**Assessment of costs of natural hazard**

**A meta-guidance document**

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**Note Implementation**

The Meta Guidance is to be implemented as a *wiki-like portal* dedicated to disaster risk reduction. It will be linked to the *Climate Adapt* and *Preventionweb* knowledge portals as a link to external source of information. A separate synthesis document (in pdf) will be produced and distributed as a stand-alone publication. The underlying guidance documents have already been uploaded to Climate Adapt portal.

 **Scope of the Guidance**

Floods, along with storms, are natural hazards that incur the highest economic losses in Europe. Over the period 1998-2009, the direct losses wreaked by flood events recorded by EM-DAT global disaster database and for which an estimate of economic impacts is available (~40% of all recorded cases) exceeded EUR 60 billion in 2009 values (EEA 2010)[[1]](#footnote-1).

Recent attention paid to assessment of disaster losses has propelled development of a number of guidance documents, differing in extent/length, focus and level of detail. This meta-guidance lends itself as an introduction and annotated reference list. We have selected the most recent, prominent or representative guidance documents [a link to the list and references will be provided in the wiki-like structure].

There will be the possibility for users to propose new items.

[Page] **Why it is important to assess the hazard losses**

[Pull-down menu] ***The damage assessment may be conducted to inform***

- Prevention and protection policies, by shedding light on the pattern of practice that drive vulnerability and risk; by identifying the pathways through which the economic and social hardship is spread beyond the directly affected area; by increasing awareness about what is at stake.

- Preparedness polices, by helping to budget resources for development of early warning and alerting systems, and for managing emergencies; and by allowing to better tailor the information provided for different communities and groups.

- Response policies, by helping to decide (and legitimise) how much resources need to be de-played to manage properly the emergency situations and constrain the damage and hardship suffered.

- Recovery and review risk management, by driving the information collection during and after the emergency; by deciding which investments can most effectively boost the recovery and welfare contributions to most vulnerable groups.

[Pull-down menu] ***Trend detection and climate change attribution***

Since the 1990s, and even more since the early 2000s’, the economics of disasters has attracted the attention of policy makers and academics who sought to analyse the relations between empirically confirmed climate change and the frequency and intensity of the extreme climate events such as tropical an extra-tropical storms, droughts, and heavy precipitation and ensuing floods. It is important to distinguish the increase of losses in nominal or current value (trend detection) from the attribution of these trends to (human induced) climate change. The latter is very difficult and only a few studies have managed to provide evidence of the existence of such a causal relationship. The recent IPCC Special Report on Managing the Risks of Extreme Events and Disasters (IPCC 2012b; IPCC 2012a)[[2]](#footnote-2) has reviewed the published research in this field and concluded that with a high level of confidence that economic losses from weather- and climate-related disasters have increased in the long-term, as people and economic assets have been increasingly exposed to risks. With other words, the observed increase of losses is caused by more people living where they may be adversely affected by disasters. Similarly, the EEA (EEA 2010; EEA 2012)[[3]](#footnote-3) founds no evidence of trends after the recorded flood-related losses when compound factors such as population and wealth growth are not taken into account.

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Key references**  | IPCC (2012a), (2012b)EEA (2010), (2012)CDKN (2012) |  |

[Pull-down menu] ***Extreme events – SREX report***

The “Special report on managing the risk of extreme events and disasters to advance climate change adaptation (SREX)” of the Intergovernmental Panel on Climate Change (IPCC 2012a) offers an overview of climate extremes and impacts. Here, we understand an “extreme climate or weather event” or “climate extreme” is defined as “the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable” (IPCC 2012a).

The report finds evidence of high likelihood that there has been a decrease in the number of unusually cold days and nights and an increase in the number of unusually warm days and nights at the global scale. It is likely that anthropogenic influences have contributed to these trends. Projected changes (up to 2100) seem to strongly confirm the above described trends.

The report is less affirmative with respect to the observed and projected change in precipitation pattern. Whereas some regions have experienced significant increases in the number of heavy precipitation events (high likelihood), there are strong regional and sub-regional variations in these trends. There is medium confidence that anthropogenic influences have contributed to the intensification of extreme precipitation at the global scale. Projected changes suggest a likely increase in the frequency of heavy precipitation events or increase in proportion of total rainfall from heavy falls over many areas of the globe.

