated a large percentage of residential and business losses from floods and storms.

10.3 Austria: statutory public compensation combined with private insurance

Austria offers generous post-disaster compensation to victims of all natural disasters financed by its structured national disaster reserve with the result that households and businesses, with the exception of windstorm, carry little private insurance for property damage. This fund statutorily compensates damages to property and contents (more recently including indirect damages), which contrasts with ad hoc disaster compensation characterizing the Netherlands and many other governments. Compensation is implemented by the Austrian states with payments averaging about 50% of losses and up to 80% in the case of hardship. Households and businesses carrying insurance do not receive public compensation.

10.4 Germany: private insurance with ad hoc public compensation

Germany does not have a structural fund like Austria for compensating victims of disasters, but the government used to intervene very generously on an ad hoc basis. After major flooding on the Elbe in 2002, for example, victims were almost fully compensated for their losses. Since then, policymakers have increasingly encouraged the use of private insurance. However, although there is no legal claim on government assistance, many Germans still self-insure (Linnerooth-Bayer, et al., 2001). Only privately offered insurance for hazards is available in Germany, where storm and hail policies are the most prevalent (95%), and to some extent they are risk based. Flood policies are marketed as part of a package with other natural disasters as supplements to home contents or property insurance for both commercial and residential properties. With regard to floods, buildings that are situated in hazard-prone areas are often excluded from insurance, or they can only be insured by very high premium. There are no government guarantees for private insurers, but regulation requires equalization reserves.

10.5 Spain: public monopoly with compulsory participation for all hazards, flat premiums

Spain has a compulsory state insurance monopoly, the “Consortio”, which covers damage from such disasters as floods, storms, tornadoes, earthquakes, tsunamis and terrorist attacks (droughts are covered under the Fund for Agricultural Calamities). The system extends to residential and

commercial properties, and pays claims for personal injury, property damage and business interruption. The public insurance covers 100% of assets exposed with no limits on indemnity. The state provides a full guarantee meaning that losses above the Consorcio reserves will be covered by government taxpayer funds. The program is administered by private insurers that issue policies, assess damage and pay claims.

10.6 Switzerland: public monopoly with compulsory participation for all hazards, flat premiums

In 26 Swiss cantons, cantonal property insurers (KGVs) operate as public monopoly institutions that offer weather-related hazard damage coverage for floods, storms, hail, avalanches, weight of snow, falling rocks, and landslides (earthquake not covered). In the remaining seven GUSTAVO cantons, protection is offered by private insurers. This parallelism has arisen as a result of referenda on the EU Council Directive on Indemnity Insurance (92/49/EWG). In all cantons, hazard insurance for property owners is compulsory and bundled with fire insurance, but optional for business interruption. For the private GUSTAVO insurers the limit is Euro 2 billion per event; for the public monopoly KGV insurers, there is unlimited liability.

10.7 France: state-backed national all-hazards insurance

The French national insurance program is based on a public-private partnership characterized by a high degree of solidarity through cross-subsidized and non-segregated pricing. Damages are compensated when the government officially recognizes a disaster. Private insurers are required to offer catastrophe insurance in an all-hazards policy that is bundled with property and home contents insurance, covering both the residential and commercial sectors. Property insurance is not compulsory; yet if one chooses to purchase this insurance there is mandatory cover for disasters. This solves problems with adverse selection, and it is claimed that insurance penetration approaches 100 percent (Swiss Re. 1998). Private insurers can choose to reinsure through a public administered fund, the Caisse Centrale de Réassurance (CCR). If this fund proves insufficient, taxpayers will be called upon to contribute through an unlimited state guarantee.

10.8 The US: privately administered public flood insurance system

The US National Flood Insurance Program (NFIP) is unique in that the federal government serves as the primary insurer offering voluntary policies to residential and commercial buildings, yet mandatory in the case of a mortgage. The US government underwrites the risks, and private insurers market the policies and carry out all administrative functions. In principle, the system does not depend on taxpayer support, although this is not entirely the case in practice. If the capital reserve is insufficient to cover claims, the Federal Emergency Management Agency (FEMA) borrows from the treasury, and the loan is paid by raising premiums.

It may be surprising to see the US flood insurance program as closer to “private liability” than France and Spain, since the government acts as primary insurer and fully underwrites risks. We must be

careful not to confuse institutional arrangements with liability. Although the US National Flood Insurance Program has a large public involvement in the underwriting of insurance, in contrast to France and Spain, the taxpayer is not called upon to contribute to disaster financing. If the insurance reserves are insufficient to cover claims, the NFIP borrows from the US Treasury with an obligation to repay the debt through premium income. Thus the full burden (legally but not always in practice) is on those in the insurance pool.

10.9 Hungary: subsidized public flood insurance program for high risk areas

Some important aspects of the US flood program have been incorporated in recent Hungarian legislation for a flood insurance program. The government will fully underwrite (optional) flood insurance in high-risk areas (where most private companies do not offer flood insurance), which will be administered by private insurance companies on a commission basis. The indemnity can reach 100% of the property value, but with a maximum of Euro 57,000. It will cover all flood and standing water damages both in protected and unprotected flood basins. In sharp contrast to the US, the government will provide back-up capital if the premium pool is insufficient to cover claims.

10.10 The United Kingdom: private market bundled hazard insurance

The hazard insurance program (mainly flood, windstorm and subsidence risk) in the UK is the most extreme in terms of private responsibility and market principles. There is only limited post-disaster public compensation, and the government does not act as a guarantee or reinsurer for primary insurers. Coverage against flood damage and other hazards is part of fire insurance, which is a part of building or home contents insurance required for a mortgage (Hubert, 2004). Market penetration is estimated to be approximately 95% (Crichton, 2005).

10.11 Summary

There are many ways to organize national insurance systems, and although some systems, such as in Spain or France, have a very strong public sector involvement, these systems can not be said to be in non-compliance with rules and regulations of the EC, yet in a further developing internal EU market, there is scope for further examining the different systems and their pros and cons. While the private-versus-public- liability characterization is useful for considering how insurance links to adaptation, there are no unambiguous grounds for preferring either end of the public versus private continuum. As discussed in Box 3, there are arguments both pro and con government involvement and individual responsibility in national insurance programs.

Box 3: Public versus private responsibility

Critics of government responsibility for private losses, usually in the form of post-disaster government assistance, argue that it discourages individuals from taking advantage of the high returns on preventive, adaptation actions. They point to the resulting “moral hazard” since recipients, expecting public support, may not engage in appropriate loss-reduction or adaptation measures, nor may they purchase insurance. For this reason, many argue in favor of making private responsibility (and insurance) a cornerstone of risk management (Kunreuther and Roth, 1998). This also means reducing cross subsidies within programs and differentiating premiums depending on location and risks.

Proponents of state intervention, alternatively, argue that governments should pay a portion of private losses because of their responsibility to invest in collective protective measures, such as mapping, zoning, levees, or fire-fighting equipment. If full liability is placed on individual households and businesses, this will send the wrong signals to government, which in turn may under invest in public protection, a situation some say plagues present-day England (Crichton, 2005). Moreover, the practice appears different from the theory. In reality, with the exception of geographic location decisions, insurers seldom differentiate premiums to reflect risk reducing behavior.

Proponents of state liability also argue that governments, because of their ability to spread and diversify risks over a large population, are well prepared to share losses. Priest (1996) refers to governments as the most effective risk financing instrument of society. Not only can government financing be efficient, it is often overlooked that national solidarity for disaster victims can reinforce social values of sharing and helping in times of distress, and evidence in Europe suggests widespread public support for taxpayer solidarity. After the extensive damage from the 1997 flood in Poland, the Prime Minister made a public statement that uninsured victims had only themselves to blame for their financial losses and should not expect government help. This remark raised such a public outcry that the Prime Minister was forced to apologize (Strippel, 1998).

11 Ranking national insurance programs

We rank the national insurance systems according to five criteria: *Capacity* for providing a reliable safety net; effectiveness for *incentivising adaptation*; *efficiency* in terms of system costs, *equity* in terms of allocating the burden in a fair and responsible way and *applicability* to other countries. The subjective rankings are shown in Table 43 and briefly discussed below.

11.1 Capacity for providing a reliable safety net

In addressing this criterion, we are asking whether European countries have secure safety nets in place, that is, are they sufficiently prepared to finance relief and recovery as losses from weather extremes continue to escalate? What portion of the risks will be compensated by premium-based

insurance systems and what portion by (reliable) public funds? What portion might households and businesses choose to self-insure? In the earlier sections we examined these issues and also discussed obstacles and opportunities for insurers to operate in Europe, both from the supply and demand sides. We know that the penetration of insurance depends strongly on whether it is compulsory, bundled, enabled through tax credits, and the limits on cover.

All countries in this survey have a reasonably reliable and secure safety net in place; yet, five countries – Austria, the monopoly-insurers in Swiss cantons, France and the UK - rank highest but for different reasons, namely:

- Austria has a publicly backed guaranteed fund that can cover all projected losses, and because it is statutorily required, compensation is reliable ;
- The Swiss public-monopoly cantons and France, insurance penetration is high and backed by the government; Spain's system is also backed by the government, but given the debt situation this may be less reliable;
- In the UK, private insurance penetration is high and insurers operate with adequate reinsurance.

The Netherlands and Germany rank lower because of the ad hoc (and thus insecure) nature of the government compensation. The US NFIP also ranks beneath the above European systems because of the lack of government back up, and what many feel is insufficient capitalization of the system.

11.2 Effectiveness for advancing adaptation

As shown in Table 43, the effectiveness of national arrangements for incentivising or requiring/supporting adaptive investments and behaviour ranks high in only three national cases:

The public-monopolies in the Swiss cantons: The most noteworthy feature of the Swiss KGVs is their right to participate in processes influencing risk reduction, including building codes and land-use planning, and also financing of the Fire Service and Cantonal Civil Defense Services. According to Ungern- Sternberg (2006), the canton monopoly insurers are heavily involved in prevention, investing twice as much (0.15‰ of sum insured) in prevention than the private insurers (0.06‰ of sum insured). In the words of Schwarze and Wagner (2009) there are economies of scope from pooling of prevention and risk transfer. These investments have significantly decreased claims.

The US Flood National Insurance Program (NFIP): A notable feature of the NFIP is that communities must take prescribed loss-reduction measures if their residents are to be eligible for (subsidized) cover. Flood insurance is only available in those communities that adopt and enforce a floodplain management ordinance that meets or exceeds the minimum NFIP standards. With the intent of reducing subsidies and moving toward differentiated risk-based premiums, the philosophy of the NFIP is that persons living in exposed areas should eventually bear their full risks. This is the case for new buildings for which premiums are based on flood risk determined by the elevation of the lowest floor of the structure relative to the elevation of the national base flood (100-year flood) standard. The NFIP has a pilot program requiring owners of repetitive-loss properties to elevate, relocate or demolish houses, with NFIP bearing some of the costs. It is claimed that this program has contributed significantly to reduce vulnerability of new buildings to flood impacts, but still needs government support in enforcing building codes, settlement areas, etc (Burby 2001).

The Hungarian national program: This system is one of the few where insurance premiums for very high-risk areas will be differentially set according to location. Note, however, that the premiums of poor households will be subsidized up to 30 percent. To counteract the subsidies, “must do” clauses are legislated meaning that insurance will be available only for homes built with a permit, thus assuring that homes are built according to building codes and not in high risk locations. The government, which provides insurance contracts for high-risk cases, will issue the permits.

This does not mean that insurance is not coupled with adaptation in the remaining five countries. In fact, two countries stand out as explicitly moving toward more direct coupling.

The French all-hazards insurance program: In France, the government sets the “natural catastrophe” surcharge, and premium differentiation is not allowed, and for this reason the system has been criticized as not advancing risk reduction. However, to counter the problem of disincentives for adaptation from the flat premiums, a recent decree sets a deductible that increases with the number of disasters in the same area (Linnerooth-Bayer and Mechler, 2007). This means that the compensation a household or business receives will continually decrease in high-risk areas, creating an incentive to relocate or take other loss-reduction measures.

Furthermore, the French insurance-funded research institute, Mission Risques Naturels (MRN) provides knowledge and prevention management services to its members companies, as well as services to the whole market. These include, for example, a contribution to collective vulnerability scoring tools for each municipality that evaluate the appropriateness and efficiency of risk-prevention plans. MRN also publishes practical guidelines for individuals containing recommendations on the actions to be taken before, during and after a catastrophic event in order to reduce losses. (Surminski, 2010)

The German private insurance system: Germany introduced the first national European system for flood risk mapping and zoning in the year 2000, having started the development in 1998 (called ZÜRS – Zoning system for flooding, heavy rain and backwater). ZÜRS was the antetype for some national systems that followed later: HORA in Austria or the French system by MRN. There are numerous independent entities, which foster prevention and raise public awareness on the issue, and the German Insurance Association (GDV) has its own branch of prevention experts. Recently GDV started research into a “certificate for a flood-proof building” along with many other stakeholders including public authorities³².

The UK private insurance system: An exceptional case is the UK, which is consciously moving toward coupling insurance, especially flood insurance, with risk reduction. Until 2013 there exists a “gentlemen’s agreement” between the Association of British Insurers (ABI) and the government, referred to as the Statement of Principles (SoP), to ensure that flood risk is managed effectively. Insurers have agreed to offer universal coverage in exchange for government engaging in risk management (adaptation) activities, including investing in new and existing defences, and providing flood risk data to insurers. In addition the government agrees to improve understanding of risk

³² See: <http://www.hkc-koeln.de/de/projekte/projekte/hochwasserpas/index.html>

through public flood maps and to ensure the planning system prevents inappropriate development in flood-risk areas. In return, insurers cover up to the 75-year risk to households and small businesses. Market penetration is estimated to be approximately 95% (Crichton, 2005). Because insurance companies have become dissatisfied with the current flood defense standards, in 2013 they will discontinue the agreement to offer universal flood cover.

As insurers move toward ending the agreement with the government, companies are beginning to differentiate premiums based on geographical risk characteristics, which encourages settlement in low-risk areas but also precludes low-income residents in high-risk areas from purchasing expensive policies. As insurers move toward more differentiated (by location) risk-based premiums, predictably there has been less investment in collective flood protection (at least in England). It is now more difficult to obtain insurance in risk-prone areas because insurance companies are dissatisfied with the current safety standards. Scotland appears to be an exception, where risks for insurance companies have not increased due to stricter building codes (Crichton, 2005).

According to the recent publication, *Climate Wise*, "the (insurance) industry is very clear that responsibility for flood risk management and prevention ultimately rests with government and they are conscious that certain individual measures could possibly even increase flood risk in surrounding areas and also possibly trigger legal disputes." (p. 8) At the same time, insurers have a role to play by pricing risks and working with governments to pass appropriate legislation, set regulations and fund programs aimed at risk reduction.

Finally, it should be recognized that differentiated premiums (premium discounts) may not incentivize risk reduction to the extent that theoreticians suggest. There is extensive evidence that individuals are myopic in the sense that they have short time horizons when planning for the future (Kunreuther and Michel-Kerjan, 2009). This means that they may not fully weigh the long-term benefits of making large up-front investments in loss reduction measures even if coupled with reductions in their insurance premiums. It is wrong to draw the conclusion that these behavioural issues can be overcome by providing individuals more information on the probabilistic risks and insurance pricing. Even with extensive public awareness campaigns about risks and insurance in earthquake-prone California, there has been little change in behaviour regarding risk mitigation (Kunreuther, 2006).

This has been reinforced by experts attending the stakeholder workshop on this topic. According to one expert:

NatCat-insurance in Germany starts with 50 EUR p. a. and goes up to approx. 400 EUR p. a. for an average private building. Even a 25 % discount on 400 EUR would not be enough, to have anyone installing prevention measures. What prevention measures could the policyholder buy with 100 EUR? In the private insurance sector the only way to get prevention measures installed, is introducing noticeable deductibles, which are lowered, when the risk is really reduced. Furthermore, policyholders need to be encouraged to take natcat-prevention into account, if they are modernizing their buildings anyway.

A novel idea (Kunreuther, 2006) that would address the dilemma of large upfront investment costs (and myopia) is to combine long-term property insurance contracts with loans for mitigating risks. If the payment on the loan is less than the premium reduction received if the mitigation measure is adopted, the investing household would receive an immediate gain. By overcoming the problem of myopia, long-term insurance will thus provide economic incentives for homeowners to invest in

mitigation, whereas current annual insurance policies (even with premium discounts) are unlikely to do so.

In summary, it appears that the systems most effective in advancing adaptation are those that combine extensive public involvement with differentiated risk-based pricing (e.g., the US and Hungary), and there is potential for novel policies to strengthen the risk-pricing incentive effect. There seem to be other advantages to public involvement, most notably that public systems appear to operate more efficiently than their private counterparts.

11.3 Efficiency in terms of system costs

Based on the study by Unger-Sternberg (2003) insurance premiums are substantially lower for public programmes offering hazard insurance (e.g. in France, Spain and Switzerland) than for private market systems with competition (e.g. in Britain and Germany). This is due to considerable savings on the part of state monopolies in terms of sales and administrative costs. Sales representatives typically receive between 15% and 20% of annual premium income, and in-house administrative and advertising costs add up to a similar amount. However, it must be recognised that in some cases the public insurance system gains its efficiency by ‘piggybacking’ on private insurers to administer the paperwork.

Moreover, public systems do not have problems of adverse selection, which also lowers premiums, and they are less vulnerable to rare extreme events, so they do not need to ‘top up’ premiums with an uncertainty load.

Ungern-Sternberg (2003) claims that since Germany switched from the public monopolies previously existing in some states to a private system (in compliance with the 3rd EU Non-Life Insurance Directive that came into force in 1994), operating expenditures have increased substantially. When opened to competition the former monopolies substantially increased their expenditures on sales representatives and administrative costs to survive in the free market. Within six years these costs more than tripled in several states. The share of these costs in premium income increased from roughly 10% to over 20%.

While some commentators note that, overall, the French system has proved to be efficient and in general insurers and insured are satisfied with the public-private arrangement (Botzen and van den Bergh, 2008), others are more critical. Ungern-Sternberg notes that private insurers have negotiated a handling fee of almost 25% to cover their “costs” of collecting the premiums, although these premiums are bundled with already collected fire insurance (the Spanish system pays only 5% handling fee).

11.4 Equity in providing security to low-income population

If “equity” means the creation of a secure safety net for low-income households and vulnerable businesses, then systems with high taxpayer involvement and/or cross subsidies, for example, Spain, France and Hungary, rank higher than systems with differentiated risk-based pricing. It should be pointed out, however, that transfers from persons who have reduced their risk to high-risk persons may be considered unfair and inequitable.

Government compensation in the Netherlands is motivated in part by the fact that the government is regarded as liable for flood (and to a lesser extent storm) damage because of its responsibilities for dike maintenance, and in part by solidarity with those least able to cope. There is a great deal of evidence that public compensation has been accompanied by extensive public investment. Still, many observers in the Netherlands are drawing attention to the disincentive effects of government compensation particularly for location and land-use decisions, and there is an on-going discussion on introducing premium-based insurance for climate-related risks (Botzen and van den Bergh, 2008).

In Germany, which relies in principle on private insurance, financially deprived households can get assistance from the public purse. Furthermore, those who rely on social welfare have the right of having their insurance premiums co-financed (law SGB II / Hartz IV).

This discussion highlights the inevitable tradeoff between the efficiency of differentiated risk-based insurance pricing and the equity of providing affordable insurance to low-income, high-risk households. Risk-based premiums penalize individuals who cannot escape risk at reasonable cost. The regulator is thus confronted with a dilemma between sharing the burden of natural peril risks in a more egalitarian way and improving efficiency through risk reduction incentives.

Addressing this tradeoff, Picard (2008) advises against abandoning differentiated risk-based pricing, at least in concept, but suggests that a central authority award targeted tax cuts on risk-based insurance contracts as a way of compensating individuals with high prevention costs. At the same time, grants should be awarded to local jurisdictions where risk management plans are enforced.

11.5 Applicability to other national contexts

The wide variety of insurance solutions available in the surveyed countries is not a surprise given the differences in the hazards addressed and loss potential, as well as the social, institutional and political contexts. None of the surveyed systems rank high on applicability to other European countries. Systems with extensive government/taxpayer involvement, like in the Netherlands or Spain, are not appropriate in countries that can spread their risks sufficiently using private means (and where the government has a tradition of designating liability to the private sector), like in the UK. Nor is the private system of the UK transferable to countries where private insurers are reluctant to operate, such as the Netherlands, and where there is a strong tradition of solidarity, like in Austria.

Of special interest to this discussion is the Swiss KGV's, which appear to rank high on a number of criteria, including their propensity to advance adaptation, their operating efficiency, reliability and equity. However, the system is not generally applicable across Europe for a number of reasons:

- The system violates the EU's 3rd Non-Life Insurance Directive that disallows state monopolies;
- Compulsory systems may be deemed unconstitutional in some countries (there is an on-going discussion in Hungary on this issue);
- State backing may create financial problems for governments of small, low-income countries (a reason to consider regional pools); and

- Some countries, e.g., the UK, are heavily invested in private insurance institutions, and are committed to market practices, and for these reasons public monopolies will not be an acceptable option.

12 Summary and policy options

12.1 Summary

This discussion highlights the variety and complexity of national insurance arrangements addressing the risks of weather-related hazards and the ways in which they encourage or require preventive, risk-reducing measures. The rankings (by the research team) of the nine national systems across selected criteria are summarized in Table 43 with more detail and rationale for the rankings in the Annex to this report. The lessons that can be drawn from the analysis include:

- No system ranks consistently high on all criteria – there is no “best” national insurance arrangement; yet, public systems, like in Spain and Switzerland, rank high on a number of criteria, including their propensity to advance adaptation, efficiency, reliable capacity (only Switzerland) and equity;
- All systems appear to have sufficient capacity for providing needed post-disaster capital and financing the needs of the most vulnerable. This capacity is in the form of public (taxpayer) backup or reinsurance; however, it can be ad hoc (for example, the Netherlands, Germany) or insecure (e.g., Spain given its budgetary financial crisis);
- Insurers do not generally enjoy a strong record of effectively incentivizing, requiring or enabling private-sector risk reduction and climate adaptation measures;
- Public responsibility and liability, and particularly public insurance systems, appear to be relatively more effective in supporting collective (public good) loss reducing measures;
- The Swiss, US and Hungarian systems stand out particularly as they work closely with public authorities in advancing land-use planning and other crucial regulations, and as they (US and Hungary) move towards differentiated (by location) risk-based pricing;
- Risk-based pricing (by location) of insurance can be an effective adaptation measure especially for discouraging construction in high-risk areas, and premium discounts can incentivize other types of adaptive behaviour; however, it is not a magic bullet. Experience shows that insurers are reluctant, and in some cases unable, to monitor risk-reducing behaviour and investment, and adjust premiums accordingly. Moreover, even informed individuals do not mitigate risks “optimally” even if insurance incentives exist. Information does not appear to improve behaviour.
- As systems move towards differentiated risk-based pricing (as in the UK, US and Hungary), they confront the efficiency-equity tradeoff (higher incentives for risk reduction vs affordability of insurance for the most vulnerable). France has confronted this tradeoff by intentionally rejecting differentiated risk-based pricing, yet investing heavily and pursuing top-down regulation for mitigating risk, and increasing deductibles with each successive loss claim. For systems adopting risk-based solutions, they might address the equity issues with subsidies and tax reductions for those confronted with high prevention costs and corresponding high insurance premiums;

Table 43: Assessing national property insurance arrangements according to key criteria*

Country/Criteria*	Risk	Insured Risk	Capacity for providing a reliable safety net	Effectiveness for incentivising adaptation	Efficiency	Equity	Applicability to other countries
Netherlands (floods) Ad hoc public compensation	Med	Low	Medium	Low	High	Medium	Low
Austria Public disaster fund and limited insurance	Med	Low	High	Low	Medium	Medium	Low
Germany Private insurance with limited ad hoc public compensation	Low	Low	Medium	Low	Low	Medium	Low
Spain Compulsory public monopoly	Low	High	Medium	Low	High	High	Low
Switzerland Cantons with public monopolies, compulsory	na	na	High	High	High	High	Low
France Gov't backed bundled insurance	Low	High	High	Medium	Low	High	Medium
United States (flood) Gov't as primary insurer, not taxpayer backed	na	Medium	Medium	High	Medium	Medium	Medium
Hungary (flood) Gov't as primary insurer, not taxpayer backed	High	Medium	Medium	High	Medium	Medium	Medium
United Kingdom Mainly private insurance	High	Low	High	Historically low	Low	Historically high	Low

*Note: Criteria ranking is based on subjective judgment by the research team.

12.2 Policy options for expanding insurance density and advancing adaptation

The overview of insurance arrangements yields no overall preferred system, nor does it give a full endorsement to move radically from public compensation to private insurance. Indeed, the most successful systems for advancing adaptation appear to be public (there is a fine line between a public insurance system and tax-based public compensation). What is perhaps most striking from this

overview is “incorrect” price signals plague both individual and collective decisions. It follows that adaptation can best be encouraged with insurance instruments that place responsibility across the public and private sectors proportional to their capacity to reduce risks in a cost-effective manner. In the flood area, most preventive measures take the form of local public goods (levees, land use planning, etc), and adaptation can best be promoted with an appropriate balance of responsibility on the part of individuals and the government. According to von Ungern-Sternberg (2003):

The main issue is to provide adequate incentives in terms of zoning, construction norms and damage reduction. The presence of a local public insurance company in the relevant planning institutions should lead to a vast improvement to the current situation, since it could severely reduce problems of regulatory capture and moral hazard in this area. Combining insurance premiums and a tax to finance preventive measures (including fire fighting) thus has a double advantage. It internalises the externalities usually associated with prevention, and it gives even the good risks the feeling that they are getting something for their money.

Effective incentives for adaptation thus call for *layered insurance systems* with responsibility allocated differentially, depending on the hazard, between the private and public sectors. This will mean that the full and differentiated risk-based premiums for floods and other hazards will not apply to households, or, alternatively, they will insure only a portion of their assets (the other portion being the responsibility of government assistance). This way of dividing the loss burden was the rationale behind a stakeholder consensus in Hungary that the government would only assist flood victims who insured a pre-prescribed portion of their homes and assets.

Where this balance is misaligned, countries may see advantages to moving towards more responsibility through insurance and other market-based solutions that embed incentives and conditions for risk reduction and adaptation. There are many different policy options for increasing the supply and demand of public/private insurance and linking these systems to risk reduction and adaptation. Insurance can be compulsory as in Spain, France and Switzerland, or required for a mortgage as in the US; it can be bundled with fire or property insurance; those most vulnerable can receive subsidies or tax breaks for the purchase of insurance as in Hungary; and perhaps foremost, the governments can reduce “free” post-disaster compensation as in the UK. Flat-rate premiums will likely increase demand among the most vulnerable, but will have negative effects on incentivizing risk reduction. Risk-based pricing, differentiated by location and risk-reducing investments, can be made more effective according to experts if it is coupled with long-term insurance contracts and loans for investments in mitigation.

Central authorities also have options for increasing insurance coverage through low-cost government capital backups to reduce reinsurance costs, post-disaster lending to insurance programs or elimination or reduction of taxes on insurer reserves (this was practiced until recently in the UK and Germany). This can be combined with public provision of data collection, which will reduce costs to insurers (along with many other advantages);

There are also novel, untested ideas for linking insurance with adaptation. As mentioned above, Kunreuther and Michel-Kerjan (2009) recommend differentiated risk-based pricing with subsidies to low-income households (perhaps similar to food stamps) for purchasing insurance. They argue that this will distort behaviour less than flat-rate premiums. The idea of subsidizing low-income, high-risk households was endorsed by a three-year stakeholder process in Hungary (Linnerooth-Bayer et al., 2006). Picard (2008) suggests that a central authority provide tax cuts on insurance contracts for

those facing high prevention costs and at the same time (to compensate for lower tax revenue) communities receive grants where risk management plans are enforced. The US Government Accounting Office (2007) has also suggested tax-deferred dollars to pay for catastrophe insurance.

The GAO also discusses property tax assessment for private insurance with the option that a central authority pays the deductible. These options will be discussed in more detail in Section 4.

13 Insuring farmers: crop and livestock insurance

13.1 An overview

Like property owners, European farmers have many diverse ways of managing, pooling and sharing risks. In addition to so-called “on farm risk management” strategies, such as diversification of the crops and livestock portfolio, vertical integration (in terms of producing, packaging and marketing), and stabilisation accounts as a form of insurance, coping options include production and marketing contracts, commodity price hedges, mutual funds, government calamity funds and finally insurance and weather derivatives as RFIs. Also like property owners, farmers rely extensively on post-disaster responses, such as emergency loans, support from family, sale of assets and state aid.

Besides insurance, other pre-disaster instruments include calamity funds, which are public funds used to compensate agricultural losses, and mutual stabilisation funds, which are funds financed by private producers (these are not priced and thus do not qualify as RFIs). Many European countries have national reserves or calamity funds to compensation agricultural losses. According to one source annual public compensation for losses from drought, hail, pests and other causes, on average totals more than €1 billion throughout the EU (Diaz-Caneja, et al. 2009). In some countries, however, most of the risk management protection for crops is privately provided, for example in the UK, while for animal diseases there is typically more government intervention (e.g., in the Netherlands, Ireland, and the UK).

Insurance is the most common risk-sharing instrument. Livestock insurance in Europe most typically covers non-epidemic diseases and accidents, that is, non-systemic risks. The most widely offered crop insurance covers hail, and if insurance covers additional hazards, it is referred to as *combined risk insurance*. *Yield insurance* covers losses in yield for a given crop due to any type of meteorological event, and revenue insurance combines losses in yield and also fluctuations in price. (see Diaz-Caneja, et al., 2009.). The different types of insurance - single-hazard, combined and yield, - across Europe are summarized in Table 44.

Agriculture insurance coverage varies across the EU in terms of how it is bundled (e.g., single-risk insurance, combined insurance, yield insurance) and how it is shared between the private and public sectors. Like with property insurance, there is a spectrum of support for agricultural insurance, ranging from little government support in the UK to strong government support in Greece and Spain. The extent of public involvement and subsidization across all EU countries is shown in Table 44. In some cases the public sector heavily subsidises insurance premiums and in other cases ad-hoc aid and calamities funds represent the government’s choice of intervention. Table 44 summarizes key characteristics of agricultural insurance schemes (single risk insurance, combined insurance and yield insurance) including their market penetration, ratio of premiums to the sum insured, loss ratio

(claims divided by premiums) as well as subsidies paid to insurance systems. Figure 36 illustrates the different systems across Europe

Table 44: Summary of agricultural insurance systems

Country	Single risk Ins	Comb-ined Ins	Yield Ins	Market penetr-ation	Premium / insured %	Loss ratio%	Ins subsidy €m (%)
Austria	PS	PS	PS	78%	2.6%	72%	24 (46%)
Belgium	P	-	-	n.d.	n.d.	65%	0
Bulgaria	P	P	-	52%	4.8%	65%	0
Cyprus	GC	GC	-	(100%)	7.2%	95%	4.4 (50%)
Czech Rep	PS	PS	-	35%	1.8%	73%	7 (30%)
Denmark	P	-	-	n.d.	n.d.	n.d.	0
Estonia	P**	-	-	<1%	n.d.	n.d.	0
Finland	P**	P**	-	<1%	n.d.	67%	0
France	P	P	PS	n.d.	1.7%	n.d.	5 (2.4%)
Germany	P	-	-	43%	1.2%	83%	0
Greece	P	GC+GS +G	-	(100%)	2.5-3%	n.d.	n.d.
Hungary	P	P	-	52%	n.d.	74%	0
Ireland	P	-	-	n.d.	n.d.	n.d.	0
Italy	PS	PS	PS	6%	7.4%	63%	180 (67%)
Latvia	PS	-	-	<1%	n.d.	n.d.	0.05 (50%)
Lithuania	PS	-	-	1%	4.3%	100%	0.55 (50%)
Luxembourg	PS	PS	PS	45%	2.3%	86%	0.55 (50%)
Netherlands	P	-	-	n.d.	n.d.	41%	0
Poland	P(S#)	-	-	7%	n.d.	64%	0
Portugal	PS	PS	-	22%	8.4%	60%	32 (68%)
Romania	PS	PS	-	12%	n.d.	32%	7 (50%)
Slovakia	PO	PS	-	n.d.	n.d.	n.d.	(50%)
Slovenia	PS***	P	-	17%	7.6%	148%	4.3 (45%)
Spain	PS	PS	PS	26%	6.3%	69%	232 (42%)
Sweden	P	P	-	60%	n.d.	n.d.	0
UK	P	-	-	7%	0.6%	n.d.	0
TOTAL							497
(Croatia)	PS	PS	-	3%	4.1	91%	2.6 (25%)
(Turkey)	PS	PS	PS	1.5%	n.d.	67%	n.d. (50%)

Legend: S Subsidized; GC Public compulsory partially subsidized; P Private non-subsidized; GF Public free; PS Private partially subsidized; # Pilot experience; G Public non-subsidized; GS Public partially subsidized; - Not existing; n.d. No data

Notes:

*) Loss ratio is computed only for a small part of hail insurance

**) Livestock only

***) a national programme in Slovenia for subsidies insurance in 2006 for the first time (30-50%)

Source: EC, 2008 with authors own calculations

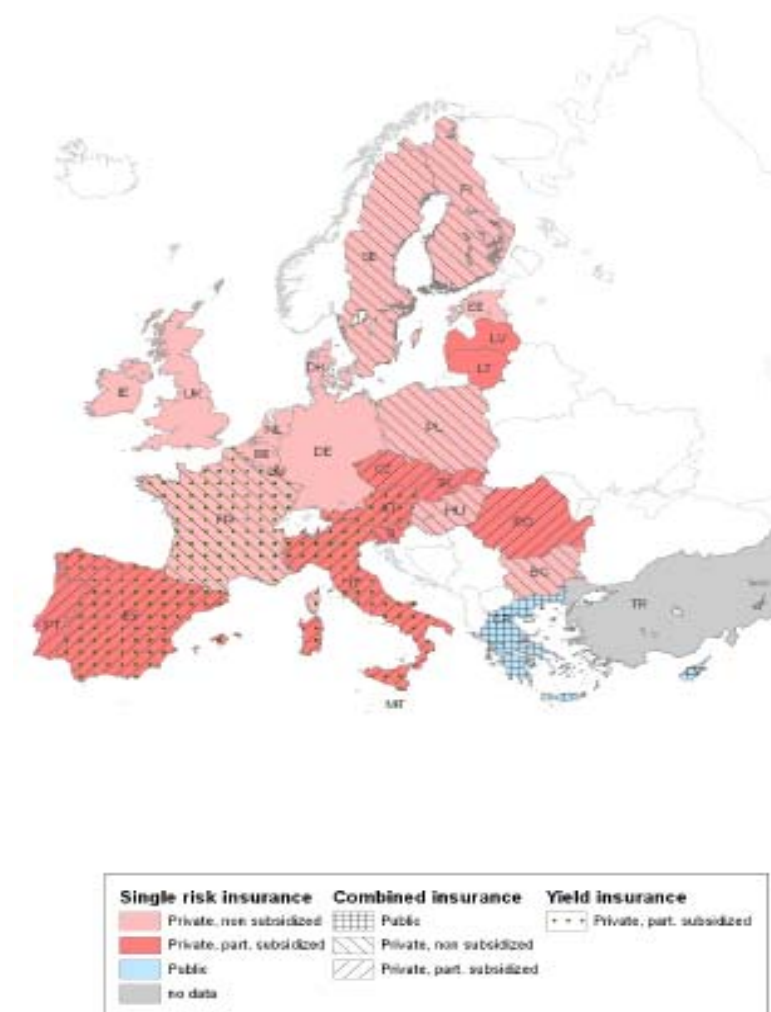


Figure 36: Agricultural insurance systems in Europe

In what follows we briefly describe the agricultural insurance systems in five selected countries: Greece, Spain, France, the Netherlands and the UK, and contrast these systems with experience in the US. We choose these systems because they represent a cross section of experience in Europe.

13.2 Reviewing the systems

13.2.1 The Netherlands: moving from government compensation to state-backed agricultural insurance, single risk

In the Netherlands, both livestock and crop insurance, mainly against hail and precipitation, are available, but the existence of generous ad hoc government compensation limits penetration of private insurance for natural perils. Recently, the European Commission (EC) approved a state-backed crop insurance scheme for which the Dutch government provides a €50 million state guarantee to encourage insurers to enter the crop insurance market. It is hoped that this will eliminate state compensation on each individual case. The Dutch Government will also be allowed to subsidise crop insurance to encourage more insurance companies to offer services in this area.

13.2.2 Greece: public compulsory, combined agricultural insurance

In Greece, agricultural insurance against hail, drought (heat waves) and other natural perils is compulsory and operated by the public insurer, the Greece Hellenic Agricultural Insurance (ELGA), which adheres to regulations that specify the risks covered, the extent of the coverage, the loss evaluation and compensation, and the level of the (farmers') special insurance contribution. There is reportedly extensive insurance penetration. The Ministry of Agriculture acts as a reinsurer for very large losses, or the case in which ELGA cannot cover claims (which may be problematic given Greece's financial crisis). Premiums are not risk based, but subsidized by the government. There are deductibles, which limit this protection to a maximum 60%-75% (with very few exceptions).

13.2.3 Spain: private-public agricultural and yield insurance

Spain has one of the most advanced and elaborate agriculture insurance systems in the EU. Crop insurance has developed significantly in Spain over the last 30 years to the current private-public agriculture insurance system which is greatly subsidized by the government. The Spanish point of view is that the cost of subsidizing insurance premiums can be less costly than emergency relief payments following a disaster. This will be the case for any subsidized system, depending of course on the amount of government relief, since the farmer takes partial responsibility. In the event that public funds are provided for drought relief, farmers who opted to not buy crop insurance when it was available are not eligible for government funds for relief, a strong disincentive not to purchase insurance! Insurance penetration is over 25%, and coverage is close to 45% for all the agricultural production (and above 70% for winter cereals and fruits).

While agricultural insurance for natural perils is not compulsory or public (as in the case of property insurance) there is strong government involvement in the insurance pool (Agroseguro), which is protected by a national reinsurance company (Consortio de Compensación de Seguros) and involvement of global reinsurers. The policies are highly subsidized (over 40%), which means there is little relation of the premiums to the risks (the premium/loss ratio is around 6%).

13.2.4 France: Minimal subsidies, single and combined, yield insurance, no subsidies

In France, there is also government subsidization of insurance premiums (2.5%), which is low compared to other Mediterranean countries. Yet, the French government provides significantly greater ad-hoc aid or post-disaster support, €156 million per year on average over the 1996-2005 period compared to less than the € 5 million average per year for both Spain and Portugal (EC, 2006).

13.2.5 UK: minimal government support for agriculture

In a similar vein to property insurance, the UK does not have a national calamity fund to deal with losses to farmers from natural perils; however, it does occasionally award ad hoc aid after disasters strike. Although the UK has a well developed private insurance industry, weather insurance for crops

is extremely limited. There is, however, some uptake of indemnity-based hail insurance, but because the government does not provide any subsidies, many farmers find it too expensive (Morgan, 2011).

13.2.6 United States: highly subsidized private agricultural insurance

In the US, crop insurance is heavily subsidized by the federal government. It protects crops against losses due to adverse weather, fire, insects, disease, and wildlife. There are three main types of insurance (Morgan 2011):

- CAT coverage, which pays 55% of the established price of the commodity if more than 50% of the crop is lost. The Government pays for this cover, and farmers contribute a \$100 administrative fee for each crop.
- Yield-based coverage, which insures farmers against yield losses based on the production history of the farm.
- Revenue Insurance Plans, which provide either revenue protection or income protection, and which can also protect farmers against losses due to market fluctuations in commodity prices.

Critics point out that subsidized premiums in the US farm insurance program have weakened incentives to plant more robust crop varieties, or to move away from farming in high drought or flood risk areas (Skees, 2001). In the words of a US insurance expert:

If the intent is to improve the well-being of farmers, it may be preferable to give them direct monetary transfers than to subsidize insurance premiums. A particularly 'bad' subsidy is one that is proportional to the premium since the disincentive to change crop practices becomes greater as the risk (and premium) increases. Furthermore, given the political economy of subsidies, it is likely that any subsidy will benefit the larger farmers more than the smaller farmers (Jerry Skees, 2007).

14 Rating the systems with respect to their applicability, effectiveness, capacity, efficiency and equity

Below we discuss the systems as they rank on the five criteria, which are summarized in chapter 15.

14.1 Applicability across Europe

There is large diversity in agricultural insurance systems across Europe, and it is not clear that any one system is more applicable to other country contexts. We have ranked their applicability as "medium" with the exception of the UK, which we rank as "low". The reason is that a fully privatized system with low insurance penetration is likely not acceptable in other European countries.

14.2 Effectiveness for incentivizing adaptation

With the exception of the UK, none of the European systems described above equate premium to the risk (except to the extent that premiums differ across crops), although most programs incorporate deductibles. Nor are there accompanying programs to help farmers minimize their weather-related losses through diversification and other strategies. In sum, the systems lack strong incentives or necessary conditionality for promoting adaptation to climate change. With the exception of the UK, thus, we rank these systems as “low” on their effectiveness for incentivizing (and enabling) adaptation.

The low ranking is reinforced by the wide-scale practice of heavily subsidizing crop insurance systems.

In the previous section, we argued for layered insurance systems where responsibility would be proportional to the responsibility for reducing the risks. The same principle should apply to agricultural systems, for which arguably there is less collective responsibility for crop losses due to hail and windstorm than, say, for floods and droughts in which case the government can invest in defences and water reserves. In the latter cases, there is more justification for the government to absorb a part of the losses through subsidies, calamity funds and other means.

14.3 Capacity for providing a secure safety net

There is a great deal of variation throughout the different insurance systems surveyed with regard to their capacity for providing security by guaranteeing a reliable source of needed capital for post-disaster relief and recovery. In the Netherlands (ranked “high”), there is generous compensation as in France (ranked “high”), although limited subsidies and thus more limited insurance penetration in the latter. Greece enjoys substantial coverage due to mandatory cover as well as Spain with its well established public-private system. Yet, both of these systems may be jeopardized in the current financial crisis (thus ranked “medium”). In the US (ranked “high”), coverage is large also, due to generous premium subsidies. Only in the UK (ranked “low”) are farmers more insecure due to more limited private insurance cover and government post-disaster assistance.

Subsidies are a concern for agricultural insurance programs, not only because of mis-placed incentives caused by market distortions, but also because many governments cannot afford to facilitate income transfers given the large segments of the population often engaged in farming.

14.4 Efficiency

There is little information available on the operating costs of the selected systems (thus ranked as in Table 45).

14.5 Equity

The rationale behind subsidies has often been to support vulnerable farmers and thus equity in the economy (thus systems with subsidies are ranked “high” in Table 47). Exceptionally, we ranked the highly subsidized US crop insurance system as “low” on this criterion. In the US, subsidies range from 40 to 60% of premium, which not only keeps farmers in high-risk production but also gives greater financial advantages to those with higher premium, meaning higher risk, practices, which may be considered inequitable. European systems also have massive subsidies, many by as much as 50% or more (Austria, Cyprus, Italy, Czech Republic, Lithuania, Portugal, Romania, Slovakia, Turkey).

This discussion on subsidies brings to the fore the inevitable trade-off between the efficiency of actuarial premiums and the equity of providing affordable insurance to low-income, high-risk farms. This is especially acute in many European countries with concerns that there will be massive flight from farm populations to urban areas, thus neglecting the rural landscapes. As with property insurance, there are many alternative ways to support farmers (for example, in Austria by paying fees for maintaining landscapes) besides subsidizing insurance and crop prices.

15 Summary and policy options

15.1 Summary

This discussion highlights the variety of national insurance arrangements addressing weather related risks to agriculture. The rankings (by the research team) of the selected five national systems across selected criteria are summarized in Table 45 with more detail in the Annex. The lessons that can be drawn from the analysis include:

- No system ranks consistently high on all criteria – there is no “best” national insurance arrangement;
- All systems appear to have sufficient capacity for providing needed post-disaster capital and financing the needs of the most vulnerable. A possible exception is the UK, where farmers have little insurance and cannot expect significant public support. The strong government involvement in Greece and Spain may also present an insecurity in the current financial environment;
- There has been little discussion of differentiated risk-based pricing mainly because, with few exceptions, the systems are highly subsidized;
- If systems move towards risk-based pricing with the elimination of subsidies, they confront the efficiency-equity trade-off (higher incentives for risk reduction vs affordability of insurance for the most vulnerable).

Table 45: Assessing current national crop insurance arrangements according to key criteria*

Country/Criteria	Risk	Insured Risk	Capacity for providing a reliable safety net	Applicability to other national contexts	Effectiveness for incentivising adaptation	Efficiency	Equity
The Netherlands From government compensation to state-backed agricultural insurance	Low	Low	High	Medium	Low	na	High
Greece Public compulsory agricultural insurance	High	High	Medium	Medium	Low	na	High
Spain Subsidized government-backed agricultural insurance	High	High	Medium	Medium	Low	na	High
UK Private insurance with ad hoc government assistance			Low	Low	medium	na	Medium
US Subsidized private agricultural insurance	High	High	High	Medium	Low	na	High
France Minimal subsidies, but large ad hoc aid	High	Low	Low	Medium	Low	Medium	High

*Note: Criteria ranking is based on subjective judgment by the research team.

15.2 Policy options

The design of agricultural insurance systems is in flux. There are many options: The multi-peril, multi-crop compulsory systems of Spain and Greece appear to have more comprehensive cover than many other countries, and eliminate the need for calamity funds; yet, some would object to requiring farmers to insure. Many observers argue for the need to eliminate or reduce the high subsidies and to substitute other forms of support for farmers. Others see a need to reduce post-disaster government assistance, or to grant partial assistance only to those who have part of their losses covered by insurance.

Tested options include low-cost government capital backups to reduce reinsurance costs, post-disaster lending to insurance programmes or elimination or reduction of taxes on insurer reserves (this was practised until recently in the UK and Germany). There are also novel ideas. Picard's (2008) suggestion that a central authority provide tax cuts on insurance contracts for those facing high prevention costs can apply as well to agricultural insurance.

There are also options for coupling agricultural insurance systems with mitigation, many of which are similar to the options discussed above for coupling property insurance with mitigation. These include:

- Differentiated risk-based pricing, premium discounts to award risk-reducing behaviour, and elimination of subsidies;
- Participation of insurers in farmer cooperatives and public policy processes that advise and regulate for risk reduction;
- Conditional insurance contracts with “must do” clauses for risk mitigation
- Tax reductions for risk-based insurance contracts;
- Index-based insurance.

These options are discussed further in Section 4.

16 Insuring and pooling public assets and government relief expenditure

Governments usually have responsibility for a large portfolio of public infrastructure assets that are at risk to natural disasters, and in addition they are typically obligated to provide post-disaster emergency relief and assistance to affected households and businesses. Reconstruction and relief expenditures can have large scale repercussions on a government’s fiscal position (Mechler, 2004).

European countries finance their post-disaster expenses from reserve funds, by diverting from their budgets, and borrowing internally and externally. In theory, there is little rationale for most European governments to insure their public infrastructure risks. This is the result of a well-known theorem by Arrow and Lind (1970), who give two reasons for the risk neutrality of the public sector: If the government shares its risk over its citizens (most usually by means of taxation), the expected and actual loss to each individual taxpayer is minimal due to the sheer size of the population. Moreover, a government’s relative losses from disasters in comparison with its assets may be small if the government manages to pool assets and thus own a large and diversified portfolio of independent assets.

Neither of these reasons may apply to small, low-income and highly exposed countries that have over-stretched tax bases and highly correlated infrastructure risks (Mechler, 2004). Even high income countries can face financing constraints, for example, after the 2002 floods in Austria, the government raised funds by diverting from other planned expenditures. In this case, it was funds targeted for purchasing fighter jets, which raised controversy contributing to the collapse of the coalition government.

As an alternative to traditional post-disaster loss financing, some governments have purchased insurance, including states in the U.S., Canada and Australia. Another option, explained in the following section, is to issue a catastrophe bond as a way of hedging infrastructure risks. Governments can reduce their costs of purchasing insurance by forming regional intergovernmental risk pools, an option that has recently been applied in Central Europe. A super-national fund, such as the European Union Solidarity Fund (EUSF), is another route to ensure sufficient funding to national governments. The relation of these instruments to other financing alternatives is shown in the table below.

Table 46: Pre- and post-disaster loss and risk financing arrangements for governments

	Mechanism	Governments: Relief and reconstruction expenditure
Post -disaster (ex post) loss financing	Market and non- market	Taxes, diversions, loans from international financial institutions, aid
Pre-disaster (ex ante) arrangement: risk financing	Non-market	Reserve funds (e.g., the EUSF)
	Risk transfer: Risk pooling and sharing	Insurance, catastrophe bonds, risk pools

In what follows, we describe the Mexican catastrophe bond, recent pools of sovereign risk in the Caribbean and central European countries and the EUSF.

16.1 Sovereign insurance in Mexico using insurance and catastrophe bonds

In 2006, the Mexican government chose to insure its catastrophe reserve fund, FONDEN, against major earthquakes with a mix of reinsurance and a catastrophe bond. The resulting contract is linked to a parametric trigger in terms of magnitude and depth of seismicity for the three-year period 2007-09. The major reinsurance company, Swiss Re, issued the bond, which pays an interest of 230 basis points if payment is not triggered. An insurance claim payment is triggered if:

- an earthquake with specified magnitude and depth is recorded with its epicentre located in one of the specified zones; and if
- there is official declaration of a disaster by a federal agency.
- Three regions in Mexico considered at highest risk were thus financially protected (Cardenas, et al., 2007).

Countries in Europe anticipating difficulties in financing projected risks could consider traditional insurance or, like Mexico, transferring their risks directly to investors through catastrophe bonds. These instruments are applicable across Europe (and thus ranked “high” on *applicability* as noted in Table 47), but the challenge is linking them with risk reduction. The parametric nature of the Mexican transactions moves in this direction because the government will retain a strong incentive to reduce risks (ranked “high” on *effectiveness for incentivising adaptation*). The catastrophe bond, however, was more costly than anticipated to issue because of the high costs of estimating risks, rating the bond, and so on (Cardenas, et al., 2007), thus ranked “medium” on the criterion of *efficiency*. Catastrophe bonds are very effective in increasing capacity (ranked “high”) since they tap into international capital markets.

16.2 Sovereign insurance using weather derivatives: The Ethiopian case

The World Food Programme, on behalf of the Ethiopian government, designed a weather derivative to provide extra capital in the case of extreme drought, the amount being based on contractually specified catastrophic shortfalls in precipitation measured in terms of the Ethiopia Drought Index (EDI). Rainfall data is taken from 26 weather stations representing the various agricultural areas of Ethiopia. If a specifically designed crop water-stress index rises above a pre-specified level, which given past observations would lead to large scale drought and crop loss, a pay-out is triggered. In 2006, WFP successfully obtained an insurance contract based on the EDI through AXA Re, a Paris-based reinsurer (Wiseman and Hess, 2007).

As discussed in section 3.2.3.2, there may be applications for parametric insurance schemes in Europe for individual farmers, and governments might also consider hedging their liabilities (ranked “medium” on *applicability* in table 47). It is unlikely however that a parametric contract, even in the absence of moral hazard, will incentivize government risk reducing investments (ranked “low” on this criterion), but it could increase capacity of governments to respond to major disasters (ranked “high” on *capacity*). If issued through major insurance companies, one must count on insurers’ fees and loading (ranked “medium” on *efficiency*).

16.3 Regional pools

The Caribbean Catastrophe Risk Insurance Facility

Large countries have the advantage that insurance contracts can be spatially diversified, therefore insurers can minimize systemic risk. This may explain why national public programs are found mainly in large countries like France, Spain and the United States (The Hungarian government underwrites risks, but with only limited cover). Small country operators will need to either diversify their portfolio outside the country or engage in insurance, catastrophe bonds and other risk-transfer instruments. This raises the cost of insurance and the premiums. This was the situation of the Caribbean Island States, which have recently formed the world’s first multi-country catastrophe insurance pool, reinsured in the capital markets, to provide governments with immediate liquidity in the aftermath of hurricanes or earthquakes. By pooling their risks, the Caribbean governments have significantly lowered their reinsurance costs.

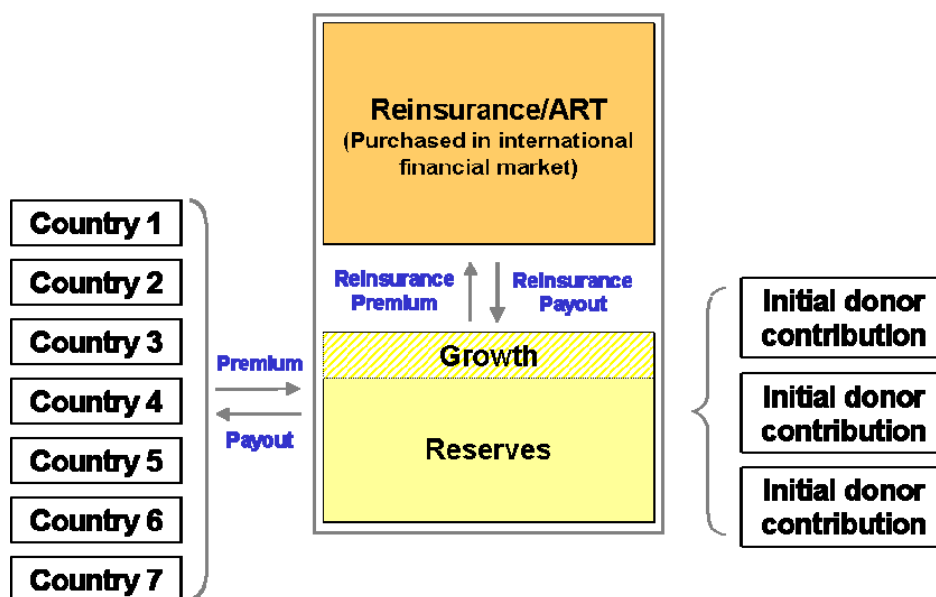


Figure 37: Structure of the CCRIF

Source: Matalon, 2005

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) went into operation in June 2007 with the participation of 16 Caribbean countries, whose governments contributed resources ranging from US\$ 200 thousand to US\$ 4 million depending on the exposure of their specific country to earthquakes and hurricanes. This better-diversified portfolio is expected to result in a substantial reduction in premium cost of about 45 – 50% for the participating countries. The fund covers up to 20% of the estimated loss, and claims will be paid depending on an index for hurricanes (wind speed) and earthquakes (ground shaking). Initial funding by donor organizations provided support for start-up costs and helped capitalize the pool. The facility will transfer the risks it cannot retain to the international financial markets through reinsurance or through other financial instruments (for example, catastrophe bonds). The accumulation of reserves over time should lessen the facility's dependence on outside risk transfer. Should the total insured losses exceed its claims-paying capacity, payouts will be pro-rated based on the total amount of expected claims compared to the remaining available funds. In addition, donors are adding to the reserves.

Southeastern and Central Europe Catastrophe Risk Insurance Facility (Europe RE)

Many European governments also face huge systemic risks with little diversification within or outside their borders. As a case in point, the Romanian floods of 2010 covered a large part of the Romanian territory, and insurers (public or private) need be prepared for very large payouts necessitating expensive risk-transfer instruments. A recent study by Mechler et al. (2010) found that flood disasters can pose substantial liabilities to Eastern European countries including the four countries discussed here, and thus present "hidden disasters deficits" (Figure 38).

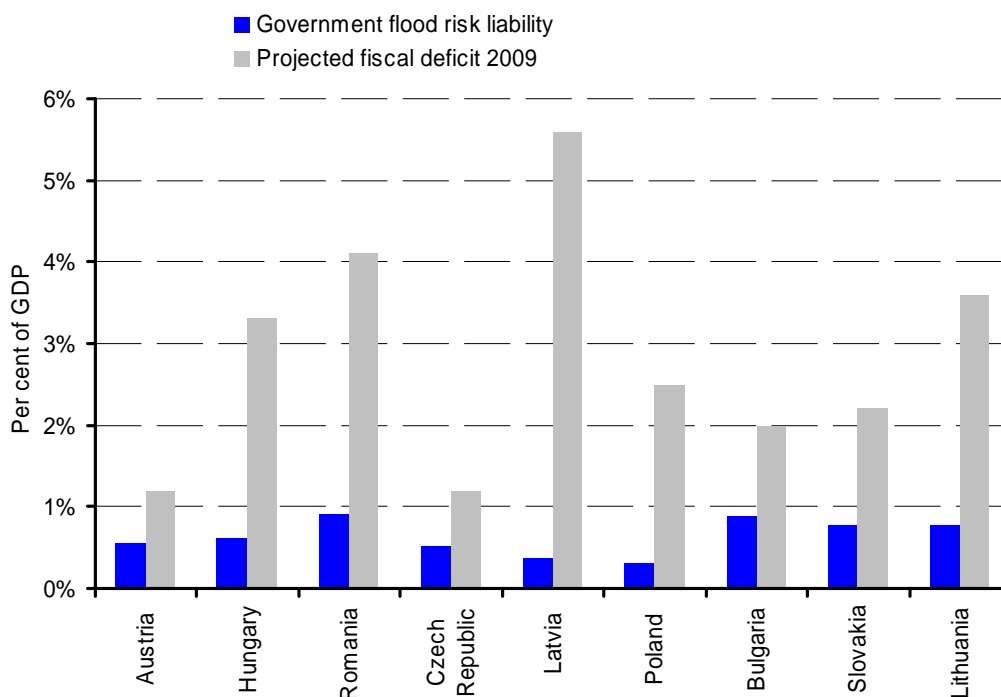


Figure 38: Governments' fiscal deficits and disaster risk liabilities in selected flood-prone European countries. Source: Mechler et al. (2010)

Following the CCRIF model, for the heavily exposed countries of Poland, Czech Republic, Hungary and Slovakia, concrete proposals have been made to tackle the flood exposures of Central European countries by way of an efficient financial and risk transfer mechanisms to mitigate fiscal losses from natural catastrophes. The proposed structure including the EUSF would look as follows.

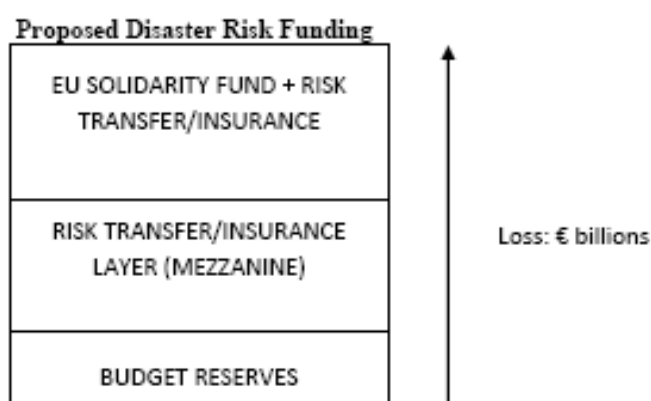


Figure 39: Proposed structure for sovereign insurance pool for Eastern Europe

Source: World Bank, 2011

The idea is to self-insure with budget reserves (i.e. taxes that thus share risks) for lower to medium losses and the respective layer; for the higher loss layer, called “mezzanine” here, that surpasses the ability of the country to respond with fiscal and other resources, sovereign risk transfer may be an option. Then, for the high loss layer with high insurance premiums, ex post support by the EUSF or additional risk transfer may be considered up to a point where premiums become prohibitive.

As already demonstrated, regional pools are applicable across different contexts and relevant for Europe (ranked “high” on *applicability* in Table 47). It would be possible to build in conditions relating to adaptation that countries would be required to meet for membership in pools, but such conditionalities have not been demonstrated (ranked “medium” on *effectiveness for incentivizing adaptation*). By decreasing reinsurance costs, they rank “high” on *efficiency*, and if lower-income countries are included in the pool (e.g., Haiti in the CCRIF) with external support, they can be an effective regional solidarity instrument (ranked “high” on *equity*).

The EU Solidarity Fund as a loss financing arrangement

Recognising that floods and other disasters may overburden national governments and necessitate international assistance even in Europe, the EU Solidarity Fund (EUSF) was created after the floods in central Europe in summer 2002 (EUFR, 2004).³³ The stated purpose of the EUSF is “to show practical solidarity with Member States and candidate countries by granting exceptional financial aid if these were the victims of disasters of such unusual proportions [...] that their own capacity to face up to them reaches to their limits” (Commission Report, 2004, p. 25). The Fund can be called upon to cover non-insurable damages, such as public expenses for restoring public infrastructure, providing services for relief and clean up, and protecting cultural heritage.

The fund provides financial aid for emergency measures in the event of a natural disaster causing direct damages above 3 billion Euros (at 2002 prices) or 0.6 percent of the GNI (Council Regulation, 2002). Fund support can be mobilized even if the threshold is not met, e.g. for a neighbouring country that is affected by the same major natural disaster or for extraordinary regional disasters which affect the majority of the population of a region and have serious effects on its economic stability and living conditions.

The payments from the Fund are limited to finance operations undertaken by the public authorities alleviating non-insurable damages (e.g. restoring infrastructure operation) (Council Regulation, 2002). The European Commission decides the amount of aid and proposes its mobilization. The maximum annual budget is 1 billion Euros per year (EUFR, 2004). The amount annually available for extraordinary regional disasters is limited to 7.5 percent of the EUSF’s annual budget (Council Regulation, 2002). However, the actual amount varies from year to year, depending on the occurrence of disasters.

Since its creation, almost all EU countries have asked for support from the Fund, and many have received assistance. In 2002 and 2003 after large scale flooding in central Europe, the fund was nearly depleted in the middle of the year. In relative terms, the support granted through the EUSF is

³³ More detail on the solidarity fund and its viability, legitimacy and efficiency can be found in the Hochrainer, Linnerooth-Bayer and Mechler (2010).

still small compared to the damages incurred; for example, Austria received 134 million Euro for financing flood losses in 2002 compared to a total direct damage of 2,900 million Euro.

In a recent paper the authors query whether the Fund has met its stated purpose of providing solidarity within the EU, whether it is sufficiently capitalized and if it promotes disaster risk reduction or adaptation (Hochrainer et al. 2010). Based on this analysis, Table 47 shows the rankings which we discuss in more detail below.

16.3.1 Effectiveness for incentivizing adaptation

In setting up the EUSF, the European Commission recognized the dangers of moral hazard if governments take on less preventive measures because they can rely on post-disaster support from the EU. Absent a price signal, incentives for reducing risks are low. This could be remedied by conditionality clauses. For example, while the Commission will (in principle) consider requests to the EUSF following droughts, it has requested provisions to check that appropriate water and drought management plans have been implemented (EC, 2007) in order to control for moral hazard.

16.3.2 Capacity for providing a reliable safety net

Clearly, the *raison d'être* of the EUSF is to provide capacity across Europe to assure a reliable safety net. A problem in meeting this criterion, especially in light of climate change, is the risk of depleted capital of the EUSF threatening its capacity to provide a reliable back up system. By design, the EUSF cannot experience a liquidity deficit since there is no obligation to grant funding for applications once the capital of the Fund is depleted. Yet, politically it will be difficult to turn down applications because of lack of liquidity, especially if a series of major disasters occurs during the year. The adequacy of the Fund's capitalization is particularly relevant given recent efforts to lower the threshold criteria and expand its scope to cover additional threats.

Based on models of flood risks across Europe, Hochrainer, et al. (2010) assessed the risk that the liabilities of the Fund exceed its €1 billion annual commitment. The model results show that floods, alone, impose a high risk of depleting the EUSF's capital. In the most likely case, there is an annual probability of 8 percent that the payment will exceed the Fund's capacity of €1 billion, meaning that the EUSF has an expected shortfall every 12 years on average. Damage due to the projected climate change is expected to increase significantly – this will further reduce capacity of the EUSF. The risk would be far higher if all hazards were included. Because of the risk of too little capacity, yet recognizing that the EUSF does increase national capacity overall, we have awarded a ranking of “medium” to this criterion.

16.3.3 Efficiency

The costs of administering the EUSF have not been assessed, so it is difficult to analyze its efficiency. In principle, a centrally administered fund will have the costs of administration plus the opportunity cost of holding large amounts of capital.

The EU Commission also seems to have recognized the risk that the Solidarity Fund crowds out private insurance, which would explain the inclusion of the important provision that EUSF assistance should only cover non-insurable damages. Most risks covered by the EUSF, however, are insurable. The practice thus deviates from the principles on which the Fund was established. As noted earlier, governments can insure their post-disaster liabilities through commercial reinsurers or by issuing catastrophe bonds.

16.3.4 Equity

The EUSF was created to promote cohesion (solidarity) in the European Union and reduce economic disparities by providing support to country governments that find it difficult to cope with the destruction of major disasters. Yet, the short history of the Fund shows that those countries least able to cope, including mainly eastern European countries, have received less assistance as a percentage of their eligible losses during this period than their western European counterparts, and the number of days from application to grant decision has been significantly higher as well. This conclusion is based on an analysis of three countries (Austria, Hungary and Romania), which shows that Austria, and probably other wealthy European countries, qualifies for aid at levels for which it can easily cope (this means that the threshold levels are set too low for wealthy countries). This appears to violate the principle of cohesion upon which the EUSF is built, and we have ranked the EUSF as “medium” on the *equity* criterion.

16.4 Summary and policy options

16.4.1 Summary

Table 47 summarizes the criteria for assessing sovereign insurance instruments and other financing arrangements as they apply to government liabilities.

Table 47: Assessing sovereign loss and risk financing arrangements according to key criteria*

Country/Criteria*	Risk	Uninsured Risk	Applicability to other national contexts	Effectiveness for incentivising adaptation	Capacity for sharing an increasing loss burden	Efficiency	Equity
Mexico ³⁴ Sovereign risk transfer	High	High	High	High	High	Medium	na
Ethiopia	High	High	Medium	Low	High	Medium	na

³⁴ As mentioned, disaster risks in Mexico are high, and the level of insurance low.

weather derivative							
CCRIF/Eastern Europe Catastrophe insurance pool	High	High	High	Medium	High	High	High
EUSF	Medium	Medium	na	Low	medium	na	Medium

*Note: Criteria ranking is based on subjective judgment by the research team.

16.4.2 Policy options

There is little experience in Europe with sovereign risk transfer, weather derivatives or catastrophe pools, and for many countries these instruments will not be necessary. Still, given the high exposure (hot spots) in Europe and the fragility of the budgets in some member countries, it may be useful to explore the relevance of these instruments. The Central European risk pool is an interesting development in this direction and should be closely analysed.

The EUSF presents an opportunity for reform in such a way that it creates the intended solidarity in Europe and at the same time contributes to risk reduction and adaptation. Hochrainer et al. (2010) have proposed that the Fund be reoriented from post-disaster response and aid instrument to a pre-disaster, (differential) risk-based solidarity instrument. In this changed capacity, it could take the form of a pre-disaster insurance pool, providing backup to government that choose to insure public infrastructure, cultural heritage sites, clean up and other relief expenditures.

As well, the EUSF might be re-oriented to support public and private insurance systems that cover private-sector losses by, among other possible activities, providing support for regional insurance pools and making available needed capitalization. The multi-hazard, state-backed insurance systems in France and Spain (and planned for Italy and Romania), for which the government serves as a reinsurer for very high-loss events, could serve as a model for the EU solidarity Fund, which would support governments by providing an additional layer of reinsurance cover at no cost. The current fragility of the Greek and Spain fiscal situation, and their extensive obligations to back the public insurance systems, illustrate the value of an EU backup mechanism. In this way, solidarity is granted before disasters occur. There are many advantages, including:

- The provision of public reinsurance helps make insurance premiums affordable to low-income property owners and in this way promotes solidarity;
- Since private insurers are reluctant to provide cover for very rare, extremely high consequence events, EU backing ensures private-sector participation in the schemes;
- Placing even partial responsibility on property owners as an alternative to post-disaster assistance will increase the costs of locating in hazardous areas and engaging in other types of hazardous behaviour;
- Finally, EU reinsurance has advantages over national government reinsurance in that it spreads or diversifies risks across the larger European economy.

Task 4: Summary of findings and policy options

In the following we present a summary of our evaluation results as well as policy options. The summary enables a comparison of the selected instruments regarding the criteria like efficiency or institutional feasibility discussed in chapters 2 and 3 above but also in terms of sector specific applicability. Based on this comparison and further results from Tasks 2 and 3 we will in the following present policy options, separately for each of the instruments that were selected for Tasks 2 and 3.

Except for the RFIs, it became apparent during the evaluation of the economic instruments that it is not possible at this stage to provide an in-depth analysis that considers the specifics of all EU Member States and all sectors and sub-sectors. The scope of the study only allows general findings and the identification of policy options, and one needs to have in mind that in some countries the position might be different. Still, the results presented below provide a good guide to the overall potential of the assessed economic instruments for promoting adaptation activities and risk sharing. It is different for the RFIs and insurance; a wealth of knowledge exists at the MS level and elsewhere, which was critically examined in detail for this study and informed the policy options described below.

1 Summary of evaluation of market based instruments to promote adaptation

In a first step towards our policy options we present a summary of findings of the evaluation of all the instruments in a tabular form. The first table describes the outcome of all the evaluation criteria except the sector specific applicability. The latter is presented in the second table. Regarding the qualitative evaluation results, the term “High” usually expresses a positive outcome or good performance whereas “Low” usually stands for suboptimal outcome or performance. However there are three exceptions, which are indicated in the first column. Based on the comparison in the table, a qualitative description of advantages and disadvantages of the instruments follows. This provides the basis of our policy options in the next chapter.

1.1 Comparison: General characteristics of market based instruments

Table 48: Overview of general evaluation results of market based economic instruments

	Subsidies		Taxes	Licences, permits	Other MBIs		FIs	
	Grants	Tax reductions	Land use taxes and fees	AMM	PES	Water pricing	Loans	Guarantees
General applicability to incentivize adaptation ³⁵	Medium	Medium	Low	High	Low - Medium	Low - Medium	Medium	Low
Institutional feasibility	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium
Consistency with other instruments	High	High	Medium	Medium	Low to medium	High	High	Medium to high
Acceptability to interest groups	High	High	Medium	Medium ¹	High	Low	High	Medium
Little resource requirements (Low = positive)	High	High	Low	Low to high ³⁶	High	Low	Medium to low	Low
Transaction costs (Low = positive)	High	High	Medium	Medium to high	High	Medium	Low	Low
Equity (Distribution)	High	High	Medium	Medium	High	Medium	High	High

³⁵ This criterion reflects the broad applicability of the instrument as described in Table 50. If the EI is applicable in many sectors it receives a "high" grade, vice versa a "low" one.

³⁶ Depends on demand system

	Subsidies		Taxes	Licences, permits	Other MBIs		FIs	
	Grants	Tax reductions	Land use taxes and fees	AMM	PES	Water pricing	Loans	Guarantees
Overall consequences	Medium	Medium	Low	Medium to high	Medium	High	Medium	Medium
Conditions and barriers (Low = positive)	Medium	Medium	Low	Medium to high	Medium	High	Medium	Medium

Scale: From High for very applicable and relevant to n.a. not applicable/relevant at all

The general evaluation of the EIs shows a mixed result. None of the instruments has positive characteristics only. It is rather a broad picture of strengths and weaknesses that emerges from this comparison. Interestingly none of the MBIs has a low performance regarding institutional feasibility and equity; all the instruments have been evaluated as able to manage these issues. Rather negative results are to be found for the important criterion of “little resource requirements for using the EI”, as many instruments need considerable financial resources for their operation. This should be reflected on by the EC before taking decisions on implementation. The MBIs that have overall the most positive performance values are land use taxes and fees, the AMM as well as loans and guarantees. However, if an instrument is not able to trigger additional adaptation activities in certain sectors, the advantage of good marks in other (or even all other) categories can at least partially compensate for that. This is true e.g. for loans, guarantees and water pricing. For instance the latter is generally assessed as a very effective instrument for specific sectors but cannot be applied at all in others. Therefore the ability to address appropriate target sectors has to be considered as well and is described in the following table.

1.2 General characteristics of risk financing instruments

All the RFIs examined are considered generally highly applicable for adaptation as they all price risk, thus deal explicitly with the potential impacts. Saying that, the incentive effect, while theoretically large, is often rather weak in practice for many reasons. Also, where RFIs are used to finance and transfer public sector and business sector risk, the incentive effect is low to medium, as the climatic risk is often given less attention than, say, fire and explosion. The efficiency of the RFIs depends very much on their actual implementation, but generally can be considered medium to high, as risks are priced and traded (transferred). The equity of the RFIs is a contentious subject, but we argue that equity in terms of distributional outcomes is low to medium for the RFIs as they price risk and assign the burdens to those potentially affected. This equity-efficiency trade-off is the key defining aspect

for the evaluation of instruments in Task 3, and we find that there is no single best solution for any of the instruments.

Table 49: Assessment for the RFI categories

Instrument	Property and goods insurance	Agricultural insurance	Sovereign insurance	Sovereign risk pools	Weather derivatives	Catastrophe bonds
Applicability	High	High	High	High	High	High
Effectiveness for incentivising physical adaptation	Medium-High	Medium-High	Medium	Medium	Low-medium	Low-medium
Efficiency	Medium – High	Medium-High	Medium-High	Medium-High	Medium-High	Medium-High
Distributional aspects	Low-medium	Low-medium	n.a.	n.a.	n.a.	n.a.

1.3 Comparison: Applicability and effectiveness of economic instruments by sector

Table 50: Overview of market-based economic instruments and their applicability/effectiveness by policy sector

	Subsidies		Taxes	Licenses, permits	Other MBIs		Financial instruments		RFI
	Grants	Tax reductions	Land use taxes & fees	AMM	PES	Water pricing	Loans	Guarantees	
Production Systems (= Industry)	Medium	High	Low	Medium	Low	Low	Low to medium	n.a. to medium	High
Physical infrastructure (public)	Low	Low	Low	High	Low	n.a.	Low to high	Medium	High
Physical infrastructure (private)	High	High	Low	Medium	Low	Low	Low	Low	High
Health and social policies	Low (social policies) to high (health policies)	Low (social policies) to medium (health policies)	Low	High (health); n.a. (social)	Low	n.a.	Low to medium	Low	Low
Agriculture & forests	Medium	Medium	Medium	Medium	Medium	High	Medium to high	Medium to high	Medium
Biodiversity, ecosystems, water	Medium	Low	High	Low to medium	High	High	Low to high	Low to medium	Low

	Subsidies		Taxes	Licenses, permits	Other MBIs		Financial instruments		
Coastal and maritime areas	Low	Low	n.a.	Low to medium	Medium	Low	Low to high	Low to medium	Low

Scale: From High for very applicable and relevant to n.a. not applicable/relevant at all

The sector specific comparison reveals substantial strengths for the individual instruments. None of the EI's has medium to high effectiveness results in all sectors. Most of the MBIs rather address certain sectors. For instance water pricing is not applicable for several sectors at all but shows high potential to address ecosystems, biodiversity, agriculture, forests and obviously water. The economic instruments that have the largest potential for application across sectors are grants, tax reductions and the specifically designed AMM.

While grants are direct subsidies, tax reductions are indirect subsidies. Both are by definition well suited to set incentives for economic agents because they face lower costs for the implementation of any action. However, they require scarce governmental resources and their optimal allocation is difficult. Besides, they might induce rent-seeking and they are only justified if the adaptive measure in question exhibits positive externalities. Taxes in the context of adaptation should only be implemented if an adaptation measure will be incentivized and if non-adaptation has negative externalities. According to our analysis, only land use taxes seem to make sense in this regard. The necessary size is as yet undetermined but first results point to the necessity for rather large tax rates in order to significantly avoid, for example, soil sealing via land use taxes. Although land use taxes do not get bad scores in any of our assessment categories, they can only be used in a few (environmentally related) sectors. Contrary to this, grants and tax reductions get some poor scores in the assessment but they are able to address sectors which other instruments cannot deal with (like private infrastructure and production systems).

The AMM is not just applicable in social policies as we also detected at least medium effects in all other sectors. It also has the potential to target health effects as it especially focuses on protection of human health through the concept of DALYs (see also chapter 2). None of the sectors is adversely affected by the MBIs, though the sector "social policies" does not achieve even a "medium" score anywhere. It is questionable if adaptation in social policies can be triggered through economic instruments at all. Interestingly the best covered sectors that might be positively addressed by several MBIs are "Agriculture and forestry" as well as "Biodiversity, ecosystems and water". RFIs target tangible impacts such as production systems (and consumer goods), public and private infrastructure, agriculture and impacts on coastal areas. Generally, for the RFIs a good quantitative estimate of what the impacts will be is necessary in order to price risk.

2 Policy options for the economic instruments

In the following sections we outline policy options for the application of selected economic instruments other than the RFIS. They are based on the comparison of the general evaluation criteria and set in context with other economic instruments. In some cases, we found that combinations of economic instruments might be very effective whereas the instruments themselves are not applicable or hardly so. General policy options for implementation in certain sectors are given, however further analysis on a country and sub-sector level is highly recommended as stated at the beginning of the chapter. Again, the situation is different for insurance, for which we develop detailed policy options later.

2.1 Grants and tax reductions

General comments:

Subsidies in direct (grants) or indirect (tax reductions) forms have great leverage in setting incentives to adapt as the costs of the underlying adaptive action are reduced. This instrument is warranted if positive externalities of the said action exist, justifying government intervention.

Policy options regarding sector applicability and effectiveness:

Grants and tax reductions are mainly suitable for the sectors production systems, private physical infrastructure and agriculture and forests. In these sectors it is most likely that sufficient externalities of adaptation exist. At the general level this study had to use, it was not possible to derive conclusions on the necessary size of the payments or reductions to induce adaptation. This strongly depends on the kind of measure, on the regional context and on the sector itself. Obviously the effectiveness rises with the amount paid or relieved, but this needs careful assessment because the relevant amount is determined by the value of the positive externality and not by the financial needs of a potential beneficiary.

Final policy options:

While grants and tax reductions are very applicable, their implementation needs very careful planning to avoid deadweight losses and windfall gains. At first sight, one could consider a reduction of goods taxes when production costs increase due to adaptation measures. The caveat here is that this adds to the complexity of the tax system. Grants can be handed out for a number of actions. The caveat here is how to choose the best alternatives given a limited amount of financial resources.

In summary, we nevertheless recommend using grants and tax reductions as sparingly as possible because they are prone to rent-seeking and persistent as soon as they are in place. However, if politically desired they could be directed towards the protection of private infrastructure and production facilities (enhancing their resilience towards weather related extreme events), the agricultural sector (crop use and irrigation methods) or health enhancing measures (construction of green areas or buildings in cities, environmentally friendly cooling of buildings).

To ensure an efficient use of public funds, grants could be provided through a competitive tender system prioritizing those activities that have high adaptive benefits. A grant programme of 100 million € with a duration of five years would allow for testing on an EU-wide scale; it could be financed by revenues from auctioning EU greenhouse gas emissions allowances.

2.2 Land use taxes

General comments:

Taxes in the understanding of this report serve the purpose of internalizing negative externalities, i.e. if an action has negative consequences and a different behaviour in terms of adaptation is desirable. Thus, taxes to promote adaptive behaviour always imply a policy of changing behaviour on purpose. In this report we were only able to come up with land use taxes as a potentially valuable tool. It is an open discussion whether other taxes might make sense.

Policy options regarding sector applicability and effectiveness:

The main goal of land use taxes is to reduce soil sealing in order to increase the resilience towards heavy precipitation and in order to reduce land use changes away from environmental use. In principle, we deem this possible but the potential size of the tax is as yet unclear. The scale depends on regional circumstances, the value of the land itself and of the use inducing the sealing of the soil, for example. Generally, this kind of tax can be applied to the sectors agriculture and forests and biodiversity, urban areas, etc. It does not address the other sector directly, but there may be small side-benefits to people's health if soil sealing indeed were reduced and this lead to a reduction of heat island effects in cities.

Final policy options:

Land use taxes could be an interesting instrument to promote adaptive behaviour in areas that are particularly vulnerable to climate change impacts. Their shortcomings are that they only address a few sectors and that the necessary size is very case-dependent. This makes implementation potentially difficult. However, in principle land use taxes are attractive as they generate revenues making the financing of other adaptation activities possible. In essence, they mainly make sense in an urban setting where soil sealing is a common problem: The heat island effect is exacerbated, water runs off more quickly and plants and animals are increasingly disadvantaged. However, the benefits of reduced soil sealing in this context are difficult to measure and the intensive use of urban land is often very attractive requiring very high tax rates to have any effects. This phenomenon is less likely in non-urban areas. But there the consequences of soil sealing are also felt, because they consist of lost ground for agricultural purposes or biodiversity losses, with both being again hard to measure. Nevertheless we recommend further (national and regional) investigation to find out whether land use taxes promote adaptation. The EU Commission may invite member states to engage in land tax pilots in particularly vulnerable areas.

2.3 Payment for Ecosystem Services

General comments:

Payment for Ecosystem Services (PES) is a (currently voluntary) transaction where a well-defined environmental service is being bought at least one buyer from at least one provider if that provider secures the provision of the service. This is a rather novel instrument increasingly used in developing and emerging countries to conserve nature and its services. Due to the multiple benefits of ecosystems, their conservation seems warranted and they have a number of co-benefits in the context of adaptation. The main idea is to make the provider of an environmental service at least indifferent between keeping up the service or using his land otherwise. Thus, PES can be interpreted as a subsidy to use land in a specific way, because this use is considered beneficial on societal grounds, i.e. it provides positive external effects.

Policy options regarding sector applicability and effectiveness:

The current applications of PES relate to forests, wetlands, and biodiversity and watershed protection. Accordingly, the sectors agriculture and forests and biodiversity etc. of the White Paper are addressed. PES is not applicable in other sectors but might have some indirect beneficial health effects. The effectiveness and size of a PES-scheme is case-dependent; the ecosystem service needs to be estimated and valued in monetary terms, a payment scheme needs to be implemented etc. Besides, the regional context plays an important role. Thus, also the (potential) effectiveness depends very much on the case at hand.

Final policy options:

PES offers an interesting option to set incentives to adapt indirectly. It has to be emphasized that ecosystems have multiple benefits of which adaptation is only one of an indirect character. It is possible that other benefits offer a better justification for implementing PES-schemes. Nevertheless, mainstreaming existing EU-programmes towards enabling PES and very importantly rechanneling funds from other uses are strongly advised. This assumes that the main obstacle in all PES-schemes is overcome, namely the potentially large transaction costs. Apart from those programmes already addressing environmentally sensitive areas one could especially look at cutting agricultural grants in favour of the implementation of PES-schemes. The potential schemes could be screened via an EU-wide competitive process with a given overall budget. This application process could result in a ranking of preferable ecosystem services worth conserving via EU-funds. Besides, forests and wetlands are key for the resilience of an area exposed to climate-related events, and PES could be introduced to maintain and protect the forest / wetland from conversion. This requires further studies to assess the resilience contribution by forest / wetland areas.

2.4 Water markets

General comments:

Water is already a scarce resource in some European regions and climate change is only going to exacerbate this situation. Adaptation to climate change with regard to water implies that the increasing gap between rising demand and decreasing supply has to be closed. In order to achieve this, water supply needs to be stabilized or enhanced by technical measures (e.g. rain harvesting). More importantly water demand and use has to be made more efficient. This can be done by technical measures, e.g. enhancing irrigation methods, or simply by behavioural measures, i.e. setting price signals to incentivize thrifty use. As water prices in most European countries are still below their efficient level, correct pricing of water itself can be considered a relevant adaptation measure. The empirical analysis shows that higher costs for water use have an immediate and sizeable effect on water use.

Policy options regarding sector applicability and effectiveness:

Generally, correct water pricing, either by implementing water markets, water trading or water taxes as a second best solution, can be an effective tool for adaptation in the regions where water scarcity is projected to increase due to climate change. In Europe those regions can be predominantly found in the South and South-East (Spain, Italy, Greece etc.), but in the future also the middle regions (France, Austria etc.) could be affected. However, this also implies that water markets address the sectors agriculture, forests, industry and households on the one hand and biodiversity, water and ecosystems on the other hand. It has no relevance in the other sectors. Its effectiveness depends very much on the circumstances; where no water markets exist and water is not priced or very cheap, the mere introduction of water markets can have sizeable effects in setting incentives to use water more sparingly. The proportion of production or household expenditure on water is also important. On the available evidence, water pricing will be most effective in the agricultural sector, because here water is more subsidized across Europe than in all other sectors.

Final policy options:

As the Water Framework Directive already states, efficient water pricing is crucial in setting incentives for thrifty use. Unfortunately, the challenges are manifold. Different sectors (agriculture, private households, industry) have to be addressed; all of them can react differently to price and cost changes, but the evidence mainly points to the agricultural sector as the most problematic, because agricultural water use is still heavily subsidized across Europe. Those subsidies should be removed as soon as possible, and consideration given to water taxes where water markets or water trading cannot be implemented. While water pricing usually lies in the hands of regional firms or authorities, it is advisable to encourage these actors to move towards more efficient water pricing. Though it is not the specific topic of this study, only EU-regulation may be able to bring about these behavioural changes. The revenues of water taxes could be used to promote water saving technologies. These measures are especially important in places like Southern Europe where future water scarcity due to climate change can be expected. There is currently much discussion in this area and a water pricing initiative could be embarked upon by the Commission and selected member states.

2.5 Adaptation Market Mechanism AMM

General comments:

Since the AMM has been specifically designed to promote adaptation activities, its major strength is a broad applicability and potentially high effectiveness and efficiency, with the latter two strongly depending on the final design of the instrument. Its open access enables all kinds of stakeholders to participate and identify cost-beneficial adaptation options and projects. The search function and inclusion of, in principle, “everyone” is a unique and particular positive feature of the instrument. An AMM guarantees transparency and, at least in theory, the most efficient outcome. Institutional feasibility and limitation of transaction costs require consideration, especially as the EU as a possible regulator would need to be impartial and uphold adaptation integrity.

Key questions are, first of all, the definition of demand. In this report we outlined several different options, such as the polluter pays principle or a tender model on EU or Member State level with the taxpayers as the likely funders of the mechanism. For the first option strong resistance can be expected from the emitters. The second challenging issue is the uncertainty of climate change projections which would be reflected in the calculations on which the AMM relies. However one has to acknowledge that such uncertainty will be a challenge to varying degrees for all instruments that allocate financial resources for ex-ante adaptation. One possibility to overcome this challenge is to allow working with proxies and standard factors or “risk zones”.

Policy options regarding sector applicability and effectiveness:

As mentioned the AMM is a highly applicable instrument to promote adaptation. It has at least medium applicability for all sectors with special strengths in promoting adaptation for public infrastructure and health policies. However one has to consider carefully the domestic context and overlaps with other policy instruments on a national and sub-sector level.

Final policy options:

As an AMM has not been applied yet, politicians and economists do not have the same level of experience about impacts and effects as for some of the more mature economic instruments. At the same time one has to consider that market mechanisms for public goods with broad accessibility like the carbon markets were almost unknown 15 years ago and currently they have been applied successfully in Europe and other countries. Hence one can build on those experiences to make use of the strengths of this mechanism, which are first of all efficiency and broad applicability. As the AMM addresses some sectors which are almost not tackled at all by other instruments, we recommend considering its application in one or several pilot schemes. As a first and simplified method to create demand for adaptation units we propose setting up a tender for acquisition of adaptation units on EU or Member State level. The appropriate starting sectors have been identified as public infrastructure and health. For the former, the EU might decide to commence with one tradable adaptation unit at first which would be property saved or property protected. Any company could submit projects whose adaptive effect would be evaluated according to methodologies specified in

the tender. Project documents would have to be audited by third parties accredited by the Commission. The projects would be ranked according to the price per adaptation unit until the total volume of adaptation units is reached. It would be necessary to consider if private property protection is eligible as well or if the mechanism would be restricted to public assets.

Additionally, the second proposed unit of DALYs could be introduced to expand the focus to human health.

To get a critical mass of experience, both pilots could have an underlying budget of at least 50 million € and run for five years, with a final evaluation after a decade. While a substantial share of payments should be made ex ante to enable project implementation, a significant share should be paid out over time after monitoring and verification of project performance. Building on the experience made in the pilot schemes the EU might finally consider widening the use of the AMM to other sectors and creating additional demand by involving private actors in financing the scheme.

2.6 Concessional Loans

General comments:

Loans with attractive interest rates are a typical instrument applied by the EU and its intermediaries like the EIB in many forms. The purpose is to support investors that do not have access to capital on the financial markets or face prohibitively high interest rates. However the instrument loan intrinsically requires the investors' wish to conduct adaptation activities. It has only restricted potential to promote further adaptation activities as only a few additional investors will be incentivized through attractive loans (low leverage). An advantage of loans is that the institutional feasibility including implementation and administration is considered high. Furthermore the amount of own resources needed is very low (restricted to loan defaults). However the EU would have to seriously consider the default risk as many adaptation projects will not directly create revenues that guarantee payback of the loans.

Policy options regarding sector applicability and effectiveness:

The study revealed that there are significant differences regarding the applicability and effectiveness of loans for private and public actors. Potential private borrowers are likely to be found in the agricultural and forestry as well as in some of the production sector. As typical projects we see e.g. investments in adaptation of irrigation systems or re-establishment assistance (see also the fact sheets in the Annex). Public interest in attractive loans for adaptation activities depend especially on the respective countries', regions' or municipalities' circumstances and financial ranking that determines the interest rates on the financial market. For public actors with a low financial credit rating the results show high applicability in the sectors public infrastructure, biodiversity, ecosystems, water and coastal or maritime areas. Typical project are e.g. flood defence measures.

Final policy options:

In the limited sectoral context described above, concessional loans seem to be a mature and effective option to enable adaptation activities. We see potential for this instrument especially for public actors and private entities in the agricultural sector. However applicability beyond these sectors is not likely without other measures. This is due to the fact that the incentive of attractive interest rates might not be strong enough for many actors to invest in adaptation to uncertain future climate change impacts. Additionally, activities that do not generate revenues face further investment barriers. Hence if the EU considers extending the use of loans, we propose combinations with other instruments, especially grants. The private sector in particular could be additionally incentivized through blended loans to e.g. trigger adaptation in the residential sector. This approach has been applied by EU and EIB in several cases. For instance the blended loans JASPERS, JASMINE or JEREMIE issued by DG REGIO are already in place. Furthermore blended loans have been implemented in adaptation as well as examples from e.g. Australia show. As an introduction we suggest that the EU considers offering loans for two or three target groups within the public infrastructure and private agriculture sector. As a pre-requirement, eligibility criteria for approval of the loan application might be published and the loans should be advertised. A local assessment of the effects of loans within the country/regional context is strongly recommended to avoid negative economic external effects like maladaptation or over-subsidization.

As a very concrete step, a window of e.g. 100 million € **concessional loans** with an interest rate of 2-3% below commercial rates could be offered by the EIB for two or three target groups within the public infrastructure and private agriculture sector, with a clear set of criteria focusing on effectiveness of projects.

2.7 Guarantees

General comments:

Generally guarantees exhibit similar advantages and challenges to loans. However on the one hand they are not as effective as loans, because only parts of the risk premiums of private lenders will be reduced. On the other hand the risk covered by the EU or its intermediaries might be lower compared to loans. A significant advantage of guarantees might be that they do not crowd out private lenders. Guarantees rather incentivize private players to spread their loan options towards adaptation as they can count on safe returns backed by EU/EIB guarantees. However a detailed assessment of these possible impacts cannot be provided without some experience.

Policy options regarding sector applicability and effectiveness:

As with loans, guarantees also target especially those sectors where private and public investors have known needs for adaptation already. Hence guarantees are likely to promote private agriculture or production systems and public investments in ecosystems, biodiversity, water, coastal or maritime areas and public infrastructure.

Final policy options

If the EU/EIB wants to keep private borrowers active in providing loans for adaptation, guarantees might be a suitable option. As the interest rates are likely to be higher than with the EIB-loan option described above, the effectiveness and efficiency of the instrument will be lower. Hence the EU might consider whether it prefers to have a lower administrative burden and less risk but also a less efficient and effective MBI when prioritizing guarantees over loans.

The 100 million € loan scheme suggested above could be coupled with an offer of loan guarantees by the EIB for loan volumes of up to 100 million €, applying the same criteria for projects. Both activities could be open for a period of five years and then be evaluated jointly.

3 Policy options for the risk financing instruments

We provide policy options for two aspects associated with risk financing: (i) options to improve the adaptive effectiveness of RFIs, and (ii) options for making markets and partnerships for risk financing work.

3.1 Options to improve the adaptive effectiveness of RFIs

In section 2.6.4, we identified four channels, through which RFIs may incentivize adaptation: (i) risk based pricing, (ii) risk reduction requirements; (iii) providing risk-relevant information and (iv) subrogation. Our review of the adaptation incentive function of insurance-related instruments identifies many barriers, such as risk ambiguity, lack of competition, short term contracts, inadequate government policy, uncertain benefits, non-competitive contract terms, high up front capital costs of risk reduction measures. This leads us to the conclusion that currently in practice the incentive effect is rather small. While price incentives have had some success for discouraging development in high-risk areas, insurers have shown little willingness to differentiate premiums for other adaptive measures arguing that monitoring and other transaction costs would be prohibitive. Moral hazard – i.e. the disincentive to embark on preventive adaptation due to the knowledge that losses are covered by insurance - exists at both the individual and collective levels, and any system of premiums that is not actuarially fair must necessarily have some adverse incentive effects. On the other hand, insurers do generally require specific standards of risk-resilience as a pre-requisite to providing cover, but often clients are resistant to incurring additional expenditure. They also provide risk-related information to their clients, but in practice this is often ineffective, since insurance customers do not always make good use of it. In terms of policy options to further incentivize adaptation we suggest the following key measures are considered, which often work through more than one of the channels and tackle several barriers at the same time.

Work with altered timescales

Currently the standard insurance contract length is one year. Insurance contracts could operate over longer time scales, including profit/loss calculation, which would reduce the uncertainty loading, and also ensure a more even flow of profit (and tax), and perhaps less reliance on the sometimes

unstable reinsurance market. Longer contracts would also encourage insurers to participate in risk reduction measures with their clients, and set more flexible premiums.

Provide improved information on risks and risk prevention measures

To overcome risk myopia, insurers could consider involving clients in active risk management through supporting community action groups, insurance intermediaries might become more actively involved in the communication and explanation of risk-relevant advice, and lenders could insist that assets purchased on credit are covered against natural hazards. In order to reduce the cost of providing such services, insurers can also collaborate with each other, or with other parties like the emergency services, to produce generic advice packages which spreads the cost. There are many examples of this by national insurance industry associations.

Reward risk reduction measures

As insurers do not reward risk-reducing behaviour because of their simplified rating procedures, and because often the client cannot modify the risk greatly without significant capital expenditure, solutions include the following:

Insurers could develop all-in financial packages that could feature finance for risk improvements with concessionary loan terms for the necessary capital expenditure and reduced premiums/less restrictive conditions (e.g. lower deductibles, higher compensation limits). after standardized risk reduction measures have been implemented.

Insurers could maximise the use of IT in order to be more flexible in their pricing structure, including where intermediaries are agents for them e.g. by micro-modelling flood risk to individual property level, rather than at a generalised postal zone level.

Encourage differential risk-based pricing

As discussed, risk-based premiums are particularly well suited for addressing losses from floods and other hazards where a key determinant of loss is exposure, by discouraging development. Price is generally combined with a range of terms and conditions, which can be effectively targeted to improve incentives for adaptation. Financial regulators and rating agencies should be more prescriptive in ensuring that insurers are setting adequate prices for climatic risks. The *European Insurance and Occupational Pensions Authority* (EIOPA), which is charged with helping to support the stability of the financial system as well as furthering transparent markets and products across member states and sectors could play an important role here, in terms of assessing risks, as well as suggesting improved insurance products that work with altered risks. As well, the Solvency II requirements including the quantitative solvency test run by EIOPA are likely to ensure that insurers are setting transparent and adequate prices for climate related risks. Regulators could mandate that repairs must be meet climate-resilient standards, or that high-risk sites must be vacated.

As a very broad consideration, regulators may also consider the introduction of mandatory natural hazard cover to standard property insurance products such as is done in France and Spain.

Monitor and adjust risk pricing and contract conditions

An important element in risk pricing would be a more responsive pricing mechanism. If a client undertakes risk prevention measures, then the premium and terms could be adjusted according to the changes in risk levels. The difference in adjusted premiums should be significant enough to lead to preventive behaviour, which can be a problem if the insurance premium is a rather small part of expenditure. It is thus also important to consider adjustments in contract conditions, such as reducing the deductible or raising the maximum claim, just as done as, for example, in car insurance, in order to provide stronger incentives.

Risk reduction requirements

Insurers could help clients to acquire finance for installing risk-reducing equipment and damage-resilient materials, and be more proactive in exploring the potential of such measures. Also after events, restoration from payouts could be required to be in compliance with climate resilient standards. The main difficulty with these ideas, is that they mean that the client has to pay more, since either the client has to fund the cost of upgrading before an event occurs, or the insurer has to increase the premium to pay for the upgrade after the event occurs. In a competitive market, and hard economic times, these propositions are not attractive. If the risk reduction requirements were mandated in building standards, then insurers could be instrumental in applying the regulations, by tying their contracts to compliance with the regulatory standards. Insurers can also contribute to setting new climate resilient standards as they are well informed about the risks.

Support generation and provision of transparent data on climate-related risks

To date, data on hazard, exposure, vulnerability and losses are typically the property of insurers and consulting firms, which have invested large sums in collecting the relevant information. Although in some cases there are public risk maps, the underlying data is classified. This is a major problem for analyzing cost-effective risk reduction. The EU member states could consider further collecting and disseminating such data for widespread use as a common good. As our analysis shows, the uncertainties around risk estimates are large.

Increased use of subrogation

Subrogation, denoting the process of insurers acquiring the rights of those whom they compensate, can be a useful, albeit complex tool for insurers to enforce risk management discipline. If insured weather damage has been exacerbated by the negligence or breach of duty of any organisations (or individuals), the insurers have the right to sue them, in order to recover the cost of the damages. In order to decrease complexity, regulators could simplify the procedures concerning how to prove breach of duty/negligence, and introduce penalties for tardy conduct in the legal process. As well, regulators should re-assess the status of prosecution-immune agencies, and clarify responsibilities for risk management (as has been done in England now for drainage). As another tool, regulators could make liability insurance mandatory for large firms, which through liability insurers consequently reviewing in detail the processes of their clients, may increase the uptake of subrogation.

Additional options for increasing the adaptation effectiveness of RFIs are further discussed below for specific insurance types.

3.2 Options for making markets and partnerships for risk financing work

In order to have the RFIs, particularly insurance, effectively provide incentives for adaptation and climate risk sharing, natural catastrophe insurance markets need to function properly. We outline options for improving the functioning of markets and building effective partnerships for risk financing, and organize this discussion according to property, agricultural and sovereign insurance.

3.3 Insuring households and businesses: policy options

The overview of insurance arrangements reveals no overall preferred system, nor does it give support to a radical move from public compensation to private insurance. Indeed, the most successful systems for advancing adaptation appear to be partnerships between the public and the private sector. (Note there is a fine line between a public insurance system and tax-based public compensation). What is perhaps most striking from this overview is “incorrect” price signals plague both individual and collective decisions. It follows that adaptation can best be encouraged with insurance instruments that place responsibility across the public and private sectors proportional to their capacity to reduce risks in a cost-effective manner. In the flood area, most preventive measures take the form of local public goods (levees, land use planning, etc), and adaptation can best be promoted with an appropriate balance of responsibility on the part of individuals and the government. According to von Ungern-Sternberg (2003):

The main issue is to provide adequate incentives in terms of zoning, construction norms and damage reduction. The presence of a local public insurance company in the relevant planning institutions should lead to a vast improvement to the current situation, since it could severely reduce problems of regulatory capture and moral hazard in this area. ... Combining insurance premiums and a tax to finance preventive measures (including fire fighting) thus has a double advantage. It internalises the externalities usually associated with prevention, and it gives even the good risks the feeling that they are getting something for their money.

Effective incentives for adaptation thus call for *layered insurance systems* with responsibility allocated differentially, depending on the hazard, between the private and public sectors. This could mean that in some circumstances the full risk-based premiums for floods and other hazards would not apply to households, or, alternatively, they would insure only a portion of their assets (the other portion being the responsibility of government assistance). This way of dividing the loss burden was the rationale behind a stakeholder consensus in Hungary that the government would only assist flood victims who insured a predetermined portion of their homes and assets.

Where this balance is misaligned, countries may see advantages to moving towards more private responsibility through insurance and other market-based solutions that embed incentives and

conditions for risk reduction and adaptation. There are many different policy options for increasing the supply and demand of public/private insurance and linking these systems to risk reduction and adaptation. We list below options for increasing the demand and supply of catastrophe property insurance, as well as for linking it with adaptation to build a bridge between the discussion on incentives above and the suggestions regarding the setup of markets and partnerships for risk financing.

3.4 Demand-related options

Tested solutions

- **Compulsory schemes:** A major advantage of compulsory systems, like those in Spain, France and Switzerland, is that they eliminate adverse selection, which reduces the risk of inadequate premiums significantly to the public insurer. Adverse selection occurs when those facing higher risks purchase insurance, and those less at risk do not. Another advantage of compulsory systems is that they maximize the pool available for paying claims.
- **Bundled insurance systems:** Many natural hazard insurance systems are bundled with property and fire insurance, for example, French insurance is bundled with property and home contents insurance, and in Swiss cantons it is bundled with fire cover. This increases insurance purchase; however, the disadvantage is that it obscures the actuarial prices.
- **Reduction of post-disaster government assistance, or granting partial assistance only to those who have part of their losses covered by insurance.** This was agreed by Hungarian stakeholders, and was instituted into the recent flood insurance programme; however, the government did not adhere to this condition and granted extensive public assistance to the uninsured shortly after legislating the insurance programme.

Untested novel ideas

- **Tax-subsidy transfers:** Picard (2008) suggests that a central authority provide tax cuts on insurance contracts for those facing high prevention costs and at the same time (to compensate for lower tax revenue) communities receive grants where risk management plans are enforced. The US Government Accounting Office (2007) has also suggested tax-deferred dollars to pay for catastrophe insurance.
- **Property tax assessment for private insurance as suggested by the GAO (2007) with the option that a central authority pay the deductible.**
- **Subsidies:** Kunreuther and Michel-Kerjan (2009) recommend providing subsidies to low-income households (perhaps similar to food stamps) for purchasing insurance. They argue that this will distort behaviour less than flat-rate premiums. The idea of subsidizing low-

income, high-risk households was endorsed by a three-year stakeholder process in Hungary (Linnerooth-Bayer et al., 2006).

3.5 Supply-related options

- Low-cost government capital backups to reduce reinsurance costs as in France and Spain, post-disaster lending to insurance programmes or elimination or reduction of taxes on insurers' catastrophe equalisation reserves (this was practised until recently in Germany);
- Public provision of data collection (as in Poland), which will reduce costs to insurers (along with many other advantages);
- Imposition and enforcement of regulations and/or public investment in risk reduction as a way of reducing liabilities on insurers (as in France and the UK).
- Special arrangements for high hazard areas, particularly where climate change has significantly increased the hazard (legacy risks). This could include risk pooling.
- The use of long-term contracts to facilitate adaptation planning and financing and relocation if appropriate. This could facilitate more flexible pricing of insurance also, by reducing the uncertainty in income for the insurer.
- Insurers could market micro-insurance contracts for low-income segments of society

3.6 Policy options for coupling property insurance with adaptation

Policy options for coupling property insurance with adaptation include consideration of:

- Layered insurance systems that place commensurate liability on the public and private sectors proportionately to their responsibility for the risks. This would entail for private sector risk that households and business would be (more) responsible for high-medium frequency risks and losses. Above that, up to a certain high-level collective threshold, private insurance could take the majority of the losses. Above that second layer, for very low-frequency, high-impact events beyond insurability and planning routines, public compensation would then be provided
- Reduced taxes for risk-based insurance contracts, reductions in other taxes or increases in the tax exemption limit if insurance is purchased, as well as subsidising community risk-reduction efforts may be additional avenues worth exploring.
- Differential risk-based pricing is effective and practical for penalizing persons locating capital in high-risk areas; however, it has not proven practical for rewarding other types of behaviour. Nor has it been demonstrated that lowered insurance rates actually motivate

individuals in many risk contexts to reduce risks (particularly if there are large up-front costs to install risk–reduction measures).

- Participation of insurers in land-use planning and other policy processes to reduce risks. This may be one of the most effective ways to couple insurance with adaptation. It has proven effective in Swiss cantons with public compulsory insurance;
- Encourage ‘best practice’ versus. ‘race to the bottom’: Insurance regulators can be more proactive in encouraging the use of ‘best practice’ contracts, and in some circumstances could allow these to be marketed with a dispensation from ‘cartel’ regulations.
- Wider use of conditional insurance contracts with “must do” clauses for risk reduction.
- Tax reductions for risk-based insurance contracts, and subsidies for community risk-reduction efforts as proposed by Picard (2008)
- Long-term insurance contracts coupled with low-interest loans for risk-reduction, which reduces the burden of mitigation since a coupled loan/insurance contract has a lower monthly payment than insurance and a loan separately (Kunreuther, 2003);
- Insurers could more actively support the research and development and testing of risk reduction measures.

3.7 Insuring farmers: policy options

In a similar vein, options for agricultural insurance can be listed as follows:

- Multi-peril, multi-crop compulsory systems. Spain and Greece appear to have more comprehensive cover than many other countries. However compulsory systems will not be transferable to all EU countries;
- Index-based contracts, which have the advantage of eliminating moral hazard; however, they are expensive to put into place and suffer from basis risk;
- Reduction of subsidies and substituting with other forms of support for farmers;
- Tax-subsidy transfers: Picard’s (2008) suggestion that a central authority provide tax cuts on insurance contracts for those facing high prevention costs can apply to agricultural insurance also.
- Reduction of post-disaster government assistance, or granting partial assistance only to those who have part of their losses covered by insurance.

- Low-cost government capital backups to reduce reinsurance costs, post-disaster lending to insurance programmes or elimination or reduction of taxes on insurer reserves (this was practised until recently in Germany);
- Public provision of data collection, which will reduce costs to insurers (along with many other advantages);
- Imposition and enforcement of regulations and public investment in risk mitigation as a way of reducing liabilities on insurers.

Policy options for coupling agricultural insurance with adaptation

There are also options for coupling agricultural insurance systems with adaptation, many of which are similar to the options discussed above for coupling property insurance with adaptation. These include:

- Risk-based pricing through the reduction of subsidies;
- Participation of insurers in farmer cooperatives and public policy processes that advise and regulate for risk reduction;
- Conditional insurance contracts with “must do” clauses for risk mitigation
- Tax reductions for risk-based insurance contracts;

3.8 Insuring governments: policy options

There is little experience in Europe with sovereign risk transfer, weather derivatives or catastrophe pools, and for many countries these instruments will not be necessary. Still, given the high exposure (hot spots) in Europe and the fragility of the budgets in some member countries, it may be useful to explore the relevance of these instruments. The proposed Central European risk pool is an interesting development in this direction and should be closely monitored.

Since there is experience with the European Union Solidarity Fund, we concentrate our policy options on its reform. The EUSF presents an opportunity for reform in such a way that it creates the intended solidarity in Europe and at the same time contributes to risk reduction and adaptation.

As an incremental step, we suggest that the EC consider introducing requirements for pre disaster risk management in the EUSF scheme. As one example, also currently discussed at the EC in the wake of considering droughts as reimbursable events, requirements for implemented drought risk management are being considered. Similar measures could be required for flood and windstorm risk, for which a host of risk management measures could be identified and suggested. Full conditionality will be very difficult to apply and actually implement. Yet, some broad generally verifiable indicators suggesting the level of risk reduction measures implemented in a given country

could be the return period of design flood events that need to be avoided by flood management authorities (often 50 year events in the EU), or building codes implemented for structures liable to windstorm damage. Another promising measure would be to further harmonize the loss assessment methodologies, which vary considerably across countries, but are the basis for granting support via the EUSF. A more radical suggestion would relate to reorienting the EUSF from a post-disaster response and aid instrument to a pre-disaster, risk-based solidarity instrument. In one variant, the EUSF would provide reinsurance cover at no cost to national or regional insurance systems, thus increasing insurability and lowering premiums

As a more radical suggestion that the EC consider reorienting the EUSF from a post-disaster response and aid instrument to a pre-disaster, risk-based solidarity instrument as proposed by Hochrainer et al (2010). One suggestion is that the EUSF provides reinsurance cover at no cost to national or regional insurance systems. It could also support government (sovereign) insurance through a disaster insurance pool, where governments would insure public infrastructure, cultural heritage sites, clean-up and other relief expenditures, eventually arriving at an intergovernmental risk pooling scheme, as implemented, in a limited form, in the Caribbean. The backup offered by the EUSF could be made conditional on governments' meeting adaptation goals. Given these additional roles and rising losses as well as the fact that the EUSF has been depleted a few times already, it is worthwhile considering providing additional finance for the EUSF.

- The provision of public reinsurance helps make insurance premiums affordable to low-income property owners and in this way promotes solidarity;
- Since private insurers are reluctant to provide cover for very rare, extremely high consequence events, EU backing ensures private-sector participation in the schemes;
- Placing even partial responsibility on property owners as an alternative to post-disaster assistance will increase the costs of locating in hazardous areas and engaging in other types of hazardous behaviour;
- Finally, EU reinsurance has advantages over national government reinsurance in that it spreads or diversifies risks across the larger European economy. Combining this with intergovernmental risk pooling seems promising in terms of invoking the insurance principle, to diversify risks as much as possible.

4 Further research needs

By evaluating appropriate economic instruments to promote adaptation in different sectors, the study identified several further research needs that could be considered before instruments are actually applied. The major ones are listed below:

- A country specific analysis could be conducted to explore in depth the context in which the adaptation instrument will be implemented. It would also estimate possible negative impacts on other instruments or the country's economy. The applicability of the instruments could be assessed for each sector or sub-sector. For instance if the country analysis shows high applicability of loans for the agricultural sector, this might not be the case for the sub-sector "livestock farming". Therefore sub-sectors, if possible linked to the country specific analysis, would be individually assessed. Effectiveness could be assessed by modelling potential quantitative effects in particular sectors and geographic locations.
- Sponsor research on consistent and comparable risk estimation including the collection and publication of data regarding extreme events and climate change hazards, as well as exposure and vulnerability. The EU Clearinghouse may be an appropriate repository for climatic information.
- Better demonstrate the benefits of RFIs: The main benefit of RFIs including insurance consists in avoiding the consequential detrimental effects of disasters. In addition, insurance helps to transfer systemic risk and thus allows a shift to more risky, yet productive activities. Not enough is known and communicated on these key functions of RFIs.
- With regards to an AMM, one could explore in more depth the applicability of the suggested adaptation units and how "baselines" and adaptive effects can be estimated and measured. This could then lead to a pilot approach.

References

- Aakre, .S, Banaszak, I., Mechler, R., Rübbelke, D., Wreford, A., Kalirai, H. (2009). Financial adaptation to disaster risk in the European Union: Improving roles for the public sector. Mitigation and Adaptation Strategies for Global Change, DOI: 10.1007/s11027-010-9232-3.
- Abildtrup, Jens; Gylling, Morten (2001): Climate change and regulation of agricultural land use: A literature survey on adaptation options and policy measures, Working Paper, Danish Institute of Agricultural and Fisheries Economics
- ADAM DIGITAL COMPENDIUM (2010). <http://adam-digital-compendium.pik-potsdam.de/>.
- Adger, W., Arnell, N. & Tompkins, E. (2005): Successful adaptation to climate change across scales, *Global Environmental Change* (15), pp. 77-86.
- Adhikari, Bhim (2009). Market-Based Approaches to Environmental Management: A Review of Lessons from Payment for Environmental Services in Asia, Asian Development Bank Institute Working Paper Series No. 134, March 2009.
- Agrawala, S. (eds.) (2007): Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management, OECD, Paris.
- Agrawala, S. and S. Fankhauser (eds.), 2008: Economic Aspects of Adaptation to Climate Change. Costs, Benefits and Policy Instruments, Paris, OECD.ECA, 2009;
- Agrawala, S., Bosello, F.; Carraro, C. & De Cian, E. (2009): Adaptation, Mitigation and Innovation - A Comprehensive Approach to Climate Policy, Working Papers Department of Economics, University of Venice, No. 25.
- and Red Crescent Societies, ProVention Consortium, Geneva.
- Arrow, K. J. and R.C. Lind (1970). Uncertainty and the Evaluation of Public Investment Decisions. *The American Economic Review* 60: 364-378
- Baumol, W. J. (1972), "On Taxation and the Control of Externalities", *American Economic Review* 62 (3): 307–322.
- Benson, C. and Twigg, J. (2004). Measuring mitigation: Methodologies for Assessing Natural Hazard
- Bindi, M. and Moriondo, M. (2010). Adam digital compendium: Drought. <http://adam-digital-compendium.pik-potsdam.de/risk-damage-maps/crop-risk-maps/results-and-key-messages/>
- Bird, R.M., Slack, E. (2005): Land and Property Taxation in 25 Countries: A Comparative Review. CESifo DICE Report 3/2005: 34-42. <http://www.ifo.de/DocCIDL/dicereport305-rr1.pdf>
- Bloomberg (2011): Bryan Keogh. Japan Fuels ,Overwhelming' \$61 Billion in Orders for ESFS Bonds, <http://www.bloomberg.com/news/2011-01-25/efsf-said-to-get-43-billion-euros-of-orders-from-500-investors.html>. Published by Bloomberg News 2011.
- Böhm B.: Öffentlich-private Partnerschaften in der kommunalen Stadtentwicklung : öffent-lich-rechtliche Vorgaben und gesellschaftsrechtliche Gestaltungen. Lang, Frankfurt am Main u.a. 1999. S. 15-40
- Botzen, W. and J. van den Bergh (2008). Insurance Against Climate Change and Flooding in the Netherlands: Present, Future, and Comparison with Other Countries, *Risk Analysis*, Vol. 28, No. 2.

- Botzen, W. and van den Bergh, J. (2008). Insurance Against Climate Change and Flooding in the Netherlands: Present, Future, and Comparison with Other Countries. *Risk Analysis*, Vol. 28, No. 2, 2008 DOI: 10.1111/j.1539-6924.2008.01035.x
- Bovarnick A, Knight C & Stephenson J. (2010): Habitat Banking in Latin America and Caribbean: A Feasibility Assessment, United Nations Development Programme.
- Burby, R. J. (2001). Flood insurance and floodplain management: The US experience. *Environmental Hazards*, 3(3–4), 111–122.
- Burton, I. Huq, S., Lim, B. Pilifosova, O., Schipper, L. (2002). From impacts assessment to adaptation priorities: the shaping of adaptation policy, in: *Climate Policy*, 2, 2, 2002 , pp. 145-159
- Business and Biodiversity Offsets Programme [BBOP], <http://bbop.forest-trends.org/guidelines/index.php>.
- Callaway, J. (2004): Adaptation benefits and costs: are they important in the global policy picture and how can we estimate them?, in: *Global Environmental Change* 14, p. 273-282
- Cantin, B., Shrubsole, D., Aït-Ouyahia, M. (2005): Using Economic Instruments for Water Demand Management: Introduction, in: *Canadian Water Resources Journal*, 30, p. 1–10
- Cardenas, V, Hochrainer, S. Mechler, R., Pflug, G. and Linnerooth-Bayer, J. (2007). Sovereign financial disaster risk management: The case of Mexico. *Environmental Hazards* 7: 40-53.
- Carraro, C. & Sgobbi, A. (2008): Climate Change Impacts and Adaptation Strategies In Italy. An Economic Assessment, *Fondazione Eni Enrico Mattei Nota Di Lavoro*, 6.2008.
- CEA (2005) The insurance of natural events on European markets. AB 5050 (06/05). Paris, France.
- CEA (2010). PML Assessment for Germany & Austria. Hamburg, November 2010
- CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors) (2010a) Catastrophe task force report on standardised scenarios for the catastrophe risk module in the standard formula. CEIOPS-DOC-79/10 11 June 2010. Website: www.ceiops.eu
- CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors) (2010b) Solvency II: Calibration Paper. CEIOPS-SEC-40'-10 15. April 2010. Website: www.ceiops.eu
- CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors) (2010a) CATASTROPHE TASK FORCE REPORT ON STANDARDISED SCENARIOS FOR THE CATASTROPHE RISK MODULE IN THE STANDARD FORMULA. CEIOPS-DOC-79/10 11 June 2010. Website: www.ceiops.eu
- CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors) (2010b) Solvency II. Calibration Paper. CEIOPS-SEC-40'-10 15. April 2010. Website: www.ceiops.eu
- CEPS & ZEW (2010a): Fiscal implications of climate change adaptation, http://ec.europa.eu/economy_finance/publications/external_studies/ex_study1_en.htm.
- CEPS & ZEW (2010b): Fiscal implications of climate change adaptation, http://ec.europa.eu/economy_finance/publications/external_studies/ex_study2_en.htm.
- Chartered Insurance Institute (2009). Coping with Climate Change: Risks and Opportunities for Insurers. ed A. Dlugolecki. Chartered Insurance Institute, February 2009
- Climatewise (2010a). Adapting to the extreme weather impacts of climate change – how can the insurance industry help?
- ClimateWise (2010b). Principles. Third Independent Review. Climatewise, 2010

- Crichton, D. (2002). UK and Global Insurance Responses to Flood Hazard. *Water International*, 27: 119–131
- Crichton, D. (2005). Flood Risk & Insurance in England and Wales: Are there Lessons to be Learned from Scotland? Technical Paper 1. London: Benfield Greig Hazard Research Centre.
- Crichton, D. (2008). Role of Insurance in Reducing Flood Risk. *The Geneva Papers on Risk and Insurance*, 33: 117–132
- Crichton, D. (2009). Small and Medium Enterprises in Dlugolecki, A. *Coping with Climate Change: Risks and Opportunities for Insurers*, CII
- Cummins, D. & Mahul, O. (2008) Catastrophe risk financing in developing countries: principles for public intervention, Washington D.C: World Bank Publications
- Cummins, J., Mahul, O. (2009). Catastrophe risk financing in developing countries. principles for public intervention. The World Bank, Washington D.C..
- Dannenbergh, A., Mennel, T., Osberghaus, D. & Sturm, B. (2009): The Economics of Adaptation to Climate Change – The Case of Germany, Zentrum für Europäische Wirtschaftsforschung Discussion Paper, No. 09-057.
- de Bruin, K., Dellink, R. & Agrawala, S. (2009): Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits, OECD Environment Working Papers No. 6.
- de Bruin, K., Dellink, R., Ruijs, A., Bolwidt, L., van Buuren, A., Graveland, J., de Groot, R., Kuikman, P., Reinhard, S., Roetter, R., Tassone, V., Verhagen, A. & van Ierland, E. (2009): Adapting to climate change in The Netherlands: an inventory of climate adaptation options and ranking of alternatives, *Climatic Change* (95), pp. 23-45.
- DEFRA (2010). Payments for ecosystem services: A short introduction, October 2010, mimeo.
- Diaz-Caneja, B., C.G. Conte, F.J. Gallego Pinilla, J. Stroblmair, R. Catenaro and C. Dittmann (2009). Risk Management and Agricultural Insurance Schemes in Europe, JRC Reference Reports, Report EUR 23943EN.
- Dixon, L., N. Clancy, S. Seabury and A. Overton (2006). The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications, RAND Corporation, Santa Monica, CA 90407
- Dlugolecki A. and S. Lafeld. (2005). Climate change – agenda for action: the financial sector's perspective. Allianz and WWF.
- Dlugolecki, A. F. (2008) "An overview of the impact of climate change on the insurance industry". In H.F. Diaz and R.J. Murnane (eds.), */Climate Extremes and Society/*, Cambridge: C.U.P. 2008
- Dlugolecki, A.F. (2006) CEO Briefing "Adaptation and Vulnerability to Climate Change: The Role of the Finance Sector" UNEP Finance Initiative, Geneva. Released at COP12, Nairobi, November 15 2006
- Dlugolecki, A.F. (2006) Why 'good' science doesn't help. *Environmental Finance*, October 2006 pp15-16
- Dlugolecki, A.F. (2007) Climate change and extreme events; estimated cost in 2030. UNFCCC, available from their website.
- Dlugolecki, A.F. (2008). Climate Change and the Insurance Sector. *The Geneva Papers on Risk and Insurance*, 33: 71–90.

Dlugolecki, A.F. and N. Silver. (2006) Environmental Professionalism and Sustainability: too important to get wrong. Actuaries: a Case Study in Professional Development and Environmental Sustainability. Greener Management International 49; 95-109 2006

Economics of Climate Adaptation (2009): Shaping climate-resilient development: a frame-work for decision-making, Economics of Climate Adaptation Working Group

EEA (2005): Vulnerability and adaptation to climate change in Europe, EEA Technical report 2005-7.

EEA (2007): Climate change: the cost of inaction and the cost of adaptation, EEA Technical 1 report No 13/2007. European Environmental Agency, Copenhagen.

EEA (2009): Report on good practice measures for climate change adaptation in river basin management plans, mimeo.

EEA glossary: <http://glossary.eea.europa.eu/>

eftec, IEEP et al. (2010): The use of market-based instruments for biodiversity protection – The case of habitat banking – Summary Report, <http://ec.europa.eu/environment/enveco/index.htm>.

EIB (2008): European Investment Bank. Das Kreditgarantieinstrument für transeuropäische Verkehrsprojekte – Fact Sheet. Published by EU Commission.

EIOPA (2011). Report on the fifth Quantitative Impact Study (QIS5) for Solvency II, Frankfurt, Germany

Engel, S., Pagiola, S., Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues, in: Ecological Economics, Vol. 65, pp. 663-674.

Eriksen, Siri; Kelly, P. (2007): Developing credible vulnerability indicators for climate adaptation policy assessment, in: Mitigation and Adaptation Strategies for Global Change, 12, p: 495-524

ESCAP (2009). Payments for Ecosystem Services, online document found under http://www.unescap.org/esd/environment/publications/PES/ESCAP_PES%20Publication%202560.pdf, accessed 23rd March 2011.

European Commission (2005). European Union Solidarity Fund Annual report 2002-2003 and Report on the experience gained after one year of applying the new instruments. Brussels.

European Commission (2006). Agricultural Insurance Schemes, European Commission DG Agriculture and DG Joint Research Centre Final Report.

European Commission (2006). European Union Solidarity Fund - Annual report 2002-2003 and Report on the experience gained after one year of applying the new instrument COM/2004/0397. EC 2006, MEMO/06/153

European Commission (2009). Adapting to Climate Change: Towards a European Framework for Action. White Paper, Brussels: The Commission of the European Communities.

European Commission (2010), Background Documents: Typology of EU financial instruments, CG IFI (2010)2, Update 7.9.2010

European Commission (2010), Taxation Trends in the European Union.

European Commission (2010b), Guarantees – The EU's 'SME Guarantee Facility' http://ec.europa.eu/enterprise/policies/finance/data/enterprise-finance-index/figures-eu-financial-instruments/guarantees/index_en.htm, accessed 13 April 2011

European Environment Agency (EEA) (2010a): Land Use, The European Environment – State and Outlook 2010, Copenhagen.

European Environment Agency (EEA) (2010b): Urban Environment, The European Environment – State and Outlook 2010, Copenhagen.

European Environment Agency (EEA) (2010c): Land in Europe: prices, taxes and use patterns. EEA Technical Report No 4/2010.

European Environment Agency (EEA) (2011a): Analysing and managing urban growth, <http://www.eea.europa.eu/articles/analysing-and-managing-urban-growth>

European Environment Agency (EEA) (2011b): Urban soil sealing in Europe, <http://www.eea.europa.eu/articles/urban-soil-sealing-in-europe>

European Union (2011), EU legislation - Concessions under Community law. http://europa.eu/legislation_summaries/internal_market/businesses/public_procurement/l22011_en.htm

Fankhauser, S., Smith, J., Tol, R. (1999): Weathering climate change: some simple rules to guide adaptation decisions, in: Ecological Economics, 30, p. 67-78

Fankhauser, S., Tol, R., Pearce, D. (1998): Extensions and alternatives to climate change impact valuation: on the critique of IPCC Working Group III's impact estimates, in: Environment and Development Economics, 3, p. 59–81

Fankhauser, S., Tol, R. (1998): The value of human life in global warming impacts – a comment, in: Mitigation and Adaptation Strategies for Global Change, 3, p. 87–88

Faure, M. and T. Hartlief (eds) (2006). Financial Compensation for Victims of Catastrophes: A comparative Legal Approach, Springer Verlag, Vienna, New York.

Fearnside, P. (1998): The Value of Human Life in Global Warming Impacts, in: Mitigation and Adaptation Strategies for Global Change, 3, p. 83-85

Feyen L, Barredo JI, Dankers R (2009) Implications of global warming and urban land use change on flooding in Europe. In: Feyen J, Shannon K, Neville M (eds) Water and urban development paradigms. Towards an integration of engineering, design and management approaches. Taylor & Francis Group, London, ISBN 978-0-415-48334-6, 217-225

Feyen, L and Watkiss, P. (2011). Policy Briefing Note 6: River Floods. The Impacts and Economic Costs of River Floods in Europe and the Costs and Benefits of daptation. Summary of Sector Results from the EC RTD ClimateCost Project .

Froot K. A. and O'Connell P.G.J. (1999). The Pricing of U.S. Catastrophe Reinsurance. In: K. Froot (ed). *The Financing of Catastrophe Risk*. Chicago: The University of Chicago Press. pp.195–232.

Gleitsmann, Christoph (2009): EIB view on financing climate change adaptation. Side event at the COP 15 climate change conference. Published by European Investment Bank (EIB).

Grafton, Q. (2005): Evaluation of Round One of the Market Based Instrument Pilot Program, Canberra

Graham, T. (2004): Review of the Small Firms Loan Guarantee – Recommendations. Published by HM Treasury, London.

Grubb, M., Laing, T., Counsell, T., Willan, C. (2010): Global carbon mechanisms: lessons and implications, in: Climatic Change, DOI: 10.1007/s10584-009-9791-z

Gupta, Sujata; Tirpak, Dennis; Burger, Nicholas; Gupta, Joyeeta; Höhne, Niklas; Boncheva, Antonina; Kanoan, Gorashi; Kolstad, Charles; Kruger, Joseph; Michaelowa, Axel; Murase, Shinya; Pershing, Jonathan; Saijo, Tatsuyoshi; Sari, Agus (2007): Policies, Instruments and Co-operative Arrangements, in Metz, Bert; Davidson, Ogunlade; Bosch, Peter; Dave, Rutu; Meyer, Leo (eds): Climate Change 2007:

Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, p. 746-807

Gurenko, E. (2004). Introduction. in E. Gurenko (Ed.). *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*, Risk Books, London, 3-16

Gurenko, E. (2009) (ed). Special issue of Climate Policy 6/6 on climate insurance.

Guy Carpenter (2011). QIS5 windstorm scenario property loss estimates. www.guycarp.com.

Hallegatte, S.; Henriet, F. & Corfee-Morlot, J. (2008): The Economics of Climate Change Impacts and Policy Benefits at City Scale: A Conceptual Framework, OECD Environment Working Papers No. 4.

Hallegatte, Stephane. Strategies to adapt to an uncertain climate change. *Global Environmental Change* 19(2009) 240-247.

Hassett, Kevin; Mathur, Aparna; Metcalf, Gilbert (2009): The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis, in: *The Energy Journal*, 30, p. 155-177

Hazell, P. and Hess, U. (2010). Drought insurance for agricultural development and food security in dryland areas. *Food Security Volume 2, Number 4*, 395-405, DOI: 10.1007/s12571-010-0087-y

Hazell, P., Anderson, J., Balzer, N., Hastrup Clemmensen, A, Hess, U., and F. Rispoli. (2010). Potential for scale and sustainability in weather index insurance for agriculture and rural livelihoods, International Fund for Agricultural Development and World Food Programme. Rome.

Hochrainer, S. and Mechler, R. (2009). Report on Europe's financial and economic vulnerability to meteorological extremes. A.2.3. final deliverable, ADAM, Brussel, Belgium.

Hochrainer, S., Linnerooth-Bayer, J. and Mechler, R. (2010). The European Union Solidarity Fund: Its Legitimacy, Viability and Efficiency. *Mitig. Adapt. Strat. Glob. Change*. DOI 10.1007/s11027-009-9209-2.

Honkatukia, J. (2002): Climate policies in Finland, www.oecd.org/dataoecd/7/28/2483355.pdf, 29.06.2011.

Hubert, M. (2004). Insurability and regulatory reform: Is the English flood insurance regime able to adapt to climate change? *Geneva Papers on Risk and Insurance*, 29(2), 169–182.

IEA (2011) - Energy prices and taxes (quarterly publication): <http://www.iea.org/stats/index.asp>.

IMF (2008): The Fiscal Implications of Climate Change, Fiscal Affairs Department, International Monetary Fund, March 2008, <http://imf.org/external/np/pp/eng/2008/022208.pdf>.

IMF (2008): The Fiscal Implications of Climate Change, Fiscal Affairs Department, International Monetary Fund, March 2008, <http://imf.org/external/np/pp/eng/2008/022208.pdf>

IPCC (in preparation) Special Report on Extreme Events (SREX) – due in 2011/12.

Keyes, W. N. (2000). *Government Contracts in a Nutshell*. 3d ed. St. Paul, Minn.: West Group

Kline, Jeffrey; Wichelns, Dennis (1996), Measuring public preferences for the environmental amenities provided by farmland. *European Review of Agricultural Economics* 23: 421-426.

Korthals Altes, W. K. (2009): Taxing land for urban containment: reflections on a Dutch debate. *Land Use Policy* Volume 26, Issue 2, April 2009: 233 – 241.

Kuch, P., Gigli, S. (2007): Economic approaches to climate change adaptation, GTZ, Eschborn

Kundzewics, Z., Luger, N., Hochrainer, S., Moriondo, M., Schelhaas, M-J., Radziejewski, M., Kedziora, A., Bindi, M., Matczak, P., Szwed, M., Piskwar, I., Graczyk, D. and Dysarz, T. (2009). Risk and

economic damage assessment for 2025 and 2100 with and without adaptation. A.2.2 final deliverable, ADAM, Brussel, Belgium.

Kunreuther, H. (2006). Disaster Mitigation and Insurance: Learning from Katrina, *Annals of the American Academy of Political and Social Science* 604: 208–227.

Kunreuther, H. and E. Michel-Kerjan, (2008). “A Framework for Reducing Vulnerability to Natural Disasters: Ex Ante and Ex Post Considerations” Report for The World Bank.

Kunreuther, H., and E. Michel-Kerjan (2009). *At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes*. New York: MIT Press.

Legal Dictionary (2011), Public Contract, <http://legal-dictionary.thefreedictionary.com/Public+Contract>, visited 4 April 2011.

Lim, B. Lim, Spanger-Siegfried, E. (eds.) (2004): *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*, Cambridge University Press, Cambridge

Linnerooth-Bayer, J. (2008). Non-insurance mechanisms for managing climate-related risks, Mechanisms to manage financial risks from direct impacts of climate change in developing countries. Technical paper. FCCC/TP/2008/9, United Nations Office at Geneva, Geneva, <http://unfccc.int/4159.php>

Linnerooth-Bayer, J. and Mechler, R. (2004). Financing Disaster Risks in Developing and Emerging-Economy Countries, Paper presented at the OECD conference, Catastrophic Risks and Insurance, Paris, November 22, 2004.

Linnerooth-Bayer, J. and R. Mechler (2006). Insurance for assisting adaptation to climate change in developing countries: A proposed strategy. *Climate Policy*, (6).

Linnerooth-Bayer, J., A. Vari, and M. Thompson. Floods and Fairness in Hungary. in *Clumsy Solutions for a Complex World: Governance, Politics and Plural Perceptions*, M. Verweij and M. Thompson, Eds. Palgrave Macmillan (2006).

Linnerooth-Bayer, J., and R. Mechler (2007). Disaster Safety Nets for Developing Countries: Beyond Public-Private Partnerships. in *Environmental Hazards*, Special issue on Financial Vulnerability, Linnerooth-Bayer, J., and A. Amendola, Eds.

Linnerooth-Bayer, J., Mechler, R. (2007). Disaster safety nets for developing countries: Extending public-private partnerships. *Environmental Hazards*, (7), 54-61.

Linnerooth-Bayer, J., Mechler, R., Pflug, G. (2005). Refocusing Disaster Aid. *Science*, 309, 1044–1046

Linnerooth-Bayer, J., Quijano-Evans, S., Löfstedt, R. and Elahi, S. (2001). The Uninsured Elements of Natural Catastrophic Losses: Seven Case Studies of Earthquake and Flood Disasters, Summary Report, Project funded by the UK Tsunami fund, IIASA, Laxenburg, Austria.

Lugeri, N., Kundzewicz, Z.B., Genovese, E., Hochrainer, S., and Radziejewski, M. (2010). River Flood Risk and Adaptation in Europe. Assessment of the Present Status. *Mitig. Adapt. Strat. Glob. Change*, 15(7): 621-639.

Lugeri, N., Kundzewicz, Z.B., Genovese, E., Hochrainer, S., and Radziejewski, M. (2010). River Flood Risk and Adaptation in Europe – Assessment of the Present Status. *Mitig. Adapt. Strat. Glob. Change*, 15(7): 621-639.

Luo, B.; Maqsood, I.; Yin, Y., Huang, G.; Cohen, S. (2003): Adaption to Climate Change through Water Trading under Uncertainty – An Inexact Two-Stage Nonlinear Programming Approach, *Journal of Environmental Informatics*, 2, p. 58-68

Mayrand, K., M. Paquin (2004). Payments for Environmental Services: A survey and assessment of current schemes, Paper by Unisfera International Centre, September 2004, Montreal.

Mechler, R. (2004). Natural disaster risk management and financing disaster losses in developing countries. Verlag Versicherungswirtschaft

Mechler, R. (2005). Cost-benefit analysis of natural disaster risk management in developing countries. Working paper. Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Eschborn.

Mechler, R., J. Linnerooth-Bayer, S. Hochrainer, G. Pflug (2006). Assessing Financial Vulnerability and Coping Capacity: The IIASA CATSIM Model. In J. Birkmann (ed.). Measuring Vulnerability and Coping Capacity to Hazards of Natural Origin. Concepts and Methods. United Nations University Press, Tokyo: 380-398

Mechler, R., S. Hochrainer, A. Aaheim, Z. Kundzewicz, N. Luger, M. Moriondo (Lead Authors) (2010). A risk management approach for assessing adaptation to changing flood and drought risks in Europe, in: Making climate change work for us, M. Hulme and H. Neufeldt (eds.), Cambridge University Press, Cambridge, UK, pp. 200-229.

Mendelsohn, R. (2000): Efficient adaptation to climate change, Climatic Change (45, 3-4), 553-569.

Morgan, D (2011). , UK farming: a changing environment, Insurance Age, <http://www.insuranceage.co.uk/>

MUNICH CLIMATE INSURANCE INITIATIVE (MCII) (2008) Insurance Instruments for Adapting to Climate Risks: A proposal for the Bali Action Plan. Submission to UNFCCC by MCII, 18 August 2008, at 3rd session of the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA 3). Accra

Munich Re (2009). TOPICS. From knowledge to solutions. Solvency II. Climate change.

Nordhaus, W. (2008): A Question of Balance - Weighing the Options on Global Warming Policies, Yale University Press.

OECD (2006): The political economy of environmentally related taxes, Paris.

OECD (2009): Managing water for all – An OECD perspective on pricing and financing, Paris.

OECD (2010a): Tax policy reform and economic growth, Paris.

OECD (2010b): Taxation, innovation and the environment, Paris.

OECD glossary: <http://stats.oecd.org/glossary/index.htm>. glossary of terms, <http://stats.oecd.org/glossary/detail.asp?ID=7214>, accessed 8 April 2011

Paklina, N. (2003). Flood Insurance, unpublished document, Organisation for Economic Co-operation and Development, Paris.

Parry, M., Arnell, N., Berry, P., Dodman, D., Fankhauser, S., Hope, C., Kovats, S., Nicholls, R., Satterthwaite, D., Tiffin, R. & Wheeler, T. (2009): Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and Other Recent Estimates, International Institute for Environment and Development and Grantham Institute for Climate Change, London.

Perils (2011). QIS5 windstorm scenario property loss estimates. www.perils.org.

Picard, P. 2008. NATURAL DISASTER INSURANCE AND THE EQUITY-EFFICIENCY TRADE-OFF

Pigou, A. C. (1954): Some Aspects of the Welfare State, Diogenes June 1954 (2), pp. 1-11.

Point Carbon (2011): Carbon Market Monitor. A review of 2010, Oslo

Priest, G.L. (1996). The Government, the Market and the Problem of Catastrophic Loss, *J. Risk & Uncertainty*, 12.

Rayment, M. E. Pirgmaier, G. de Ceuster, F. Hinterberger, O. Kuik, H. L. Gower, C. Polzin, A. Varmaa (2009): The economic benefits of environmental policy, Amsterdam, http://ec.europa.eu/environment/enveco/economics_policy/pdf/report_economic_benefits.pdf.

Rhinard, M. (2010). The European Union's Solidarity Clause: Empty Letter or Effective Tool? An Analysis of Article 222 of the Treaty on the Functioning of the European Union, Occasional Papers No 2, Swedish Institute of International Affairs.

Risks and the Net benefits of Mitigation - A Scoping Study. International Federation of the Red Cross

Rusmini, M. (2009). Pan European flood hazard and damage assessment; evaluation of a new If-SAR Digital Terrain Model for flood depth and flood extent calculation. Thesis.. International Institute for Geo-information Science and Earth Observation, Netherlands.

Schwarze, R. and G. Wagner (2009). Natural Hazards Insurance in Europe – Tailored Responses to Climate Change Needed, Working Papers in Economics and Statistics, 2009-06 University of Innsbruck.

SFLG Annual report (2008): Small Firms Loan Guarantee – Annual Report for Financial Year 2007/2008. Published by CfEL.

SFLGfinance (2011): Small Firms Loan Guarantee Scheme – Scheme Features & Criteria, http://sflgfinance.co.uk/scheme_criteria.aspx

Silver, N. and A. Dlugolecki (2009). The Insurability of the Impacts of Climate Change. IARU International Scientific Congress on Climate Change, March 2009, Copenhagen Powerpoint only.

Stern, N., 2006: Stern Review: Economics of Climate Change, Cambridge University Press, Cambridge. UNDP (2007)

Storm (1888): Der Schimmelreiter, Eine Novelle, Paetel, Berlin.

Strippel, J. 2005. Climate Change after the International: Rethinking Security, Territory and Authority. Doctoral dissertation. Lund: Department of Political Science.

Surminski, Swenja (2010). Adapting to the extreme weather impacts of climate change – how can the insurance industry help? Climate Wise, London, www.climatewise.org.uk

Swiss Re (2008). Sigma: Natural catastrophes and man-made disasters in 2007: high losses in Europe. Zurich: Swiss Re Reinsurance Company.

Swiss Re. (1998). Floods—An Insurable Risk? A Market Survey. Risk Perception Report. Zurich: Swiss Re Reinsurance Company.

Thieken, A. H., Petrow, T., Kreibich, H., & Merz, B. (2006). Insurability and mitigation of flood losses in private households in Germany. *Risk Analysis*, 26(2), 383–395.

Tokila, A., Haapanen, M. (2008): Evaluation of deadweight spending in regional enterprise financing, <http://www.isbe.org.uk/content/assets/BP08-AnuTokila.pdf>, 2905.2011.

Tol, Richard (1997): The social cost controversy – a personal appraisal, in: Sors, A., Liberatore, S.; Funtowicz, S., Hourcade, J.; Fellous, J. (eds.): Proceedings of the international symposium “Prospects for integrated environmental assessment: Lessons learnt from the case of climate change”, Brussels, p. 35-40

UNEP and SBI (2011). Advancing adaptation through climate information services.

UNEPFI (2011) Advancing adaptation through climate information services. UNEPFI (Geneva) and SBI (Berlin), January 2011

UNFCCC (2008) Mechanisms to manage financial risks from direct impacts of climate change in developing countries" UNFCCC. FCCC/TP 2008/9. 21 November 2008

Ungern-Setrtnberg, T. (2003). State intervention on the market for natural damage insurance in Europe, CESIFO Working Paper, No. 1067, category 9.

Ungern-Setrtnberg, T. (undated). Die Katastrophen-Versicherung in Spanien, Universität Lausanne, <http://www.hec.unil.ch/deep/textes/9716.pdf>

US Government Accounting Office (GAO) (2005). Federal Emergency Management Agency, Challenges Facing the National Flood Insurance Program, GAO Highlights, Washington DC, October, 2005.

US Government Accounting Office (GAO). (2007). Natural Disasters: Public Policy Options for Changing the Federal Role in Natural Catastrophe Insurance, Highlights of GAO-08-07, report to the Ranking Member, Committee on Financial Services, House of Representatives. Washington D.C.

Vries de, E. J. (1998). Vergoeding van rampschade. Nederlands, *Juristenblad* 42, 1908–1915.

Warner, K., Ranger, N., Surminski, S., Arnold, M., Linnerooth-Bayer, J., Erwann, M.-K., Kovacs, P., Herweijer, C. (2009). Adaptation to climate change: linking disaster risk reduction and insurance Munich Climate Insurance Initiative (MCII) and United Nations International Strategy for Disaster Reduction Secretariat (UNISDR)

Watkiss, P. and Hunt, A., 2010. Review of Adaptation Costs and Benefits Estimates in Europe for SOER 2010. Contribution to the EEA SOER 2010. Report to the European Environment Agency.

World Bank, 2010: Economics of Adaptation to Climate Change. World Bank, Washington, D.C

World Health Organization (WHO, 2010a): Disability weights, discounting and age weighting of DALYs, http://www.who.int/healthinfo/global_burden_disease/daly_disability_weight/en/index.html, accessed 16/10/2010

World Health Organization (WHO, 2010b), Global Burden of Disease, World Health Organization; http://www.who.int/healthinfo/global_burden_disease/en/, accessed 16/10/2010

Wunder, S. (2005). Payments for Environmental Services: Some Nuts and Bolts. Occasional Paper No. 42. CIFOR, Bogor.

Wunder, S., S. Engel, S. Pagiola (2008). Taking stock: A comparative analysis of Payments for Environmental Services Programs in developed and developing countries, in: Ecological Economics, Vol. 65, pp. 834-852.

Yamin, Farhana (ed.) (2005): Climate change and carbon markets. A handbook of emission reduction mechanisms, Earthscan, London.

Appendix

Table A.1: Capital stock estimates in constant 2011 bn Euro based on different databases/sources.

	Constant 2011 billion Euro								
Country	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Selected
Austria	814	492	673	632	1117	1014	975	1025	1025
Belgium	901	538	600	681	0	982	814	1650	982
Bulgaria	67	0	0	57	0	0	0	396	396
Czech R.	451	0	0	330	12373	0	298	758	758
Germany	7836	4486	5265	5524	10873	8840	9159	6092	8840
Denmark	505	349	474	483	6853	4198	763	763	763
Estonia	23	0	0	36	0	0	13	85	85
Spain	2863	470	1879	1936	3441	3335	2386	1932	1932
Finland	479	393	444	409	551	497	476	1131	1131
France	5216	3084	4033	4124	0	6625	5247	6374	6374
Greece	522	0	368	356	0	787	0	482	482
Croatia	97	0	18	51	0	0	0	184	184
Hungary	370	0	83	174	0	0	302	697	697
Ireland	247	0	286	226	0	521	198	380	380
Italy	4387	2438	3014	3095	5474	4974	3640	3590	3590
Lithuania	62	0	0	88	0	0	40	223	223
Luxembourg	71	0	78	59	0	79	74	130	130
Latvia	35	0	0	41	0	0	0	69	69
Netherlands	1458	1050	1240	1087	2008	1701	1650	1247	1247
Poland	1209	0	305	482	0	0	924	1327	1327
Portugal	559	165	369	344	0	504	280	401	401
Romania	433	0	0	238	0	0	113	998	998
Sweden	791	619	764	747	7452	10477	643	1418	1418
Slovenia	115	0	9	44	54	0	46	103	103
Slovakia	298	0	0	184	0	0	341	363	363
United Kingdom	4072	2469	4199	4161	3468	3765	3118	4418	4418

Sources:

- (1) Sanderson WC, Striessnig E (2009). Demography, Education, and the Future of Total Factor Productivity Growth. IIASA Interim Report IR-09-002 [February 2009, 55 pp].
- (2) Duffy and Papageorgiou 2000. A cross-country empirical investigation of the Aggregate Production Function Specification .
- (3) Nehru, V. and A. Dhareshwar, 1993: A New Database on Physical Capital Stock: Sources, Methodology, and Results,” Rivista de Analisis Economico, 8:37-59.
- (4) Miketa, A., 2004: Technical description on the growth study datasets. Environmentally Compatible Energy Strategies Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, October 2004. http://www.iiasa.ac.at/ECS/data_am/index.html
- (5) O’Mahony, Mary and Marcel P. Timmer (2009), “Output, Input and Productivity Measures at the Industry Level: the EU KLEMS Database”, Economic Journal, 119(538), pp. F374-F403
- (6) Annual macro-economic database: http://ec.europa.eu/economy_finance/db_indicators/ameco/zipped_en.htm
- (7) Derbyshire J., Chou Y., Gardiner B., Stenning J., Waights S. (2010) Estimating the Capital Stock for the NUTS2 Regions of the EU27. Cambridge Econometrics
- (8) Luger, N., Kundzewicz, Z.B., Genovese, E., Hochrainer, S., and Radziejewski, M. (2010). River Flood Risk and Adaptation in Europe. Assessment of the Present Status. Mitig. Adapt. Strat. Glob. Change, 15(7): 621-639.

Table A.2: Capital Stock Projections: A2 Scenario

Capital Stock Projections: A2 Scenario Billion Euros	2011	2030	2050	2070	2100
Austria	1025	1310	1590	1857	2266
Belgium	982	1271	1563	1847	2307
Bulgaria	396	738	1104	1457	2006
Czech Republic	758	1499	2300	3098	4281
Germany	8840	12566	15444	17272	20557
Denmark	763	948	1136	1324	1624
Estonia	85	166	261	341	453
Spain	1932	2744	3554	4197	5184
Finland	1131	1386	1643	1895	2300
France	6374	8673	10659	12074	14577
Greece	482	768	1048	1307	1684
Hungary	697	1,313	1,964	2,606	3,562
Ireland	380	500	635	779	1,007
Italy	3,590	4,406	4,999	5,735	6,860
Lithuania	223	560	1,091	1,621	2,418
Luxembourg	130	167	216	277	383
Latvia	69	156	285	402	563
Netherlands	1,247	1,654	2,064	2,450	3,083
Poland	1,327	3,060	4,882	6,499	9,139
Portugal	401	646	888	1,116	1,455
Romania	998	2,385	4,289	6,092	9,026
Sweden	1,418	1,748	2,081	2,407	2,934
Slovenia	103	134	165	213	278
Slovakia	363	704	1,055	1,415	1,992
United Kingdom	4,418	6,169	7,720	8,856	10,904

Table A.3: Capital Stock Projections: B1 Scenario .

Capital Stock Projections: B1 Scenario Billion Euros	2011	2030	2050	2070	2100
Austria	1,025	1,380	1,722	2,017	2,420
Belgium	982	1,351	1,718	2,053	2,608
Bulgaria	396	782	1,273	1,858	2,876
Czech Republic	758	1,611	2,640	3,952	6,357
Germany	8,840	13,321	16,625	18,429	25,265
Denmark	763	982	1,202	1,408	1,685
Estonia	85	174	284	396	579
Spain	1,932	2,766	3,650	4,449	5,371
Finland	1,131	1,447	1,742	2,002	2,377
France	6,374	9,237	11,484	12,921	16,679
Greece	482	829	1,227	1,601	2,165
Hungary	697	1,384	2,174	3,160	4,972
Ireland	380	547	732	913	1,169
Italy	3,590	4,675	5,343	5,702	6,940
Lithuania	223	687	1,536	2,503	4,247
Luxembourg	130	180	244	315	419
Latvia	69	173	337	509	790
Netherlands	1,247	1,763	2,266	2,703	3,465
Poland	1,327	3,311	5,463	8,818	15,137
Portugal	401	696	1,041	1,379	1,934
Romania	998	2,519	5,158	8,931	15,981
Sweden	1,418	1,832	2,219	2,557	3,061
Slovenia	103	147	197	255	355
Slovakia	363	804	1,379	2,101	3,429
United Kingdom	4,418	6,723	8,707	10,037	14,474

Table A.4: Uncertainty ranges for the 200 year event loss and average annual losses (AAL) for today.

2011	200 year event loss (bn 2011 Euros)		AAL (million 2011 Euros)	
	min	max	min	max
Austria	3.25	9.59	90	516
Belgium	3.26	8.15	93	394
Bulgaria	0.48	1.16	19	72
Czech R	2.07	3.08	63	190
Germany	5.37	13.25	162	805
Denmark	1.44	11.43	37	780
Estonia	0.19	0.46	6	26
Spain	1.98	5.62	50	341
Finland	2.06	5.45	90	335
France	7.10	22.23	210	1448
Greece	0.61	1.62	20	92
Hungary	1.58	3.17	45	192
Ireland	0.94	2.49	26	140
Italy	5.89	17.12	189	1054
Lithuania	0.42	1.14	11	70
Luxembourg	0.98	3.13	62	167
Latvia	0.26	0.72	7	38
Netherlands	3.51	6.71	142	372
Poland	1.45	4.28	46	265
Portugal	0.31	0.63	11	38
Romania	1.41	4.27	44	277
Sweden	1.83	5.58	94	348
Slovenia	0.63	1.25	31	69
Slovakia	1.61	3.98	46	205

Annex I

Long list of PI (Excel Sheet)

Annex II

Policy Instrument Fact Sheet: “Grants for preventive measures”

Category				Specification
<input checked="" type="checkbox"/> MBI	<input type="checkbox"/> RMI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Grant
Country		Sweden		
Administrative entity		Municipalities / Swedish Rescue Services Agency		
Summary of policy instrument / approach				
<p>The climate scenarios for Sweden show that weather-related events such as floods, storms and landslides will increase over the next hundred years. A key issue is where the responsibility lies for preventing or dealing with any damage. Since the 1980s the Swedish Rescue Services Agency (SRSA) has had an appropriation of SEK 25 million to assist municipalities with preventive measures against natural disasters. The pressure on this appropriation has steadily risen. In 2002 the SRSA responded to a request to revise the grants system, and in 2005 petitioned for certain changes to the grant. The instructions for this commission of inquiry consequently included a separate remit to propose ways in which the system for preventive measures by government relating to floods and landslides can be made more effective. In addition to the issue of the management of the appropriation, the more fundamental issue of principles of funding is raised - when and on what basis is it reasonable for government to provide support for municipalities and individuals? This is also closely linked to where the responsibility is to lie when damage does occur, and thus how responsibilities in society can be shared between central government, municipalities and individuals, and what incentive structures are created (Swedish Government Official Reports 2007; p.573f).</p> <p>The current structure for applying and approving grants for preventive measures is outlined in the following:</p> <p>The SRSA has the full responsibility for administer a budget for grant of SEK 40 million today. To guarantee fair distribution the SRSA has developed criteria for entitlement to grants and their decisions cannot be appealed. The appropriation applies to a “natural event which is not common or does not follow a slow non-dramatic course”. Erosion is therefore not included.</p> <p>Municipalities need to identify eligible preventive measures. Flood prevention can include embankments and dykes, pumping equipment or shutting-down devices for water supply and sewage systems. Landslide prevention can entail slope stabilisation measures. Many of them are large in scale and take several years to implement. For measures that have not already been implemented, the municipalities receive half the granted appropriation when the project is launched and the remainder when it is completed. The application process generally takes about six months. The SRSA passes the documents to expert institutes, which contribute with technical review and assessment of those applications that relate to their areas (geotechnics and hydrology). The site relating to the applications which may be considered for receipt of grants is often visited. Processing of the applications takes</p>				

around 75 per cent of a full-time post per year, including travel. The appropriation applies to existing building development. Grants are thus not made for measures taken in connection with planning activity. The size of the grant is related to the cost of the project. Funds are granted for up to 80 per cent of the cost.

If an area is estimated to have satisfactory safety with the consequence that planned measures do not need to be implemented and finally still get damaged, the municipality can apply for compensation. Compensation payments are only possible for restoring the area to its original standard.

In what context and national setting it has been applied

Central government is generally responsible for national infrastructure such as roads, railways and backbone networks for power transmission. Central government can also be said to have overarching responsibility for crisis management and protection against large scale risks in the form of floods, storms, erosion, landslip and landslide risks and large-scale epidemics. Where large investments have been required, central government has in some cases shared in the financing for example of embankments, tunnels and channels. Municipalities and county councils have equivalent responsibility for more local risks of flooding and landslides. The general mapping done by the SRSA identifies areas that appear to have inadequate safety, areas where the municipality should therefore go on to undertake detailed studies. This process including grants for preventive measures has therefore been applied since 1980. However, as Sweden has recognized increased needs for adaptation in a changing climate the grants were increased and the application process was improved. So it seems that the grant system was upgraded and adjusted to a climate change adaptation measure.

Lack of experience in implementation / lessons learnt so far

The SRSA communicated to the Government the following suggestions for improving the grant system. It requests

that measures in accordance with binding rules or decisions of authorities required to implement the preventive measure should be eligible for compensation, that the preparation of documents, in addition to detailed study, for implementation of the measure should be an expense eligible for reimbursement, that preventive measures relating to coastal erosion that threaten building development should be eligible for reimbursement, that the costs of cleaning and dredging in watercourses to prevent flooding upstream should be eligible for reimbursement.

The SRSA also requests clearer conditions regarding the definition of eligibility of measures and how measures are to be prioritized. There seems to be a lack of adequate criteria in the process.

The two involved expert institutes consider the grant to be of very great benefit as it would not be possible for the vast majority of the measures to be implemented if the grant did not exist. Furthermore the application process and related studies are seen as a form of effective knowledge and capacity building for the municipalities.

Municipalities claim that they have difficulties to spend money for the detailed studies which are required as they are very expensive. Furthermore some municipalities cite difficulties with individual

land-owners refusing access to their land. As the municipality does not have a way to force anyone of taking preventive action or allow access for the community individuals can therefore stop projects completely. There seems to be a need for clearer legislation that clarifies responsibilities and the rights and obligations of the various effected parties.

Institutional requirements

Swedish Rescue Services Agency.

Swedish Geotechnical Institute and the Swedish Meteorological and Hydrological Institute for expert assistance and recommendation of suitable projects for funding.

Municipalities identifying eligible preventive measures and applying for grants.

Key barriers to implementation

Evaluation reports or independent assessments outlining key barriers to implementation of the grants for preventive measures could not be identified.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Additionality determination is reflected as the municipalities need to demonstrate that the project activity is not part of normal planning activity. Positive effects for municipalities beside the prevention measures shall usually not be part of the grants.

Cost effectiveness/efficiency:

As prioritization of projects is conducted by SRSA, a qualitative procedure for selecting the most efficient projects per year is implemented. Hereby the expert assistance by Swedish Geotechnical Institute and the Swedish Meteorological and Hydrological Institute is likely to guarantee quality standards. However, the evaluation does not follow a 100% transparent assessment procedure. Decision of SRSA cannot be appealed. As outlined before the SRSA lacks clearer conditions regarding the definition of eligibility of measures and how measures are to be prioritized.

Distributional considerations:

An average number of about 25 municipalities are applying for grants annually. This number has increased since 2004. The total sum applied for annually hovered around SEK 150 million in the last 10 years, so the Government decided to increase the annual grant budget from SEK 25 million to SEK 40 million in 2007. This enhances chances for large-scale projects which were often rejected before. The Swedish Commission on Climate and Vulnerability suggest reducing individual grants of up to 80% of project costs which would allow a larger number of projects to be funded per year.

Institutional feasibility:

The institutional administration is based on municipalities applying for grants and the SRSA approving appropriations. To assist the SRSA in selecting the most promising projects the

Swedish Geotechnical Institute and the Swedish Meteorological and Hydrological Institute are involved. This composition of responsibilities and expert knowledge is likely to guarantee good quality in project selection and implementation.

Conditions and barriers:

As part of the application procedure detailed studies are required from the municipality. Due to the barrier of a restricted budget, expensive large-scale measures have low chances of approval.

Research gaps

The Swedish Commission on Climate and Vulnerability conducted a detailed evaluation report in 2007 including recommendations for improvements. Several critical issues identified in the report have been reflected in this PI fact sheet. The SRSA and other involved parties seem to report frequently to the government. Therefore it seems that no obvious research gaps are existent.

References and further Information

- Ministry of the Environment Sweden. 2009. Sweden's Fifth National Communication on Climate Change.
http://unfccc.int/resource/docs/natc/swe_nc5.pdf
- Swedish Government Official Reports. 2007. Final report from the Swedish Commission on Climate and Vulnerability.
<http://www.sweden.gov.se/sb/d/574/a/96002>
- Swedish Civil Contingencies Agency (MSB) webpage:
<http://www.msb.se/en/Civil-contingencies/Natural-Disaster-Risk-Reduction/>

Policy Instrument Fact Sheet: "FarmReady program"

Category				Specification
<input checked="" type="checkbox"/> MBI	<input type="checkbox"/> RMI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Grant
Country		Australia		
Administrative entity		Department of Agriculture, Fisheries and Forestry (DAFF)		
Summary of policy instrument / approach				
<p>Australia's FarmReady program is a government initiative to improve productivity and help farmers manage climate change and climate variability by providing AUS\$ 26.5 million in four years (the program will cease in 2012). Several "soft" adaptation measures like capacity building or communication campaigns are supported to improve uptake of risk management and business management skills, increase the use of new technologies, and best practice management. The program consists of two separate elements:</p> <p>FarmReady Reimbursement Grants to individual primary producers and Indigenous land managers to attend approved climate change training activities. Courses registered with the program aim to improve the capacity of primary producers to adapt to climate change and increase self reliance and preparedness. The participants can receive up to AUS\$1500 each financial year to cover the cost of approved training activities, with additional support available for associated expenses such as excess travel, accommodation and childcare.</p> <p>FarmReady Industry Grants to organizations to undertake projects that will enable their members to adapt to climate change. Funding of up to AUS\$ 80,000 per financial year is available for projects which increase industry self reliance and preparedness to adapt to climate change. Eligible participants are the following legal entities carrying out business in Australia:</p> <p>Groups of primary producers that team up specifically to undertake an eligible project.</p> <p>Established primary producer industry organization/group at the local, regional or national level.</p> <p>Natural resource management groups at either a local, regional or national level.</p> <p>Project proposals should focus on activities that are responsive to the potential impacts of climate variability and climate change on industry and regional groups and will provide skills, knowledge or strategies to help industry address these issues. Proposals may include new educational or training programs, adaptation of existing programs or implementation of current research results. Activities could include:</p> <p>Identifying strategies to combat emerging climate change issues.</p> <p>Industry-specific training plans at a local, regional, state or national level.</p> <p>Reviews of existing programs and strategies to assess effectiveness.</p>				

Climate change related communication campaigns.

Identification of skills requirements.

Identification and removal of specific barriers that inhibit access to climate change information.

Facilitation of uptake of best management techniques, strategies, practical adoption of climate variability and climate change adaptation and mitigation practices.

Not eligible for grant funding is e.g. purchasing of infrastructure, applicant marketing campaigns, development of prototypes or activities which are funded already by other state programs.

To apply for grants, applicants need to submit a predefined application form including supporting documentation and a detailed calculation of project costs. The maximum amount of grant is AUS\$ 240,000 over 3 financial years. Measurement of performance against the objectives of the project has to be outlined as well and a final and audit report is required at the end of the project to verify that expenditure has occurred in accordance with the Funding Agreement.

An independent advisory panel will assess the applications and recommend suitable projects for funding. All selected projects are published in the internet. Two rounds of granting have been conducted and the whole program budget is distributed.

Most of the following sections are targeting especially issues related to FarmReady Industry Grants as they have a significant higher volume of funding and more complex appliance and approval procedures.

In what context and national setting it has been applied

The Australian primary industries face unique challenges in a changing climate and could face a broad range of repercussions. There may be physical impacts (e.g. changing rainfall patterns), social impacts (e.g. changes to farm business structures, community demographics, health and wellbeing) and economic impacts (e.g. changing productivity levels and markets). Primary producers reported significant barriers to adapting to changes in climate such as financial stress from prolonged drought, an ageing workforce and succession issues.

Therefore the Australian Government initiated several elements within the so-called “**Australia’s Farming Future**” initiative to help primary producers adapt and respond to climate change:

The **Climate Change Research Program** provides funding for research projects and on-farm demonstration activities.

Climate Change Adjustment Program assists farmers in financial difficulty to manage the impacts of climate change. Farm Business Analysis and Financial Assessments and professional advice and training are individually tailored to help farmers adjust to climate change and to set goals and develop action plans to improve their financial circumstances. Rural financial counsellors can assist eligible farmers to take action to improve their long term financial position. Re-establishment assistance provides farmers who sell their farms with assistance to re-establish themselves.

Transitional income support is linked to the climate change adjustment program and provides short-term income support and advice and training opportunities to farmers in serious financial difficulty,

while they adapt their farm to changing circumstances, including climate change.

Community Networks and Capacity Building activities will focus on increasing the leadership and representative capacity of target groups including women, young people, Indigenous Australians and people from culturally and linguistically diverse backgrounds.

FarmReady helps industry and primary producers develop skills and strategies to help them deal with the impacts of climate change. It was chosen to be outlined within this PI Fact Sheet because it was identified as an approach which can be applied for by a broad variety of stakeholders and the implemented procedures seems to be mature. Additionally the highest volume of funding is spent for FarmReady from the selection of the initiatives described above.

Lack of experience in implementation / Lessons learnt so far

As two rounds of grants have been accomplished already in 2009, the implementation procedure of this adaptation instrument is likely to be mature. Evaluation reports or independent assessments for the FarmReady program could not be identified.

Institutional requirements

- Department structure (e.g. DAFF has to be established already).
- Independent expert advisory panel for assessment of applications and recommendation of suitable projects for funding.
- Decision maker (e.g. minister of department) for considering proposals against each other and determine priority for funding.
- A final and an audit report are required at the end of the project to verify that expenditure has occurred in accordance with the Funding Agreement.

Key barriers to implementation

Evaluation reports or independent assessments outlining key barriers to implementation of the FarmReady program could not be identified.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Additionality determination is reflected as the applicant needs to demonstrate that the project activity is not part of normal business and there is no other state support available. However there are no generally comparable indicators for measuring the adaptive effect. Transparency about the volume of funding and the selected projects is given.

Cost effectiveness/efficiency:

As prioritization of projects is conducted by decision maker, a qualitative procedure for selecting the most efficient projects per round is implemented. Hereby the expert panel with skills and knowledge in agribusiness, learning, climate change and other areas of relevant technical

expertise identifies priority sectors and groups where a FarmReady grant would make a difference. However, the expert advisory panel does not follow a 100% transparent assessment procedure.

Distributional considerations:

Every applicant who fulfils the legal entity requirements can apply for funding. On the one hand the restriction of project size to 80.000 \$AUS p.a. guarantees equitable distribution, on the other hand it avoids large scale ideas.

Institutional feasibility:

The institutional administration (DAFF) is a recognized part of the Australian Government. Consistency with other policy instruments is given by integration of the program into the National Adaptation Framework. Double funding through several policy instruments is not allowed.

Conditions and barriers:

Certain conditions are required by the applicant. They seem to be appropriate to allow the participation of a broad variety of target stakeholders. Funding of “hardware” (infrastructural assets like water tanks or fencing) is not possible.

Research gaps

As no evaluation reports or independent assessments for the FarmReady program could be identified there obviously exists a research gap related to the outcome verification of the program.

References and further Information

- Government of Australia. 2010. Adapting to Climate Change in Australia. Published by Department of Climate Change.
<http://www.climatechange.gov.au/en/government/~media/publications/adaptation/190210-dcc-positionpaper.ashx>
- Government of Australia. 2007. National Climate Change Adaptation Framework
http://www.coag.gov.au/coag_meeting_outcomes/2007-04-13/docs/national_climate_change_adaption_framework.pdf
- DAFF. 2009. FarmReady Industry Grants – Round 2
http://www.daff.gov.au/_data/assets/pdf_file/0004/1221376/farmready-industry-guidelines-r2.pdf
- DAFF. FarmReady information webpage : <http://www.daff.gov.au/climatechange/australias-farming-future/farmready>

Policy Instrument Fact Sheet: "Climate Change Adjustment Program"

Category				Specification
<input checked="" type="checkbox"/> MBI	<input type="checkbox"/> RMI	<input checked="" type="checkbox"/> PPP	<input type="checkbox"/> Other	Grant, Public Private Partnership
Country		Australia		
Administrative entity		Department of Agriculture, Fisheries and Forestry (DAFF)		
Summary of policy instrument / approach				
<p>Australia's Climate Change Adjustment Program is a government initiative to assist farmers managing the impacts from climate change. It is embedded in the Australia's Farming Future initiative which shall prepare and support farmers in changing climate conditions. The Adjustment Program consists of three elements which are partially interrelated:</p> <p>Adjustment advice and training grants to individual primary producers. The grant may be used for professional advice and/or training to manage climate change impacts. It may cover financial assessment and planning, advice and training related to climate change impacts on agronomic, climate forecasting and carbon emissions mitigation. Furthermore advice and training to assist the transition off the enterprise into either an alternative career or retirement is eligible. Up to AU\$ 5,500 is available for funding the activities, including travel costs. Applicants have to submit an application either in cooperation with a Rural Financial Counsellor or independently via the Australian Centrelink. The first one is open for farmers in difficult financial situations.</p> <p>Transitional Income Support will assist farmers, regardless of location or industry, who are in need of short term income support to assist recovery from drought, and to help them manage the impacts of climate change. Farmers receiving Transitional Income Support will be obliged to take action to achieve financial self-reliance and to increase their preparedness for changing economic and climatic conditions. Principle features are a connection with the advice and training scheme and maximum support duration of 12 months.</p> <p>Re-establishment Grant offers re-establishment assistance of up to \$150,000 to farmers who sell their farm enterprise and do not own or operate a farm enterprise for at least 5 years. To receive assistance, the applicant has to fulfil several eligibility requirements such as main income from the farm, comply with a total net asset limit or satisfy an income and assets test at the time selling the farm.</p> <p>All three initiatives have been established in the year 2008 and are running for three years.</p>				
In what context and national setting it has been applied				
<p>The Australian primary industries face unique challenges in a changing climate and could face a broad range of repercussions. There may be physical impacts (e.g. changing rainfall patterns), social impacts (e.g. changes to farm business structures, community demographics, health and wellbeing) and</p>				

economic impacts (e.g. changing productivity levels and markets). Primary producers reported significant barriers to adapting to changes in climate such as financial stress from prolonged drought, an ageing workforce and succession issues.

Therefore the Australian Government initiated several elements within the so-called “**Australia’s Farming Future**” initiative to help primary producers adapt and respond to climate change:

The **Climate Change Research Program** provides funding for research projects and on-farm demonstration activities.

Climate Change Adjustment Program assists farmers in financial difficulty to manage the impacts of climate change. Farm Business Analysis and Financial Assessments and professional advice and training are individually tailored to help farmers adjust to climate change and to set goals and develop action plans to improve their financial circumstances. Rural financial counsellors can assist eligible farmers to take action to improve their long term financial position. Re-establishment assistance provides farmers who sell their farms with assistance to re-establish themselves.

Transitional income support is linked to the climate change adjustment program and provides short-term income support and advice and training opportunities to farmers in serious financial difficulty, while they adapt their farm to changing circumstances, including climate change.

Community Networks and Capacity Building activities will focus on increasing the leadership and representative capacity of target groups including women, young people, Indigenous Australians and people from culturally and linguistically diverse backgrounds.

FarmReady helps industry and primary producers develop skills and strategies to help them deal with the impacts of climate change. It was chosen to be outlined within this PI Fact Sheet because it was identified as an approach which can be applied for by a broad variety of stakeholders and the implemented procedures seems to be mature. Additionally the highest volume of funding is spent for FarmReady from the selection of the initiatives described above.

Lack of experience in implementation / Lessons learnt so far

As the initiatives are running since the year 2008, the implementation procedure of this adaptation instrument is likely to be mature. Evaluation reports or independent assessments for the Climate Change Adjustment Program could not be identified.

Institutional requirements

- Department structure (e.g. DAFF has to be established already).
- Professional “prescribed” advisors carrying out CCAP Advice and Training.
- Rural Financial Counsellors for identification course of action and development of action plans with the applicants for Transitional Support.
- The Centrelink network including “Authorized Officers” for administration of appliances.

Key barriers to implementation

Evaluation reports or independent assessments outlining key barriers to implementation of the FarmReady program could not be identified.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Additionality determination is reflected as applicants are required to demonstrate that there is urgent need for financial support.

Cost effectiveness/efficiency:

As applicants have to fulfil a set of conditions before transitional support or re-establishment funding is provided, the selection process is likely to guarantee that only farmers with financial difficulties receive funding. There is no independent assessment about different options for the affected farmers available. Obviously a research gap exists if the outlined CCAP initiatives have good performance regarding cost effectiveness.

Distributional considerations:

Every applicant who fulfils the legal entity requirements can apply for grants or funding. Financial assessments account individual needs which get approved by either the Rural Financial Counsellor or the Authorized Officer at Centrelink. Funding caps guarantee broad distribution of funding.

Institutional feasibility:

The institutional administration (DAFF) is a recognized part of the Australian Government. Consistency with other policy instruments is given by integration of the program into the National Adaptation Framework. Interrelations between the three initiatives are by purpose, e.g. the training program identifies the need for transitional support.

Conditions and barriers:

Certain conditions are required by the applicant. They seem to be appropriate to allow the participation of a broad variety of target stakeholders. If the net assets of applicants are exceeding a certain threshold (AUS\$ 575,000 for re-establishment; 1.5 million for transitional support) they are not eligible for funding.

Research gaps

As no evaluation reports or independent assessments for the Climate Change Adjustment program could be identified there obviously exists a research gap related to the outcome verification of the program.

References and further Information

- Government of Australia. 2010. Adapting to Climate Change in Australia. Published by Department of Climate Change.
<http://www.climatechange.gov.au/en/government/~media/publications/adaptation/190210->

[dcc-positionpaper.ashx](#)

- Government of Australia. 2007. National Climate Change Adaptation Framework
http://www.coag.gov.au/coag_meeting_outcomes/2007-04-13/docs/national_climate_change_adaption_framework.pdf
- DAFF. 2008. CCAP Advice and Training Grant policy guidelines:
http://www.daff.gov.au/_data/assets/pdf_file/0019/1058131/ccap-training-nov10.pdf
- DAFF. 2008. CCAP Re-establishment Grant policy guidelines:
http://www.daff.gov.au/_data/assets/pdf_file/0003/1058133/ccap-re-estab-dec2010.pdf
- DAFF. 2010. Transitional Income Support policy guidelines:
http://www.daff.gov.au/_data/assets/pdf_file/0005/1058135/tis-guidelines-december-2010.pdf
- DAFF. Climate Change Adjustment Program information webpage :
<http://www.daff.gov.au/climatechange/australias-farming-future/climate-change-adjustment-assistance>

Policy Instrument Fact Sheet: “Local flood defence levy”

Category				Specification
<input checked="" type="checkbox"/> MBI	<input type="checkbox"/> RMI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Levy
Country		United Kingdom		
Administrative entity		Environment Agency (Regional Flood Defence Committees)		
Summary of policy instrument / approach				
<p>The Regional Flood Defence Committees (RFDC) of the Environment Agency raise funding for (smaller-scale) projects improving local flood protection by local authorities. The funding is realised by imposing local levies on local county councils and unitary authorities within the committees’ boundaries. The levy is an additional, locally-raised source of income for Regional Flood Defence Committees. It is used to support, with the approval of the relevant committee, flood risk management projects that are not eligible for national funding. The local levy enables the Environment Agency, through the RFDC, to implement locally important projects to reduce the risk of flooding within the committees’ areas.</p> <p>In the following see two regional examples of fundraising for local flood protection by RFDCs in the Northumbria and Wessex:</p> <p>1. In the North East, the RFDC approved a funding package £2.4 million for this financial year (2011/2012) that will be assigned to flood protection projects. The funding is raised from local authorities in the North East by the Northumbria Regional Flood Defence Committee. The Northumbria Local Levy is used to finance around thirty projects during the financial year 2011/12 including the following schemes (see News release by the Environment Agency, January 2011):</p> <p>Repairing and raising the floodwalls in an area along the Ouseburn in Newcastle;</p> <p>Building flood banks and walls to protect properties in some of the areas close to Lustrum Beck in Stockton-Upon-Tees;</p> <p>The continuation of flood work in Belford, Northumberland. In previous years levy money has paid for the creation of a series of “leaky ponds” to hold back flood water. The next stage is to carry out work to the channel so that flood water can be conveyed quickly through the town.</p> <p>The expansion of the successful Living Waterways project into Teesside. The project team works with communities to reduce flood risk and improve urban streams and their associated green spaces for people and wildlife.</p> <p>2. The Wessex Flood Defence Committee has agreed a levy of £3.16 million in the financial year 2011/2012 in order to fund flood protection measures for homes and businesses across Somerset, Bristol, Dorset and Wiltshire. Overall, the proposed levy programme shall increase the flood protection for more than 800 homes within the next five years. Almost half of the funds during the</p>				

financial year 2011/2012 will be assigned to the largest project, the River Jordan flood defence scheme at Weymouth. The rest will be spent on several other projects, such as two culvert improvement schemes in Bristol and Crewkerne or other individual property protection projects. (see WaterBriefing, January 2011)

In what context and national setting it has been applied

The local levy for flood protection measures enable the Environment Agency, through the Regional Flood Defence Committees, to fund local, smaller scale flood protection schemes, that are not eligible to national funding.

Lack of experience in implementation / Lessons learnt so far

No evaluation or independent assessments for the work of the RFDCs and the local flood defence levy could be identified. This may be due to the fact, that the RFDC funding benefits numerous small-scale projects all over England and Wales.

Institutional requirements

Work on flood risk management in local areas of England and Wales carried out by the Environment Agency through the Regional Flood Defence Committees (RFDC). The RFDCs were established by the Environment Act 1995, Section 14. They present a type of governmental body and consists of a chair appointed by the Secretary of State and a number of other representatives appointed by

local authorities,

Environment Agency

Department for Environment, Food and Rural Affairs

The RFDC has various statutory powers including the following:

to maintain or improve any watercourses which are designated as main rivers

to maintain or improve any sea or tidal defences

to install and operate flood warning equipment

to control actions by riparian owners and occupiers which might interfere with the free flow of watercourses

to supervise internal drainage boards

The RFDCs are required to take an interest in all flood matters in their area and in particular to take

decisions about the annual programmes of improvement and maintenance work to be carried out by the Agency. They must also decide on such matters as the extension of main rivers, the making and operation of land drainage byelaws and various issues affecting any internal drainage boards in their area. They are required annually to approve estimates of expenditure and to determine the amounts to be levied by the Agency on constituent councils. (see www.defra.gov.uk)

Key barriers to implementation

Evaluation reports or independent assessments outlining key barriers to implementation of local flood defence levies could not be identified. However, since the levy is raised by local authorities it seems to be reasonable to assume, that there are local budget constraints.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

The levy funds numerous regional smaller scale project. The levy's effectiveness as a whole could not be identified.

Cost effectiveness/efficiency:

Evaluation of the levy's efficiency could not be identified.

Distributional considerations:

As the levy is raised on the local level, there is a redistribution of funds within the boundaries of an RFDC to homeowners and businesses (also communities) that benefit from funded projects in terms of the decreasing flood risk.

Institutional feasibility:

The RFDCs consist of members appointed by the local authorities, the Environment Agency and the Department for Environment, Food and Rural Affairs. Therefore, the committees have to consider local as well as national policies and needs. This should ensure consistency between local and national policy instruments.

Conditions and barriers:

The RFDCs have to prioritise projects due to limited funding. Distributional effects between the communities within the boundary of an RFDC might play a role, as local councils are involved and not all communities may benefit equally.

Research gaps

As there are no evaluation reports or independent assessments identified, there obviously exists a research gap related to the outcome-verification of the local flood levy funding.

References and further Information

- Environment Agency, 24 January 2011

<http://www.environment-agency.gov.uk/news/126859.aspx>

- Department for Environment, Food and Rural Affairs (DEFRA)
<http://www.defra.gov.uk/environment/flooding/who/rfdc.htm>
- WaterBriefing, 17 January 2011
<http://www.waterbriefing.org/index.php/home/flooding/item/3752-flood-protection-local-levy-funding-for-2011/12-published>
- Environment Act 1995
<http://www.legislation.gov.uk/ukpga/1995/25/contents>

Policy Instrument Fact Sheet: “Temporary Flood Reconstruction Levy”

Asdasda

Category				Specification
<input checked="" type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Levy
Country		Australia		
Administrative entity		Australian Government		
Summary of policy instrument / approach				
<p>Devastating floods have caused damages estimated up to 6bn AUS\$ in the Australian state of Queensland and surrounding provinces in December 2010 and early 2011. As Queensland relies on a long-standing arrangement which requires the Commonwealth (National State) to cover 75% of disaster damages, the Australian Government reacted twofold to finance reconstruction: On the one hand deferred and cut spending (especially on new infrastructure projects like roads) will enable the Government to finance rebuilding of about 4bn AUS\$. On the other hand missing funding will be sourced by a temporary flood reconstruction levy.</p> <p>Hence the Government introduced a “Bill for an Act to amend the law relating to taxation, and for related purposes” into the Parliament of Australia. The conceptual design is based on an additional income tax for the 2011-12 financial year.</p> <p>Only people with taxable income exceeding AUS\$ 50,000 will have to pay the extra levy, most persons affected by natural disasters between 1 July 2010 and 30 June 2012 are exempted.</p> <p>The extra tax rates are graduated according to the following taxable income:</p> <p>Individuals with a taxable income of \$50,000 or less in the 2011-12 financial year will not pay the levy.</p>				

Individuals with a taxable income between \$50,001 and \$100,000 will pay a 0.5 per cent levy on that part of taxable income above \$50,000 in the 2011-12 financial year only.

Individuals with a taxable income of \$100,001 or more will pay a 0.5 per cent levy on that part of their taxable income between \$50,001 and \$100,000 and a 1.0 per cent levy on that part of their taxable income above \$100,000 in the 2011-12 financial year only.

The Government justifies the national tax levy as follows: “A legislative instrument provides the flexibility to act quickly in providing tax relief to individuals who have been adversely affected by the ad hoc and unpredictable natural disasters that occur in Australia.”

In what context and national setting it has been applied

Even though the Government of Australia is aware of negative climate change driven impacts and reacted in form of several adaptation initiatives, a national insurance strategy for the special situation of extreme events has not been established yet. But as a special form of risk based management the states receive support from the Commonwealth of Australia under the “Natural Disaster Relief and Recovery Arrangements”. In the case of Queensland the national state has to cover 75% of disaster damages. As state insurance is absent and individual insurance approaches are occasional and many affected people in Queensland and surrounding provinces have not prepared themselves, some sort of governmental reaction was legally unavoidable.

Lack of experience in implementation / Lessons learnt so far

The ad hoc reaction of implementing a tax levy for financing reconstruction proofed a lack of preparedness for these cases of extreme events. There is no evidence that the national government followed a pre-defined strategy as the related bill was elaborated after the flooding.

However some of the affected states claimed that this kind of government intervention was prioritized over insurances as the alternative option. The Premier of Queensland, Anna Bligh, stated: 'We've made a judgement that because of the number of natural disasters we have and the nature of them, it's actually more cost effective for us to deal with our money when it happens (and not pay for insurance),'

As the levy is under preparation there is no evaluation of effects available so far.

Institutional requirements

The major requirement is the elaboration and introduction of the tax levy bill by the executive institution Australian Government and the legislative institutions House and Senate which have to approve it. As governmental majorities in the Senate are able to change overtime, a political consensus is an additional requirement. In case a consensus can't be achieved the bill would be declined in the worst case. This inherits a significant risk for the operability of this form of policy instrument.

The institution which is responsible for implementing and execution of the bill, the National Treasury, is established.

Key barriers to implementation

As outlined before the key barrier will be achieving political consensus to accept a tax levy bill for reconstruction post the extreme event.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Additionality determination is reflected as there was no national insurance or support mechanism for reconstruction of extreme event damages in place. However one could argue that due to the contract with the state Queensland, the Commonwealth would have to pay 75% of damages anyway.

There is no evidence that this policy instrument has an adaptive effect besides the risk management. Transparency about the volume and sources of funding as well as selected population groups is given. There is no transparency yet who will receive which amounts in detail and which distribution criteria will be applied.

Cost effectiveness/efficiency:

As claimed by several state governments they preferred a post disaster tax levy instead of pre disaster insurances because of economical effectiveness. Insurance companies cited in several press releases state the opposite point of view. They claim that an insurance mechanism would have had economical benefits and the government support of affected population groups will further discourage people to rely on insurances as the state cares anyway. With less participants insurance prices would end up with higher rates which further discourage insurance based risk management.

Distributional considerations:

According to government statements "all" affected individuals, communities and states will receive support for reconstruction. As described there is no detailed information about distribution criteria available.

Institutional feasibility:

The institutional administration for distribution of finance (Treasury) is a recognized part of the Australian Government. Consistency However political consensus within the institutions which are required to accept the bill (House and Senate) is not guaranteed for all cases of that kind of policy instrument. There can be discussion and risk of failure at all future comparable situations the Government aims to use this kind of instrument.

Conditions and barriers:

Besides obviously damages from extreme events the major condition is political consensus of the majority of the Legislative. This issue can be the most relevant barrier at the same time. There are no special conditions for affected population beside the need for support.

Research gaps

There are two opposing statements from state Governments and insurance companies about cost efficiency of this policy instrument. On the one hand the Governments claim that this way reflects the most efficient way of dealing with extreme events however this opinion could be influenced by short-term state budget reasons which avoid regular spending on insurance.

On the other hand insurance companies argue that a broader use insurance mechanisms would have been the cost efficient alternative and the tax levy will further discourage the application of insurances. This opinion could be influenced by their main interest of profit through the sale of their insurance products.

An independent assessment for the specific case of Australian extreme events which compares tax levies with insurance based products is not available and therefore can be seen as a research gap.

References and further Information

- Government of Australia. 2011. Tax Laws Amendment (Temporary Flood Reconstruction Levy) Bill 2011.
http://www.austlii.edu.au/au/legis/cth/bill_em/tlafrlb2011613/memo_0.html
- Government of Australia. 2011. Legislation making or amending Australian Tax Laws
<http://www.taxmap.com.au/pdfs/ON-LINE%20-%2002%20~%20Part%207%20-%20Bills%20before%20the%20Parliament.pdf>
- Government of Australia. 2011. Natural Disaster Relief and Recovery Guidelines:
http://www.ema.gov.au/www/emaweb/emaweb.nsf/Page/EmergencyManagement_RecoveringfromEmergencies_NaturalDisasterReliefandRecoveryArrangements_NDRRAGuidelines
- The Daily Telegraph – Govt will consider disaster insurance:
<http://www.dailytelegraph.com.au/govt-will-consider-disaster-insurance/story-fn6b3v4f-1226009002098>
- Xinhuanet – Insurers oppose Australians gov't to introduce floods levy for reconstruction:
http://news.xinhuanet.com/english2010/world/2011-01/25/c_13706131.htm
- SkyNews – Flood levy not related to insurance:
<http://www.businesschannel.com.au/politics/article.aspx?id=573035&vld>

Policy Instrument Fact Sheet: Household insurance: Mandatory all hazards insurance system (Catastrophes Naturelles)

Category				Specification
<input checked="" type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Mandatory all hazards insurance system (Catastrophes Naturelles)
Country		France		
Administrative entity		French Government		
Summary of policy instrument / approach				
Private insurers in France are required to offer catastrophe insurance in an all-hazards policy that is bundled with property insurance. Policies are not risk based, and there are large cross-subsidies inherent in the system. The program is reinsured through a public administered fund, the Caisse Centrale de Réassurance (CCR). If this fund proves insufficient, taxpayers will be called upon to contribute.				
In what context and national setting it has been applied				
As in many countries, private insurers are often not prepared to fully underwrite disaster risks, France legislated a public-private national insurance systems for natural perils with mandatory participation of the insured backed by taxpayer money.				
Lack of experience in implementation / Lessons learnt so far				
The present system has been in place since 1982.				
Institutional requirements				
By Government decree.				
Key barriers to implementation				
Mandatory insurance always faces strong resistance, which can be overcome if premiums are cross-subsidized.				
Summary of advantages and disadvantages according to evaluation criteria				
<p><u>Adaptation effectiveness:</u></p> <p>To counter the problem of disincentives from the cross subsidies, a recent decree sets a deductible that increases with the number of disasters in the same area. This means that the compensation a household or business receives will continually decrease in high-risk areas,</p>				

leading to incentives to relocate or take other loss-reduction measures.

Cost effectiveness/efficiency:

Cost effectiveness is not the major concern, as premiums are not risk based and cross-subsidized from low to high risk areas.

Distributional considerations:

The French have rejected risk-based premiums in favour of a flat rate as a percentage of the property value.

Institutional feasibility:

Government acts as insurer and thus takes on disaster insurance as a monopoly provider.

Conditions and barriers:

Government on case by case basis decided what constitutes a natural disaster, so some uncertainty remains as to whether the affected will indeed be compensated post event, which however has mostly happened

Research gaps

A gap is the potential for required changes in cross-subsidization of premiums in a c hanging climate regime.

References and further Information

Aakre, S., I. Banaszak, R. Mechler, D. Rübelke, A. Wreford and H. Kalirai (2010). Financial adaptation to disaster risk in the European Union. Mitigation and Adaptation Strategies for Global Change 15 (7): 721-736

Schwarze, R. and G. Wagner (2009). Natural Hazards Insurance in Europe – Tailored Responses to Climate Change Needed. University of Innsbruck. Working Papers In Economics and Statistics 2009-06.

Van den Bergh, R., Faure, M. (2006). Compulsory Insurance of Loss to Property caused by Natural Disasters: Competition or Solidarity?. World Competition, 29: 25-54

Policy Instrument Fact Sheet: Agricultural insurance Spain

Category				Specification
<input checked="" type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input checked="" type="checkbox"/> PPP	<input type="checkbox"/> Other	Agricultural insurance
Country		Spain		
Administrative entity		Government and private sector		
Summary of policy instrument / approach				
<p>Spain has one of the most advanced and elaborate agriculture insurance systems in the EU. Crop insurance has developed significantly in Spain over the last 30 years to the current private-public agriculture insurance system which is greatly subsidized by the government. The Spanish point of view is that the cost of subsidizing insurance premiums can be less costly than emergency relief payments following a disaster. This will be the case for any subsidized system, depending of course on the amount of government relief, since the farmer takes partial responsibility. In the event that public funds are provided for drought relief, farmers who opted to not buy crop insurance when it was available are not eligible for government funds for relief, a strong disincentive not to purchase insurance. Insurance penetration is over 25%, and coverage is close to 45% for all the agricultural production (and above 70% for winter cereals and fruits).</p> <p>While agricultural insurance for natural perils is not compulsory or public (as in the case of property insurance) there is strong government involvement in the insurance pool (Agroseguro), which is protected by a national reinsurance company (Consorcio de Compensación de Seguros) and involvement of global reinsurers. The policies are highly subsidized (over 40%), which means there is little relation of the premiums to the risks (the premium/loss ratio is around 6%).</p>				
In what context and national setting it has been applied				
Agriculture				
Lack of experience in implementation / Lessons learnt so far				
Government bail out clause suggests that farmers who opt to not buy crop insurance are not eligible for government funds for relief, a strong disincentive not to purchase insurance.				
Institutional requirements				
Public private partnerships				
Key barriers to implementation				

Efficient partnership with key actors.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Potentially high as incentives for risk reduction are provided to farmers. Government no bail out clause suggests that farmers should take action if they are not insured

Cost effectiveness/efficiency:

Medium to large subsidies in the system.

Distributional considerations:

High, as farmers are targeted.

Institutional feasibility:

Depending on the national setting and willingness to provide subsidies and reinsurance

Conditions and barriers:

Depending on the national context.

Research gaps

Effective incentives provided in the scheme and uptake of risk reduction by farmers.

References and further Information

European Commission (2006). Agricultural Insurance Schemes, European Commission DG Agriculture and DG Joint Research Centre Final Report.

Policy Instrument Fact Sheet: Sovereign insurance: EU solidarity fund (EUSF)

Category				Specification
<input type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input checked="" type="checkbox"/> PPP	<input type="checkbox"/> Other	EU solidarity fund (EUSF)
Country		EU		
Administrative entity		Commission		
Summary of policy instrument / approach				
<p>Recognising that floods and other disasters may lead to overburdening national governments and necessitate international assistance even in Europe, the EU Solidarity Fund (EUSF) was created after the floods in central Europe in summer 2002 and entered into force already on November 15th of that year. Member states, and countries applying for accession, can request aid in the event of a major natural or technological disaster. The fund provides financial aid for emergency measures in the event of a natural disaster causing direct damages above 3 billion Euros (at 2002 prices) or 0.6 percent of the GNI. Fund support can be mobilized even if the threshold is not met, e.g. for a neighbouring country that is affected by the same major natural disaster or for extraordinary regional disasters which affect the majority of the population of a region and have serious effects on its economic stability and living conditions.</p>				
In what context and national setting it has been applied				
<p>The payments from the Fund are limited to finance operations undertaken by the public authorities alleviating non insurable damages (e.g. restoring infrastructure operation). The European Commission decides the amount of aid and proposes its mobilization. The maximum annual budget is 1 billion Euros per year. The amount annually available for extraordinary regional disasters is limited to 7.5 percent of the EUSF's annual budget. However, the actual amount varies from year to year, depending on the occurrence of disasters.</p>				
Lack of experience in implementation / Lessons learnt so far				
<p>Since its creation, almost all EU countries have asked for support from the fund, and many in fact have received assistance. There have even been situations, such as in 2002 and 2003 after large scale flooding in central Europe, where the fund was nearly depleted already in the middle of the year. In relative terms, the support granted through the EUSF is still small compared to the damages incurred; for example, Austria received 134 million Euro for financing flood losses in 2002 compared to a total direct damage of 2,900 million Euro. Member states have suggested that the criterion of the EUR 1 billion losses to acquire access to the EUSF is set too high, and that the criterion of at least half of an affected region's population having incurred losses may also not easily be fulfilled.</p>				

Institutional requirements

Regulated by EU decree.

Key barriers to implementation

Already implemented

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

The EUSF is an inefficient instrument insofar as post-disaster “free” assistance encourages risky behaviour and especially further construction in high risk areas. The Fund was meant to cover only uninsurable risks, but most risks covered by the EUSF are, indeed, insurable. This means European solidarity is crowding out private and public responsibility and reducing incentives for preventing disaster losses in Europe. Such effects are usually subsumed under the term “charity hazard” (see Raschky and Weck-Hannemann, 2007)

Cost effectiveness/efficiency:

Based on modelled flood disaster losses across Europe (see Hochrainer, et al., 2010), there may be a significant risk that the EUSF is not sufficiently capitalized. In the worst case, major disasters in western Europe may deplete the Fund, leaving no capital to cover claims from major disasters occurring in eastern Europe at a later date. This liquidity risk will worsen if the eligibility criteria are lowered as presently discussed, or in light of climate, land-use and other changes increasing disaster risks in Europe.

Distributional considerations:

The EUSF was created to promote cohesion in the Union and reduce economic disparities by providing support to countries struck by major disasters. Yet, the short history of the Fund shows that eastern European countries have received less assistance as a percentage of their eligible losses during this period than their western European counterparts, and the number of days from application to grant decision has been significantly higher for eastern European countries. Whereas the purpose of the Fund is to grant exceptional financial aid if the government’s capacity to face up to the losses reaches their limits, it appears that Austria, and probably other wealthy European countries, qualifies for aid at levels for which it can easily cope. This appears to violate the principle of cohesion upon which the EUSF is built.

Institutional feasibility:

The EUSF appears to enjoy general acceptance among member countries; yet, to date there are no analyses examining its performance.

Conditions and barriers:

While specific EU funds to address floods exist, there is no equivalent to addressing drought and water scarcity. In this domain, problems may become more pronounced if losses are increasing and the scope for applying for relief payments is widened, as is currently discussed in the EU. The Commission has actually already expressed its readiness to examine all requests for EUSF aid following droughts but will ensure that “the request is not the indirect result of inefficient water management and that appropriate drought management plans are in place.” Moreover, the Commission will assess whether changes need to be made to the definition of the criteria and eligible operations so that the EUSF may respond better to drought and other events, which are currently not covered.

Research gaps

Little is known about the capacity of the EUSF compared to the risk it should cover, specifically what relates to multiple risks. Also, the contribution of climate change over the next years to decades is still very difficult to assess.

References and further Information

Council Regulation (2002). No. 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund.

Commission Report (2004). European Union Solidarity Fund Annual report 2002-2003 and Report on the experience gained after one year of applying the new instrument. COM (2004) 397 final, Brussels, 26.5.2004.

Commission Report (2005). European Union Solidarity Fund Annual Report 2004. COM (2005) 709 final, Brussels, 23.12.2005.

Commission Report (2006). European Union Solidarity Fund Annual Report 2005. COM (2006) 444 final, Brussels, 7.8.2006.

Commission Report (2007). European Union Solidarity Fund Annual Report. COM (2007) 632 final, Brussels, 25.10.2007.

Commission Report (2008). European Union Solidarity Fund Annual Report. COM (2008) 722 final, Brussels, 12.11.2008.

Hochrainer, S., J. Linnerooth-Bayer and R. Mechler (2010). The European Union Solidarity Fund. *Mitigation and Adaptation Strategies for Global Change* 15 (7): 797-810

Linnerooth-Bayer, J., Mechler, R. (2007) "Disaster safety nets for developing countries: Extending public-private partnerships." In: Amendola, A., Linnerooth-Bayer, J., Okada, N., Shi, P. (Ed.), Special issue on Disaster Risk Management, *Environmental Hazards* 7(1): 54-61.

Raschky, P., Weck-Hannemann, H. (2007) Charity Hazard – A real Hazard to Natural Disaster Insurance? *Environmental Hazards* 7: 321-329

Policy Instrument Fact Sheet: Mexico sovereign insurance

Category				Specification
<input checked="" type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input checked="" type="checkbox"/> PPP	<input type="checkbox"/> Other	Mexico sovereign insurance
Country		Mexico		
Administrative entity		Finance Ministry		
Summary of policy instrument / approach				
<p>In 2006, the Mexican government concerned about the large and increasing public cost of dealing with disaster risk, chose to insure its national catastrophe reserve fund, FONDEN, against major earthquakes with a mix of reinsurance and a catastrophe bond. The resulting contract is linked to a parametric trigger in terms of magnitude and depth of seismicity for the three-year period 2007-09. The catastrophe bond provides cover of US\$160 million out of a total cover of \$450 million for a premium/interest totaling \$26 million. The major reinsurance company, Swiss Re, issued the bond, which pays an interest of 230 basis points if payment is not triggered. An insurance claim payment is triggered if:</p> <ul style="list-style-type: none">• an earthquake with specified magnitude and depth is recorded with its epicenter located in one of the specified zones; and if• there is official declaration of a disaster by a federal agency. <p>Three regions in Mexico considered at highest risk were thus financially protected. Mexico received substantial technical assistance from the World Bank and Inter American Development Bank over the years, but as a middle-income developing country and member of the OECD, it financed the transaction out of its own means. (Cardenas, et al., 2007). The transaction has since been repeated and cover been bought for the period 2010-12 for both hurricane and earthquake risk.</p>				
In what context and national setting it has been applied				
National context, public finance				
Lack of experience in implementation / Lessons learnt so far				
<p>It is possible to insure public sector liabilities in the reinsurance and financial markets. The premium paid was relatively low compared to similar transactions by the insurance and reinsurance sectors. One explanation could be that the market is/was (pre financial crisis) interested in public sector disaster risk.</p>				
Institutional requirements				
Transaction done by the finance ministry with approval by the parliament.				

Key barriers to implementation
Data and modelling., approval by the parliament
Summary of advantages and disadvantages according to evaluation criteria
<p><u>Adaptation effectiveness:</u></p> <p>Lower as little incentives for risk reduction are provided in such a macro transaction.</p> <p><u>Cost effectiveness/efficiency:</u></p> <p>Medium to high, as high layers of losses implying large fiscal costs are transferred to the international markets. Premium paid was relatively low compared to other transactions.</p> <p><u>Distributional considerations:</u></p> <p>Limited, as this is a macro transaction.</p> <p><u>Institutional feasibility:</u></p> <p>Depends on the national setting. and the fiscal vulnerability of the country. Many countries prohibit sovereign insurance.</p> <p><u>Conditions and barriers:</u></p> <p>Data and modelling, depending on the national context.</p>
Research gaps
References and further Information
Cardenas, V, Hochrainer, S. Mechler, R., Pflug, G. and Linnerooth-Bayer, J. (2007). Sovereign financial disaster risk management: The case of Mexico. Environmental Hazards 7: 40-53.

Policy Instrument Fact Sheet: Sovereign insurance; Caribbean Catastrophe Risk Insurance Facility (CCRIF)

Category				Specification
<input type="checkbox"/> MBI	<input checked="" type="checkbox"/> RMI	<input checked="" type="checkbox"/> PPP	<input type="checkbox"/> Other	Caribbean Catastrophe Risk Insurance Facility (CCRIF)
Country		Caribbean countries		
Administrative entity		National governments		
Summary of policy instrument / approach				
<p>The <i>Caribbean Island States</i> have recently formed the world's first multi-country catastrophe insurance pool, reinsured in the capital markets, to provide governments with immediate liquidity in the aftermath of hurricanes or earthquakes. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) went into operation in June 2007 with the participation of 16 Caribbean countries, whose governments contributed resources ranging from US\$200 thousand to US\$4 million depending on the exposure of their specific country to earthquakes and hurricanes. This better-diversified portfolio is expected to result in a substantial reduction in premium cost of about 45 – 50 per cent for the participating countries. The fund covers up to 20 per cent of the estimated loss, and claims will be paid depending on an index for hurricanes (wind speed) and earthquakes (ground shaking). Initial funding by donor organizations provided support for start-up costs and helped capitalize the pool. The facility will transfer the risks it cannot retain to the international financial markets through reinsurance or through other financial instruments (for example, catastrophe bonds). The accumulation of reserves over time should lessen the facility's dependence on outside risk transfer. Should the total insured losses exceed its claims-paying capacity, payouts will be pro-rated based on the total amount of expected claims compared to the remaining available funds. In addition, donors are adding to the reserves. The governments of Bermuda, Canada, France, the United Kingdom, as well as the Caribbean Development Bank and the World Bank recently pledged a total of US\$47 million to the CCRIF reserve fund.</p>				
In what context and national setting it has been applied				
Caribbean.				
Lack of experience in implementation / Lessons learnt so far				
Several payouts post disaster, yet, for instance, Hurricane Dean (2007) imposed damages on Jamaica, but not sufficient to trigger compensation from the pool.				
Institutional requirements				

The CCRIF acts much like mutual insurance. It is established as an independent legal entity and is managed by a specialized firm under the supervision of a Board of Directors composed of representatives from the donors.

Key barriers to implementation

International support in terms of technical assistance and backup capital. Also, there is a need for aligning risk cultures across a wide variety of governance systems.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Risk are being monitored over time, and premiums may be adapted

Cost effectiveness/efficiency:

The facility appears well protected against insolvency with reinsurance and pro-rated contracts. Once again, a major concern about the long-term acceptance and viability of the pool is basis risk.

Distributional considerations:

There are distributional considerations, and premiums of poorer countries are subsidized or completely paid for by international finance institutions involved in setting up the system.

Institutional feasibility:

There had already been efforts in the 1990s to establish a similar system after the large scale hurricane events in the early 1990s. These efforts were not successful mainly due to the perceived incompatibility of risk governance cultures in Caribbean countries with diverse colonial backgrounds and institutions.

Conditions and barriers:

Coverage is still limited and related to emergency relief expenditures only

Research gaps

One research gap may be related to considering broadening the remit of the pool to also cover reconstruction costs or household and business risks.

References and further Information

Ghesquiere, F., Mahul, O., Forni, M., Gartley, R. (2006). Caribbean Catastrophe Risk Insurance Facility: A solution to the short-term liquidity needs of small island states in the aftermath of natural disasters, www.aidandtrade.org, IAT03-13/3.

World Bank (2007). The Caribbean catastrophe risk insurance initiative. Results of Preparation Work on the Design of a Caribbean Catastrophe Risk Insurance Facility. World Bank, Washington DC.

Policy Instrument Fact Sheet: Ethiopia weather derivative

Category				Specification
<input type="checkbox"/> MBI	<input checked="" type="checkbox"/> RFI	<input type="checkbox"/> PPP	<input type="checkbox"/> Other	Ethiopia weather derivative
Country		India		
Administrative entity		Consortium of public and private bodies		
Summary of policy instrument / approach				
<p>To supplement and partly replace their traditional food-aid response to famine, the World Food Programme (WFP) supports the government-sponsored Productive Safety Net Programme (PSNP) by insuring it against extreme droughts. The PSNP provides immediate cash payments in the case of food emergencies. In the case of very severe droughts, however, this donor/government system is sufficient to save lives, but not to save livelihoods. The WFP thus designed a weather derivative to provide extra capital in the case of extreme drought, the amount being based on contractually specified catastrophic shortfalls in precipitation measured in terms of the Ethiopia Drought Index (EDI). Rainfall data is taken from 26 weather stations representing the various agricultural areas of Ethiopia. The cover was based on a call option with the underlying being (lack of) precipitation measured at 26 rain gauges. If a specifically designed crop water-stress index rises above a level, which, given past observations, would lead to large scale drought and crop loss, a pay-out would be triggered. In 2006, WFP successfully obtained an insurance contract based on the EDI through AXA Re, a Paris-based reinsurer. No event was triggered and due to many reasons, the contract was not renewed (Wiseman and Hess, 2007).</p>				
In what context and national setting it has been applied				
Development assistance provided by the WFP in collaboration with the government of Ethiopia.				
Lack of experience in implementation / Lessons learnt so far				
A few lessons learnt only as the transaction occurred only once and no payout was triggered. One lesson concerned is institutional applicability, and many donors supporting the WFP, and this transaction, question whether it is appropriate to provide donor funds for a transaction with the private sector, here a reinsurer.				
Institutional requirements				
Partnership between WFP and government of Ethiopia.				
Key barriers to implementation				

Data, government and donor will.

Summary of advantages and disadvantages according to evaluation criteria

Adaptation effectiveness:

Lower as little incentives for risk reduction are provided in such a macro transaction.

Cost effectiveness/efficiency:

Potentially high, as insecure, and thus costly, ex post disaster assistance is replaced with a trigger based mechanism, which also reduces transaction costs, as the event is insured, not the losses.

Distributional considerations:

Funds would go to the WFP and Ethiopian government, and then would be distributed to the affected through the regular channels.

Institutional feasibility:

Low, as donors unwilling to purchase financial protection from the private sector

Conditions and barriers:

Data, modelling expertise, and institutional applicability

Research gaps

References and further Information

Linnerooth-Bayer, J. and Mechler, R. (2007). Disaster Safety Nets for Developing Countries: Extending public-private partnerships, *Environmental Hazards* 7 (2007), 54-61.

Annex III

Detailed description of an Adaptation Market Mechanism

Background on market mechanisms for production of a public good

The quest for efficient policy instruments has led environmental policymakers to go beyond mandatory regulation and to look into mechanisms that provide an incentive to reduce pollution where it can be done at lowest cost (see Gupta et al. 2007). While market mechanisms to address pollution were already proposed in the early 1970s, it took until the late 1980s until they were applied in practice and until the mid-1990s to see large-scale implementation. In climate change mitigation, market mechanisms were first proposed in the early 1990s and have started actual implementation in the early 2000s (see Yamin 2005, Grubb et al 2010). By 2010, global markets for mitigation reached a turnover of 92 billion € (Point Carbon 2011), dwarfing all other market mechanisms with regards to size. Trading systems have also been introduced in the case of other scarce commodities, such as access to fisheries or production rights for milk.

Market mechanisms can take different forms. The purest is the trading of quotas, with each quota embodying one unit of the public good. It requires definition of actors and a public regulation that requires to surrender quotas to engage in an activity. Another form is the generation of tradable units through projects that produce the public good. These units can be used to comply with a public regulation. In the context of emissions mitigation, quota trading systems exist in a number of jurisdictions whereas project-based systems allow to generate units ("offsets") through projects outside these jurisdictions; these units can then be imported into quota systems. Some authors also include taxes in the definition of market mechanisms; we however see them as a separate mechanism.

Regarding adaptation, with the exception of Callaway (2004), nobody has assessed the possibility to use market mechanisms. Callaway (2004, p. 281) proposed a system of adaptation credits "to narrow the difference between marginal benefits and marginal costs" but did not elaborate on it. Where adaptation is linked to the reduction of resource use, market mechanisms have already been applied to optimize resource utilization, e.g. in the case of tradable water access rights (see Cantin et al. 2005, Grafton 2005 and Luo et al. 2003). Classical literature on adaptation policy such as Fankhauser et al. (1999), Burton et al. (2002), Bo and Spanger-Siegfried (2004) and Agrawala and Fankhauser (2007) has not discussed market mechanisms et all.

A market mechanism requires a quantifiable policy target regarding generation of a public good and an array of possibilities to contribute to this policy target whose cost per unit differ considerably. There should only be limited negative externalities involved with the production of the public good to avoid local hotspots of impacts.

Whereas some forms of adaptation only generate private benefits, as would be in the case of the construction of a dam around a private property, a large share of adaptation activities has a wide range of beneficiaries. Most activities that prevent climate change impacts will generate benefits for an extended community or an entire region, where non-rivalry and non-excludability exist. Defined more widely, protection against impacts of climate change generally can be seen as public good, similarly to the provision of public security. As shown by Economics of Climate Adaptation (2009),

unit costs of adaptation projects differ considerably. Therefore, the necessary conditions for an adaptation market mechanism are given. Below, we describe the different design options for such a mechanism.

Defining the unit to be traded in the adaptation market mechanism

A universally accepted and verifiable trading unit is a precondition for a market mechanism. For an adaptation mechanism, the unit should be applicable to all types of adaptation activities to enable maximization of the cost reduction potential.

An adaptation project is successful if it delivers protection against negative climate change impacts. The protection can address private and public property as well as human lives. The “perfect” adaptation project would prevent any negative impact on those. Theoretically, the trading unit should thus be denominated in net present value currency units of property and human life protected. Then the challenge arises how to value human life and human health. Fankhauser and Tol (1998) argue that “values of a statistical life” embodying people’s attitude to mortality risks should be used for that valuation. These values strongly depend on the income of the person and thus are substantially lower for a poor person than that of a rich person, varying by a factor of 15 between China and OECD countries (Fankhauser et al. 1998, p. 70). This approach thus became heavily contested in the elaboration of the 2nd Assessment Report of the IPCC, when developing country authors and policymakers strongly attacked what was seen as “Northern arrogance” (described condescendingly by Tol 1997). As a response to the controversy, Fearnside (1998) suggested to separate human lives and property values. In our view, Fearnside’s approach should be followed to avoid endless political debates about an equitable valuation of human life and health. Thus two trading units should be defined:

Net present value of property saved, expressed in current currency units

Disability-adjusted life years saved (DALYs) DALYs calculate the number of years of life lost due to premature mortality and the number of years lived with disability. The basis for comparison is standard life expectancy, and different types of disability / illness get different weights (WHO 2010a, b)

General functioning of the Adaptation Market Mechanism

The basis of the Adaptation Market Mechanism (AMM) is the specification of mandatory adaptation commitments by governments. This specification would be in form of double property and human health protection targets for a predefined period. For example, the EU could set an annual target of protection of 5 billion € of property (“saved wealth”, SW) and 10,000 DALYs (“saved health”, SH).

Subsequently, these commitments would have to be allocated to a predefined group of entities. Under the polluter pays principle, the allocation should be made proportionally to greenhouse gas emissions levels. The other possible allocation principles – ability to pay and inverse of vulnerability are less compelling. To avoid overly high transaction costs due to the high fixed element of costs for monitoring and verification, the covered entities should be identical with those covered by the EU Emissions Trading System, which would lead to approximately 11,000 emitting entities covered. At current annual emissions of 2 billion t CO₂, each t of CO₂ emission would entail the allocation of an adaptation target of 2.5 € SW and $5 \cdot 10^{-6}$ DALYs SH. The biggest emitter in the EU, the German

electricity producer RWE with emissions of 150 million t CO₂, would thus be responsible for protection of 325 million € and 750 DALYs.

Companies could comply with their adaptation target through different ways

- directly investing in adaptation projects that generate adaptation units
- acquiring adaptation units from dedicated adaptation project developers
- acquiring adaptation units from covered companies with a surplus of such units

Politicians would have to decide about the regional scope for adaptation project investment. From an efficiency point of view, a global scope would be preferable. A global scope would also enable to account flows to developing countries as part of the financial pledges for mitigation and adaptation. If the adaptation benefit for the EU is to be maximized, the scope should be limited to the EU. Such a limitation would however increase the costs per adaptation unit due to the lower supply of projects. As a solution the concept of complementarity as known in the mitigation concept could be applied.

Before a project can qualify to generate adaptation units, its standardized documentation would need to be validated by an auditor which checks the assumptions and parameters underlying the estimate of SW and SH. The parameters should be calculated on the basis of politically agreed climate models that should be updated every 5 years. A key parameter for calculation of SW is the projection of the autonomous development of the property value of the relevant region during the duration of the adaptation project. On its basis, and on the basis of a frequency distribution of climate-change induced events derived from the approved climate model the property that would be lost due to climate change in the absence of the adaptation project can be calculated. Finally, regional discount rates should be used to calculate the net present value of SW.

Box 1: Example of Saved Wealth calculation for a river embankment

A region in a river basin, populated by 0.5 million people, historically has not been touched by floods. Recently, rainfall patterns in the country have changed and much more heavy rainfall is observed in spring and fall whose runoff exceeds the capacities of the river bed, but so far no embankments have been established to protect human life and wealth. Climate change is expected to significantly worsen the situation and independent studies project a strong increase in frequency and power of flood events. The expected damage-frequency function is summarized below.

Type of wealth	Loss from floods <2% probability	Loss from floods 2-5% probability	Loss from floods 5-15% probability	Total wealth in region (€)
Infrastructure	20%	5%	1%	0.5 billion
Private property	30%	10%	2%	2.5 billion
Total	28.3%	9.2%	1.8%	3 billion

From the damage function, the average annual damage can be calculated

Type of wealth	Loss from floods <2% probability	Loss from floods 2-5% probability	Loss from floods 5-15% probability	Total annual loss (% and million €)
Infrastructure	0.2%	0.18%	0.1%	0.48% = 2.4
Private property	0.3%	0.35%	0.2%	0.86% = 21.4
Total	0.28%	0.32%	0.18%	0.78% = 23.8

Assuming a project lifetime of 50 years for the embankment, Saved Wealth is calculated as follows:

Saved Wealth: 23.8 million \$ *50 years = 1019 million €

Calculation of Saved Health requires an estimate of the population in the project area throughout the project duration and of the health impacts of climatic-change induced events.

Box 2: Example of DALY calculation for a river embankment

Using the same example again, we estimate health loss from flooding.

Type of health loss	Loss from floods <2% probability	Loss from floods 2-5% probability	Loss from floods 5-15% probability
Deaths	0.1%	0.05%	0.01%
Fractures	2%	1%	0.1%
Diarrhoea	20%	5%	1%

The numbers of cases accruing over 50 years are:

Type of health loss	Loss from floods <2% probability	Loss from floods 2-5% probability	Loss from floods 5-15% probability
Deaths	250	438	250
Fractures	5000	8750	2500
Diarrhoea	50,000	43,752	25,000

We use the following disability weights DW for the health loss categories: death = 1, fractures = 0.27, diarrhoea = 0.11 (WHO 2010a). Besides this, we assume that the average duration of fractures is two

months, and the one of diarrhoea is 1 month. The average life expectancy is 70 years, the average age of people is 40 years. Total DALYs achieved by the embankment thus reach the following value

$$\text{DALY} = \text{YLL} + \text{YLD}$$

where:

YLL (years of life lost due to premature mortality) = N (number of deaths) * L (standard life expectancy at age of death (in years)).

$$\text{YLL} = 938 * (70-40) = 28,140 \text{ DALYs}$$

YLD (Years lived with disability) = I (number of incident cases) * DW (disability weight) * L (average duration of disability (years)).

$$\text{YLD Fractures} = 16,250 * 0.27 * 0.167 = 733$$

$$\text{YLD Diarrhoea} = 118,752 * 0.11 * 0.083 = 1084$$

Total DALYs of the project amount to 29,957.

To preserve credibility of the trading scheme, the generation of adaptation units by projects should be subject to a strict verification by independent auditors. Such verification should be done at least every 5 years. The audits should be based on standardized monitoring reports for outcome parameters of the project and cross-checked by a regulatory Adaptation Unit Panel (AUP). The AUP would have the power to reject issuance of adaptation units. For each distinct adaptation project type, monitoring methodologies are to be defined. For example, in the context of the embankment project, monitoring would check whether the embankment has actually been constructed as per the project design and whether its maintenance status assures stability as per the design parameters. If for example the verification finds a risk of the embankment failing the maximum design flood of 25%, the adaptation unit level would be decreased by 25% compared to the estimate in the validated project documentation.

Once the adaptation units have been issued, they can be transferred. Similarly to the mitigation market, the emergence of brokerage companies will be fast provided a sufficient number of entities is covered by the AMM. At the end of each year, companies would have to surrender sufficient adaptation units to cover their targets. Non-compliance should be punished with a prohibitive penalty (2 €/ € SW, 1 million €/ DALY SH). Revenues from collected penalties should be reinvested in adaptation projects.

Annex IV

This Appendix provides detailed information on the national insurance arrangements for nine selected countries: the Netherlands, Austria, Germany, France, Spain, Switzerland, France, the UK, Hungary, and the US. In particular, it provides details on the rankings of these systems according to five criteria:

- *Capacity* for providing a reliable safety net
- *Effectiveness* for incentivizing adaptation
- *Applicability* in different national contexts
- *Equity* in providing security to low-income population
- *Efficiency* in terms of transaction costs

The results are summarized in the Table X.1 below, followed by a detailed description and rationale for the rankings.

National property insurance arrangements covering selected hazards according to five criteria

Country/ Criteria*	Capacity for providing a reliable safety net	Effectiveness for incentivizing adaptation	Applicability	Equity	Efficiency
Netherlands Full government liability	Medium Government compensation is generous, creating a strong safety net, but no reserve disaster fund and payments ad hoc.	Low Little incentives for private sector adaptation.	Low State-dominated arrangement not applicable in more individualistic cultures. Inappropriate for states with high exposure and fiscal constraints.	Medium Compensation to low-income agents, and little distinction between those who pay (taxpayers) and those who benefit.	High Expense and contingency loads very low
Austria Extensive public compensation and limited private insurance	High Government has capacity to provide compensation to the private sector for almost all foreseeable disasters; Disaster fund renders payments less ad hoc.	Low Besides "charity hazard", compensation only goes to uninsured. No deductibles on residential properties; segregation only based on location. Incentive for high public investment	Low Generous post-event compensation not possible for fiscally constrained governments	Medium Public compensation more generous for those most in need; however, some may object to large transfers from low-risk to high-risk areas.	Medium Expense and contingency loads very low for government compensation, but transaction costs high for private insurance.
Germany Private insurance with public compensation	Medium Penetration for flood insurance low (less than 10%), higher for windstorm; yet, government compensation assures safety net. Can be ad hoc.	Low Low insurance penetration (partly segregated pricing) and extensive government assistance provides little incentive for risk reduction. Many individuals self insure which acts as deductible. Government has incentive to invest in prevention.	Low Inappropriate for states with high exposure and fiscal constraints.	Medium Does not distinguish support to most vulnerable and wealthy.	Low Evidence shows that sales and other transaction costs increased significantly when Germany converted to a private market system.
Spain Compulsory state insurance	Medium Mandatory insurance with 100% cover for assets and no limits on indemnity creates strong safety net. Government backing; however, may be a problem with fiscal security.	Low Flat rate premiums and no extra programs to reduce risks.	Low System violates EU directive, and in some countries mandatory insurance is viewed as unconstitutional.	High Flat rate premiums mean that high-risk, low-income housing can afford cover.	High Very low administrative costs plus no dividends to shareholders necessary.
Switzerland Cantons with public monopolies and compulsory insurance	High Mandatory insurance, unlimited government backup, strong and reliable safety net.	High Flat rate premiums associated with adverse incentives; however, public insurers make substantial investments in prevention	Low This system would violate EU directive, and in some countries mandatory insurance is viewed as unconstitutional	High Flat rate premiums mean that high-risk, low-income housing can afford cover.	High Very low administrative costs plus no dividends to shareholders necessary.

France Publicly backed national insurance	High Bundled with voluntary fire/property, penetration 100%	Medium Lack of premium segregation limits incentives for prevention, although government regulations and increasing deductibles encourage adaptation. Public sector investment also incentivised through public reinsurance.	Medium Public-private partnership appropriate for many European countries wishing to combine solidarity with private responsibility. Public component limited in poorer European countries with strong fiscal constraints. Mandatory nature may also be an issue.	High Cross subsidies make it possible for all property owners to be in the system. Transfers from taxpayers to those locating in high-risk areas are less than in case of post-disaster public compensation.	Low High handling costs of private insurers.
United States Publicly underwritten flood insurance program with private administration	Medium Government provides insurance in participating communities, and insurance required for mortgages. Penetration approx 50%, of those living in risk zones. Government provides soft loans, etc after major disasters.	High Communities must take prescribed measures to reduce risk to be eligible for program. All new buildings subject to risk based pricing. Since government underwrites risk, strong incentive for public investment in risk reduction	Medium European governments (exception Hungary) appear reluctant to underwrite risks of flood and other natural perils. No public backup means only applicable for large countries where risks can be diversified.	Medium Old buildings eligible for subsidies to support low-income residents, but new buildings s.t segregated pricing.	Medium Administrative expenditures low. Problem is solvency of the system without government backup (partly blamed on subsidies).
Hungary Publicly underwritten flood program with subsidies for low-income households	Medium Low penetration of insurance, but potentially higher if subsidies increased.	High Risk based policies only for homes with permit will encourage risk reduction in private sector. Public underwriting will encourage public investment.	Medium Challenge is to increase penetration.	Medium Subsidies for low-income residents, although appear to be too low.	Medium. Reports that NFIP is not financially secure
United Kingdom Market insurance	High Penetration >75%, insurers for most part reinsured. Strong and dependable private safety net	Historically low Cross subsidies and little segregation; however, this is changing and insurers increasingly segregating premiums by location.. Negligible state liability has reduced incentives for public investment.	Low Doubtful other countries would accept minimal public intervention. Also private insurers reluctant to insure flood and other systemic risks in high risk countries outside the UK.	Historically high Cross subsidies made insurance universal. Moving away from these subsidies will mean low-income housing lacking insurance.	Low Administrative costs are high and little price competition of premiums.

*Note: Criteria ranking is based on subjective judgment by the research team.

Insuring households and businesses: a description of national arrangements and rankings

In the following, we discuss the nine selected national insurance arrangements with particular attention to how they rank on the five criteria.

Systems with extensive tax-financed government compensation

The Netherlands (flood risk)

The Netherlands is exposed to a significant and increasing burden from floods and storm (including hail), and weather-related hazards are expected to increase in their intensity, severity and frequency. Below we describe insurance/compensation arrangements in the Netherlands according to our five criteria.

Capacity for providing a reliable safety net (Rank: medium)

In the 1950s Dutch insurers entered into a binding agreement not to provide cover for flood and earthquake risks. Due to regulations issued by the EU, the binding (cartel) agreements were changed to non-binding recommendations, but have not led to insurers offering cover for flood damage. As a result, the government passed the 1998 Calamities and Compensation Act (WTS), which provides for compensation for uninsurable disaster losses (excluding storm surge) that cause considerable disruption and loss. The limit on compensation is €450 million per year (Paklina, 2003).

There is voluntary private hazard insurance covering mainly storm and hail risks for the agricultural sector, and also some business interruption risks. As part of the North Atlantic windstorm area, this has remained one of the most important exposures for Dutch insureds and cedents. Windstorm Daria (January 25, 1990) was the most devastating windstorm to impact the country in the past two decades. Windstorm Kyrill (January 18, 2007) represented a loss burden of about EUR350 million (USD525 million) for the Dutch insurance industry, mainly as a result of damages to greenhouses and the high-value crops inside them. Windstorm, flood and hail are also covered under motor hull and construction policies.

Given the reluctance of private insurers to cover the co-variant risks, a government disaster fund (separate from the WTS) also provides compensation for major natural and man-made disasters, and this fund has historically compensated a large percentage of residential and business losses from floods and storms. The goal of the WTS was to provide a less ad hoc system of compensation (Faure and Hartlief, 2006); still, the government decides whether the loss threshold for compensation is reached as well as on the extent of compensation. According to Botzen and van den Bergh (2008) “these decisions are influenced by political will and public pressure, which can be regarded as arbitrary and subjective.”

Effectiveness for incentivizing adaptation (Rank: low for private sector)

A rationale for extensive government responsibility, at least for floods, appears to be a general sense that the government is liable for damages since it has responsibility for maintenance of the dikes and coastal protection measures (Botzen and van den Bergh, 2008). There is a great deal of evidence that public compensation has been accompanied by extensive public investment. Moral hazard is addressed to some small extent because the government does not compensate fully. Still, many observers in the Netherlands are drawing attention to the disincentive effects of government compensation particularly for location and land-use decisions, and there is an on-going discussion on introducing premium-based insurance for climate-related risks (Botzen and van den Bergh, 2008). In the words of Botzen and van den Bergh (2008) “... government compensation schemes result in a governmentally subsidized incentive to take on risk.”

Applicability in different national contexts (Rank: low)

In addition to concerns about the disincentives of “free” post-disaster compensation, another major concern limits the applicability of Netherlands’ reliance on taxpayer support for disaster victims. Governments in the EU and particularly the lower-income member states are facing fiscal constraints on spending. For this reason, finance ministries across Europe are looking for ways to transfer more of the post-disaster burden to the private sector. At the same time, some countries (like the Netherlands) have such high risks for floods and other natural perils that the private sector is reluctant to enter these markets. This is one reason that the Netherlands along with many other member states is considering a public-private arrangement for sharing liability for disaster losses.

Equity in providing security to low-income population (Rank: medium)

Government compensation in the Netherlands is motivated in part by the fact that the government is regarded as liable for flood damage because of its responsibilities for dike maintenance, and in part by solidarity with those least able to cope. After recent floods, the public viewed the government as liable for the incurred damage due to insufficient investments in coastal protection and dikes (de Vries, 1998). It should be pointed out that relative to other European countries, the Dutch population is more uniformly exposed to floods (much of the country is at risk) and for this reason taxpayer compensation might be regarded as fair since a large part of the public is in the risk pool.

Efficiency in terms of transaction costs (Rank: high)

From an efficiency standpoint, public compensation ranks high. The reason is the relatively small transaction costs in *ad hoc* government payment and in creating a tax-financed government fund, and the general efficiency of payments minimizes the expense load. The contingency load is also very low for governments where the risks can be diversified and spread over a large population, which even in the geographically small Netherlands is possible because of the wealth of the population (the Netherlands government probably does not need to reinsure its disaster fund). For these reasons, Priest (1996) refers to governments as the most effective risk financing instrument of society.

Mixed private insurance and government compensation

Austria

Austria is exposed to climate-related risks including flood, storm, landslide, avalanche and hail, in addition to (low) earthquake risk.

Capacity for providing a reliable safety net (Rank: medium)

Austria offers generous post-disaster compensation to victims of all natural disasters financed by its structured national disaster reserve fund with the result that households and businesses carry little private insurance for property damage. The Austrian Disaster Fund was created by a statute in 1996. This fund statutorily compensates damages to property and contents (more recently including indirect damages), which contrasts with *ad hoc* disaster compensation characterizing many other

governments, for example, the Netherlands (partly) and Germany. Compensation is implemented by the Austrian states with payments averaging about 50% of losses and up to 80% in the case of hardship. The state expenses are reimbursed 60% by the disaster fund. By law the disaster fund capitalization cannot exceed €29 million, which can cause strains on its liquidity. The fund is capitalized by a defined percentage (1.1%) of the federal share of income taxes, taxes on capital yield and corporations.

In the case of depletion, the government raises funds by borrowing and diverting from other budgeted projects. A recent analysis showed that the government can cope with most events with its disaster fund and good credit rating (Hochrainer and Mechler, 2009; Hochrainer et al., 2010). The exception was found to be only very rare floods expected to occur about every 250 years or less.

Private insurance penetration (voluntary) is low; estimates range from 10 to 25% (see section 3). Compensation limits are also low, ranging from Euro 3700 to 10000. The government offers no support for private insurers in the form of guarantees or tax exemptions for reserves.

Effectiveness for incentivizing adaptation (Rank: low)

What appears unique to Austria, the government provides post-disaster compensation only to uninsured victims and not to households or businesses holding an insurance contract. This provision creates a strong disincentive to purchase insurance, what is sometimes referred to as a “charity hazard”, in addition to the disincentive of the post-disaster compensation to reduce losses. Private insurers operate on a market basis, and premiums reflect to some small extent locational risk, but not other forms of risk reduction. In the case of compensation from the disaster fund, there is a deductible of €1000; for private insurance, deductibles are incorporated in policies only for commercial clients.

Austria offers an example of insurers working with government to promote flood risk awareness. The Austrian Insurance Trade Association working jointly with the Austrian government and local authorities have developed a risk zoning and mapping tool accessible free of charge to anyone. The purpose of this adaptation measure, called HORA, is to raise the awareness of policy holders and the insurance industry, as well as government officials, to weather-related risks. It includes flood, windstorm, hail, snow pressure, lightning and landslide. It will also help insurers to move increasingly toward risk-based pricing. (Surminski, 2010).

Applicability in different national contexts (Rank: low)

As in the case of the Netherlands, there are limits to the applicability of Austria’s tax-based system. Many country governments cannot continue to absorb private sector losses. This was quantitatively illustrated in a study by Hochrainer, Linnerooth-Bayer and Mechler (2010), which compared the coping capacity of governments of Austria, Hungary and Romania. As would be expected, the shortage of resources available to Hungarian and Romanian authorities, including reserve funds, tax capacity, ability to borrow and divert funds from other budgets, renders them less able to cope with disasters than Austrian authorities. Examining only flood disasters it was estimated that Hungary and Romania can cope with floods up until about the 80- and 50-year events, respectively, compared with Austria which can cope up until about the 250 year flood. It should be added that this analysis

results in an optimistic estimate of coping capacity since in practice governments have political constraints that limit their ability to divert from existing budgeted items or incur new debt.

Equity in providing security to low-income population (Rank: medium)

Austrians appear to be motivated by solidarity since the disaster fund embeds extensive tax-based transfers. Tax-funded disaster compensation can be up to 80% of losses for those in particular need. Exempting households with insurance may also result in a higher proportion of funds helping the most in need.

The government offers no support for private insurers in the form of guarantees or tax exemptions for reserves. As an exception to the Netherlands, where a large percentage of the population is exposed to flood risks, Austria's alpine landscape means that only those in the river valleys are exposed. This raises the question of the "fairness" of equivalent tax payment from high-ground and low-ground residents.

Efficiency in terms of benefits and costs (Rank: high)

Like in the Netherlands, the Austrian system of government compensation is efficient insofar as the costs of provision (expense and contingency loads) are lower than indemnity based insurance. However, there are political costs, which became evident after extreme floods in 2002 depleted the government's disaster fund. As a solution, the government announced plans to divert funds from planned expenditures on fighter jets. This (among other political pressures) raised such a controversy that the government was forced to call new elections.

Germany: private insurance with ad hoc public compensation

Germany experiences climate-related risks including flood, storm, landslide, and hail. The flood risk is substantially lower than the Netherlands and Austria, with average losses of about 0.01% GDP and uninsured losses nearly as high.

Capacity for providing a reliable safety net (Rank: medium)

Germany does not have a structural fund (like Austria) for compensating victims of disasters, but the government intervenes very generously on an ad hoc basis. As a case in point, after major flooding on the Elbe in 2002, victims were almost fully compensated for their losses. However, there is no legal claim on government assistance, and many Germans self insure (Linnerooth-Bayer, et al., 2001).

Only privately offered insurance for hazards is available in Germany, where storm and hail policies are the most prevalent (95%). Flood policies are marketed as part of a package with other natural disasters as supplements to home contents or property insurance for both commercial and residential properties. With regard to floods, buildings that are situated in hazard-prone areas are often excluded from insurance, or they can only be insured by very high premium. There are no government guarantees for private insurers, but regulation requires equalization reserves.

The market penetration of flood insurance is only about 10% for home contents and 4% for residential buildings in most parts of Germany (Thieken et al., 2006). Market penetration for industrial risks is also smaller than 10%. Adverse selection is argued to pose a major problem.

This has been explained by the voluntary nature of the insurance cover and dependence on public compensation for flood damage.

Effectiveness for incentivizing adaptation (Rank: low)

Flood insurance arrangements include deductibles to stimulate loss-reducing measures by individuals, and policies are priced according to risk zones. Apart from zoning and deductibles, stimulation of damage-reducing measures by insurance companies is minimal (Thieken et al., 2006). It is reported that many Germans consciously self insure, which increases their motivation for taking risk-reducing measures (Linnerooth-Bayer, et al. 2001).

Applicability in different national contexts (Rank: low)

A mixed public compensation – private market system has three major shortcomings that limit its applicability:

- Limited supply of private insurance, especially in high risk areas, given adverse selection and lack of public guarantees;
- Limited demand for insurance given generous post-disaster compensation.
- Generous public compensation not applicable for fiscally constrained governments.

Equity in providing security to low-income population (Rank: medium)

Post-disaster compensation by the government has historically provided for low-income households and businesses. However, the fairness of using tax revenues to compensate middle- and high-income households and businesses is questionable.

Efficiency in terms of benefits and costs (Rank: low)

Ungern-Sternberg (2003) claims that since Germany switched from the public monopolies previously existing in some states to a private system (in compliance with the 3rd EU Non-Life Insurance Directive that came into force in 1994), operating expenditures have increased substantially. When opened to competition the former monopolies substantially increased their expenditures on sales representatives and administrative costs to survive in the free market. Within six years these costs more than tripled in several states. The share of these costs in premium income increased from roughly 10% to over 20%.

Public monopoly with compulsory participation for all hazards, flat premiums

Spain

Spain is exposed to climate-related natural hazards, including drought, flood, storms and tornadoes, as well as (marginally) to earthquakes. Compared to other European countries the economic losses from floods are relatively low; however, drought losses outpace most other European countries. On average, Spain expects flood losses of less than 0.01% GDP, most of which are insured.

Spain has a compulsory state insurance monopoly, the Consorcio de Compensacion de Seguros (the “Consorcio” for short), which covers damage from such disasters as floods, storms, tornadoes, earthquakes, tsunamis and terrorist attacks (droughts are covered under the Fund for Agricultural Calamities discussed below). The system extends to residential and commercial properties, and pays claims for personal injury, property damage and business interruption.

Capacity for providing a reliable safety net (Rank: high)

The public insurance covers 100% of assets exposed with no limits on indemnity. The state provides a full guarantee meaning that losses above the Consorcio reserves will be covered by government taxpayer funds. The program is administered by private insurers that issue policies, assess damage and pay claims. In addition, private insurers pay for ‘non-exceptional’ losses i.e. localized incidents.

A major advantage of a compulsory system is that it eliminates adverse selection, which reduces the risks significantly to the public insurer. Adverse selection occurs when those facing higher risks purchase insurance, and those less at risk do not. Especially for large-scale systems, purchasers often have information that is not known to insurers, or costly to obtain. This asymmetric knowledge jeopardizes the insurance pool. Another advantage of compulsory systems is that they maximize the pool available for paying claims, since everyone has to contribute to it.

While claims have outpaced premiums in six catastrophic years since the establishment of the Consorcio in the early 1950’s, reserves have remained sufficient to deal with exceptionally costly years. In contrast to the French system, reserves are secure from political intervention. Still, given the debt crisis of the Spanish government, a question must be raised whether the government budget can continue to guarantee the system, which may mean high payments in the event of extreme or multiple events.

Effectiveness for incentivizing adaptation (Rank: low)

The Consorcio does not differentiate premiums on the basis of risks. There is a deductible for commercial property only

The Consorcio (Article 16) is required to be active in promoting risk reduction, but in practice (and unlike the Swiss cantons) this has not been the case. Ungern-Settnberg (undated) attributes this to several factors, including

- The Consorcio has no voice in land-use regulations;
- The premium income of the Consorcio is too small for a fund to invest in preventive measures;
- The Consorcio is not active in fire insurance procedures.

Applicability in different national contexts (Rank: low due to EU directive)

Because the Consorcio violates the 3rd EU Non-Life Insurance Directive, which on account of international and domestic competition does not allow state monopolies, premiums are considered a “surcharge” on property, which all homeowners are required to pay.

Compulsory systems, however, are not applicable to governments whose citizens view mandatory purchase as a violation of their constitutional rights. This debate concerning the desirability and

constitutionality of compulsory insurance has been part of the recent policy discussion in both Hungary and Germany.

Equity in providing security to low-income population (Rank: high)

Because of flat-rate premium pricing, there are large cross subsidies from those living in low-risk areas to those in high-risk areas, and also across regions differentially affected by natural and social/political perils. To the extent that low-income housing and businesses are located in high-risk areas, this will mean transfers from the wealthier to the poorer. Moreover, the unlimited government guarantee eliminates the costs of reinsuring, and in this way lowers premiums, making them more affordable to low-income residents.

Efficiency in terms of benefits and costs (Rank: high)

The pricing record of the Consorcio does not follow what economists would expect from a monopoly since it exhibits lower premiums than those observed for similar cover offered by private insurance suppliers. According to Ungern-Sternberg (2006) the Consorcio covers its administrative and commission costs with only 10% of its premium income. Of this, five percent (compared to 25% in France) is paid to private insurers for premium collection, and five percent covers other administrative costs, like claims processing. This can be compared to Spanish private insurers that spend almost 40% of their premium income on administrative and commission costs. As pointed out by Ungern-Sternberg, the Consorcio need not pay dividends to shareholders, thus all interest on the reserves flows into paying costs. Moreover, the state guarantee means that the contingency load is very low.

Switzerland

Switzerland is exposed to climate-related risks including floods, landslides, avalanches, droughts, windstorms and hail.

In 26 Swiss cantons, cantonal property insurers (KGVs) operate as public monopoly institutions that offer weather-related hazard damage coverage for floods, storms, hail, avalanches, weight of snow, falling rocks, and landslides (earthquake not covered). In the remaining seven GUSTAVO cantons, protection is offered by private insurers. This parallelism has arisen as a result of referenda on the EU Council Directive on Indemnity Insurance (92/49/EWG). In what follows, we rank only the KGV insurers.

Capacity for providing a reliable safety net (Rank: high)

In all cantons, hazard insurance for property owners is compulsory and bundled with fire insurance, but optional for business interruption. For private GUSTAVO insurers the limit is Euro 2 billion per event; for the public monopoly KGV insurers, there is unlimited liability. Because of the legal contracts, claims payments are reliable.

Effectiveness for incentivizing adaptation (Rank: high for public interventions; overall medium)

For private insurers, rates are fixed by law and for public insurers rates are fixed by respective cantons. The flat rates discourage adaptation, which may be mitigated somewhat by the imposition of deductibles.

The most noteworthy feature of the Swiss KGVs is their right to participate in processes influencing risk reduction, including building codes and land-use planning, and also financing of the Fire Service and Cantonal Civil Defense Services. According to Ungern- Sternberg (2006), the canton monopoly insurers are heavily involved in prevention, investing twice as much (0.15% of sum insured) in prevention than the private insurers (0.06% of sum insured). In the words of Schwarze and Wagner (2009) *there are economies of scope from pooling of prevention and risk transfer*. These investments have significantly decreased claims. It is however difficult to establish whether this lower incidence of damage is due to improved prevention.

Applicability in different national contexts (Rank: low)

Adopting the Swiss model of KGV's in other EU countries would face the same barriers as that faced by Spain's Consortio:

- The system violates the EU's 3rd Non-Life Insurance Directive that disallows state monopolies;
- Compulsory systems may be deemed unconstitutional in some countries;
- State backing may create financial problems for governments of small, low-income countries; and
- Some countries, e.g., the UK, are heavily invested in private insurance institutions, and are committed to market practices, and for these reasons public monopolies will not be an acceptable alternative.

Equity in providing security to low-income population (Rank: high)

Flat premiums will allow low-income persons to purchase insurance, and unlimited government support will lower premiums making it more affordable. Because the palate of risks goes beyond flooding to include avalanches and other mountain risks, the distribution and thus burden sharing is somewhat more evenly distributed (commensurate with the flat rates).

Efficiency in terms of benefits and costs (Rank: high)

Ungern-Sternberg (2006) compared operating expenses of the KGV and market insurance operators, which showed that the efficiency of the public monopolies is significantly higher than that of the private insurers

Bundled private-market insurance with unlimited public backing, flat premiums

France: state-backed national all-hazards insurance

France experiences a full range of climate-related hazards, including floods, droughts, wind storms, avalanches, landslides and hail. France stands out in Europe with its strong tradition of state protection and solidarity, and the French expect their state to provide assistance in the case of disasters. The French national insurance program is based on a public-private partnership characterized by a high degree of solidarity through cross-subsidized and non-segregated pricing.

Damages are compensated when the government officially recognizes a disaster and the area where the damage occurred as a disaster area.

Capacity for providing a reliable safety net

Private insurers are required to offer catastrophe insurance in an all-hazards policy that is bundled with property and home contents insurance, covering both the residential and commercial sectors. Property insurance is not compulsory; yet if one chooses to purchase this insurance there is mandatory cover for disasters. This solves problems with adverse selection, and it is claimed that insurance penetration approaches 100 percent (Swiss Re. 1998). Private insurers can choose to reinsure through a public administered fund, the Caisse Centrale de Réassurance (CCR). If this fund proves insufficient, taxpayers will be called upon to contribute through an unlimited state guarantee.

Effectiveness for incentivizing (or requiring) adaptation (Rank: medium)

The government sets the “natural catastrophe” surcharge, and premium differentiation is not allowed. To counter the problem of disincentives from the flat premiums, a recent decree sets a deductible that increases with the number of disasters in the same area (Linnerooth-Bayer and Mechler, 2007). This means that the compensation a household or business receives will continually decrease in high-risk areas, creating an incentive to relocate or take other loss-reduction measures. This incentive, however, is tempered by the clause that the government must officially recognize a disaster.

The French insurance-funded research institute, Mission Risques Naturels (MRN) provides knowledge and prevention management services to its members companies, as well as services to the whole market. These include, for example, a contribution to collective vulnerability scoring tools for each municipality that evaluate the appropriateness and efficiency of risk-prevention plans. MRN also publishes practical guidelines for individuals containing recommendations on the actions to be taken before, during and after a catastrophic event in order to reduce losses. (Surminski, 2010)

Applicability in different national contexts (Rank: medium)

The French system may not be applicable in fiscally constrained small countries, which have less diversification and where the governments may not be able to offer and guarantee reinsurance. One problem facing the French system is that insurers are not obliged to reinsure with the CCR, and the larger companies have opted to cover the “good risks” with little reinsurance, leaving the “bad risks” to smaller local insurers who have opted for high reinsurance cover. This has led to large losses to the CCR.

Efficiency in terms of benefits and costs (Rank: low)

The evidence is mixed with regard to the efficiency of the system. While some commentators note that, overall, the French system has proved to be efficient and in general insurers and insured are satisfied with the public-private arrangement (Botzen and van den Bergh, 2008), others are more critical. Ungern-Sternberg notes that private insurers have negotiated a handling fee of almost 25% to cover their “costs” of collecting the premiums, although these premiums are bundled with already collected fire insurance (the Spanish system pays only 5% handling fee).

Equity in providing security to low-income population (Rank: historically high)

Solidarity is recognized as one objective of the system, and policies are not risk based (it is also difficult to risk price bundled policies). The large cross subsidies from low- to high-risk households and businesses assures affordability to low-income persons. The state guarantee for the CCR reduces the need for costly reinsurance, also leading to lower premiums.

Publicly underwritten single hazard insurance

United States: public-private flood program with government assuming all risk

The United States faces a wide spectrum of climate-related natural hazards, including hurricanes, floods, tornadoes, ice and hail storms and drought, and also a large earthquake risk. In this section we focus on floods and the National Flood Insurance Program (NFIP) because of the lessons it holds for Europe.

The NFIP was created in 1968, and to this day is unique in that the federal government serves as the primary insurer offering voluntary policies to residential and commercial buildings, yet mandatory in the case of a mortgage. The US government underwrites the risks, and private insurers market the policies and carry out all administrative functions. In principle, the system does not depend on taxpayer support, although this is not entirely the case in practice. If the capital reserve is insufficient to cover claims, the Federal Emergency Management Agency (FEMA) borrows from the treasury, and the loan is paid by raising premiums.

In addition to the NFIP, the US federal government provides a great deal of ad hoc post-disaster support for major floods and other “declared” disasters. This usually takes the form of grants for relief and low-interest loans. Because of the expectation of public support, the uptake of flood insurance is reduced.

Capacity for providing a reliable safety net (Rank: medium)

A RAND study in 2006 estimated that about one-half of single family homes in special flood hazard areas had purchased NFIP policies (about one percent carried other private flood insurance contracts). While it appears that compliance does not decline as mortgages age, there is strong evidence that market penetration rates are low for homes that are not subject to the mandatory purchase requirement.

The aftermath of Hurricanes Katrina, Wilma and Rita in 2005 created large debts in the NFIP. An ensuing government study claimed that the program is not actuarially sound in that it does not collect sufficient premium income to build reserves to meet long-term expected future flood losses, partly because the US Congress authorized subsidized insurance rates for some properties. Four catastrophic hurricane-induced flood events in 2004 required extensive loans from the US Treasury to pay claims. Another concern is that properties that suffer repeated flooding and yet pay subsidized insurance rates constitute a significant drain on NFIP resources. (US Government Accounting Office, 2005).

Effectiveness for incentivizing adaptation (Rank: high)

A notable feature of the NFIP is that communities must take prescribed loss-reduction measures if their residents are to be eligible for (subsidized) cover. Flood insurance is only available in those communities that adopt and enforce a floodplain management ordinance that meets or exceeds the minimum NFIP standards. With the intent of reducing subsidies and moving toward risk-based premiums, the philosophy of the NFIP is that persons living in exposed areas should eventually bear their full risks. This is the case for new buildings for which premiums are based on flood risk determined by the elevation of the lowest floor of the structure relative to the elevation of the national base flood (100-year flood) standard. The NFIP has a pilot program requiring owners of repetitive-loss properties to elevate, relocate or demolish houses, with NFIP bearing some of the costs. It is claimed that this program has contributed significantly to reduce vulnerability of new buildings to flood impacts, but still needs government support in enforcing building codes, settlement areas, etc (Burby 2001).

Applicability in different national contexts (Rank: medium)

The continuing debt of the NFIP is one problem limiting its general applicability although this will be remedied as the system moves toward risk-based premiums and phases out subsidies. The Katrina disaster also revealed a great deal of discontent of NFIP and private insurer procedures, especially the delineation between cover for flood and wind damages. Because the NFIP does not reimburse wind damage, many argue that the US should institute a national all-perils policy similar to the French system. Without taxpayer back up, the system can function best in large countries with sufficient diversification.

Equity in providing security to low-income population (Rank: historically high, now medium)

The NFIP was founded on a commitment to provide insurance to all homeowners and businesses within qualifying communities. The program's more recent commitment to risk-based pricing and elimination of subsidized policies will reduce the solidarity in the system. For this reason, some experts have suggested that the government provide vouchers to low-income persons to enable them to purchase risk-based insurance (Kunreuther and Michel-Kerjan, 2009). The advantage of a voucher over a subsidy is that the purchaser pays a risk-based premium that can be reduced to reflect investments in preventive measures.

Efficiency in terms of benefits and costs (Rank: medium)

Administration expenditures are low; however, there is a contingency load because of the absence of a "free" taxpayer backup (there is, however, the possibility of a market-based treasury loan). Because the system diversifies risks over a large territory and population, it reduces the risk of insolvency, lowering the contingency load.

Hungary: subsidized public flood insurance program for high risk areas

Hungary is exposed to climate-related risks including floods, droughts, hail and windstorm. The flood risk is especially high, and flood losses average more than 0.08% GDP, about half being insured.

Capacity for providing a reliable safety net (Rank: medium)

Some important aspects of the US flood program have been incorporated in recent Hungarian legislation for a flood insurance program. According to the new legislation, the government will fully underwrite (optional) flood insurance in high-risk areas (where most private companies do not offer flood insurance), which will be administered by private insurance companies on a commission basis. The indemnity can reach 100% of the property value, but with a maximum of Euro 57,000. It will cover all flood and standing water damages both in protected and unprotected flood basins. In sharp contrast to the US, the **government will provide back-up capital if the premium pool is insufficient to cover claims.**

This system is superimposed on traditional practices of the government assuming full responsibility for protecting citizens against floods, and where this fails, fully compensating them. After the devastating floods of 2001, the government fully rebuilt a large number of destroyed homes. While the government has stated that ex post compensation will not be given to uninsured individuals, it did not hold to this promise in later years. (Linnerooth-Bayer et al., 2006).

Applicability in different national contexts (Rank: medium)

While this system ranks high in encouraging adaptation, penetration remains very low. One explanation is that high-risk areas, such as the Upper Tisza region, are inhabited by very low-income households and farms, and the 30% subsidy is not sufficient for insurance to be affordable (Linnerooth-Bayer et al., 2006). One also must ask whether the Hungarian government, given its huge budget deficit, can provide the guarantee if there are very costly floods (although the guarantee imposes less of a fiscal burden than full government compensation). The most serious limitation is the continuation of government assistance thus limiting the purchase of voluntary insurance.

Effectiveness for incentivizing adaptation (Rank: high)

Insurance premiums will be risk-based, but the premiums of poor households will be subsidized up to 30 percent. To counteract the subsidies, “must do” clauses are legislated in the sense that insurance will be available only for homes built with a permit, thus assuring that homes are built according to building codes and not in high risk locations.

Equity in providing security to low-income population (Rank: medium)

The 30% subsidies for low-income households were meant to assure affordability to the many residents living in poor, high-risk locations, such as the areas around the Upper Tisza river. In addition, the government guarantee eliminates the need for expensive reinsurance. Still, as discussed below, this support has not had the intended result, and the government continues to provide generous post-disaster compensation.

Efficiency in terms of benefits and costs

No data on expense load.

Free market insurance with minimal post-disaster government assistance

The United Kingdom: private market bundled hazard insurance

Major hazards in the U.K. are flood, windstorm and subsidence. Annual average expected losses from flooding, alone, is by far the highest in Europe, perhaps contributing to the fact that insurance is widespread throughout the UK.

The hazard insurance program (mainly flood, windstorm and subsidence risk) in the UK is the most extreme in terms of private responsibility and market principles. There is only limited post-disaster public compensation, and the government does not act as a guarantee or reinsurer for primary insurers. Coverage against flood damage and other hazards is part of fire insurance, which is a part of building or home contents insurance required for a mortgage (Hubert, 2004).

Capacity for providing a reliable safety net (Rank: high)

Until 2013 there exists a “gentlemen’s agreement” between the Association of British Insurers (ABI) and the government, referred to as the Statement of Principles (SoP), to ensure that flood risk is managed effectively. Insurers have agreed to offer universal coverage in exchange for government engaging in risk management (adaptation) activities, including investing in new and existing defences, and providing flood risk data to insurers. In addition the government agrees to improve understanding of risk through public flood maps and to ensure the planning system prevents inappropriate development in flood-risk areas. In return, insurers cover up to the 75-year risk to households and small businesses.. Market penetration is estimated to be approximately 95% (Crichton, 2005). Because insurance companies have become dissatisfied with the current flood defense standards, in 2013 they will discontinue the agreement to offer universal flood cover

Effectiveness for incentivizing adaptation (Rank: medium)

In order to offer universal coverage, insurers historically have adopted flat premiums so that low-income residents in high-risk locations can afford the policies (necessary for universal coverage). One major reason for ending the SoP has been recognition that the cross subsidies and flat premiums have distorted market incentives for homeowners to take steps to improve their flood resilience. As insurers move toward ending the agreement with the government, companies are beginning to differentiate premiums based on geographical risk characteristics, which encourages settlement in low-risk areas but also precludes low-income resident from purchasing expensive policies. The agreement with the government on universal coverage has required that the government assure high levels of safety through public investments. As insurers move toward more risk-based premiums, predictably there has been less investment in collective flood protection (at least in England). It is now more difficult to obtain insurance in risk-prone areas because insurance companies are dissatisfied with the current safety standards. Scotland appears to be an exception, where risks for insurance companies have not increased due to stricter building codes (Crichton, 2005).

While this arrangement has ensured extensive government investment, insurers have on occasion played an active role in damage prevention. For example, one insurer, AVIVA, in cooperation with the local Council, British Red Cross and others, carried out a flood simulation exercise in Boroughbridge to examine how insurers can provide better support in an emergency situation (Surminski, 2010). The rationale for involving the community in the exercise is that it will result in greater self-protection

measures installed by homeowners or improved community action (such as increased knowledge for upkeep of infrastructure such as drains or river gates). In another example, the insurer, RSA, is working with the World Wildlife Fund and the Thames River Restoration Trust to introduce a sustainable urban drainage system and increase natural capacity for flood waters in the town of Mayesbrook. RSA staff has been involved in tree planting, pond clearing and other conservation activities (Surminski, 2010). Moreover, the ABI sees itself as a lobbying organization working with policy makers to promote adaptation (Surminski, 2010).

Applicability in different national contexts (Rank: low)

The UK private insurance system is less applicable in smaller countries with very high risk and thus less opportunity for local insurers to diversify policies within the country. Adverse selection and moral hazard have contributed to this reluctance, most notably for flood coverage, and also the systemic nature of the risks which means insurers can be overexposed in these markets. Climate change is adding additional uncertainty and cited by insurers as another factor adding to their reluctance to insure against weather-related natural perils

Continental Europeans also appear to have a stronger preference for social insurance and the solidarity that often goes along with it. There may be less inclination to privatize insurance supply.

Equity in providing security to low-income population (Rank: medium (historically high but decreasing))

As noted above, insurers are moving towards abandoning cross subsidies and adopting risk-based premiums. Today insurance coverage is low (30%) for poor households compared to the total market penetration. It is generally assumed that the government will gradually play a larger role in compensating victims who cannot afford insurance (Faure and Hartlief, 2006)

Efficiency in terms of benefits and costs (Rank: low)

Like other private market systems, the transaction costs appear high. Approximately 35% of premium income is used to cover commissions, administrative and operating costs, and only about 50% of premium income covers claims (although it is likely that insurers achieve 50% claims ratio or less in good years, but these are offset by very high ratios in 'event' years).

According to Unger Sternberg (2003) competition by sales representatives appears to play a greater role in this market than price competition.