There is medium confidence that some regions of the world have experienced more intense and longer droughts for instance in southern Europe and West Africa but opposite trends also exist. There is medium confidence that these observed changes in drought patterns are attributed to anthropogenic influences and medium confidence in projected increase in duration and intensity of droughts in some areas of the globe such as southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil and southern Africa.

There is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scale, however, there is high confidence in trend toward earlier occurrence of spring peak river flows in snowmelt and glacier fed rivers. There is low confidence that anthropogenic warming has an impact on the magnitude or frequency of floods at global scale, however, there is medium confidence that anthropogenic influences have contributed to changes in some components of the water cycle such as precipitation and snowmelt which affected floods. Projected changes underline low confidence in global projections of changes in flood magnitude and frequency and very likely earlier spring peak flows in snowmelt- and glacier-fed rivers.

Furthermore, it is likely that there has been an increase in extreme coastal high water related to increases in mean sea level. Finally, there is high confidence that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high-mountain phenomena such as slope instabilities, mass movements, and glacial lake outburst floods. There is also high confidence that changes in heavy precipitation will affect landslides in some regions (IPCC 2012a; CDKN 2012)[[4]](#footnote-4).

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Key references**  | - IPCC (2012a) (2012b), IPCC 4th and 5th ARCDKN (2012) |  |

[Page] **Understanding impacts**

Natural hazards represent exogenous, internal or external (if international trade is affected) supply shocks to economies with far-reaching ripple effects, touching almost every aspect of economic life.

***Direct*** impacts encompasses harm to human health (injury and death), property (physical destruction) and the environment, whereas the indirect impacts are associated with disruptions in economic and social activities (Messner et al 2007) [[5]](#footnote-5). *Direct tangible costs or losses* due to natural hazards represent economic (social welfare) value of the hazard consequences. They may encompass the value of the physical assets destroyed or damaged, and/or value of the foregone production (Bubeck & Kreibich 2011; Green et al. 2011)[[6]](#footnote-6).

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Case study** | PREEMPT (2013)[[7]](#footnote-7), Ch. 2, p. 18Green et al. (2011), Ch. 4, p. 39Bubeck et al. (2011), Ch. 2, p. 9Meyer et al (2013) 7, p. 1354 |  |

*Indirect tangible costs* are triggered by the disruption of the flows of goods and services, and are sometimes referred to as induced or indirect losses (ECLAC 2003; World Bank 2010; Przyluski & Hallegatte 2011)[[8]](#footnote-8). Indirect damages arise as the effects of natural hazards spread beyond the immediately affected area, through disruption of lifeline services (e.g. transportation, water or energy supply), or as resources needed for reconstruction pulls resources away from their initial destination. Indirect damages also include additional costs incurred from the use of alternative and potentially inferior means of production and/or distribution of normal goods and services (IPCC 2012b)[[9]](#footnote-9).

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Case study** | PREEMPT (2013)[[10]](#footnote-10), Ch. 2, p. 18Green et al. (2011), Ch. 4 p. 57Przyluski et al. (2011), Ch. 2 p. 9 and Ch. 4, p. 33Meyer et al (2013), p. 1354 |  |

A special case is the one highlighted in Meyer et al (2013), where business interruption costs, usually listed among the direct and indirect tangible costs, are treated as a separate category.

The *intangible* losses include loss of human lives, cultural heritage, and ecosystem services. These losses are difficult to measure in monetary value, and thus they are poorly reflected in the estimates of losses (IPCC 2012a)[[11]](#footnote-11). Among them, social impacts include

1. stress as a result of the event itself, and associated psychological and physical health effects;
2. impacts on physical health and loss of life;
3. damage to or loss of irreplaceable possessions such as photographs or paintings, and or property such as gardens;
4. social disorder;
5. loss of local labour and increased working hours;
6. temporary evacuation from the home;
7. disruption to daily life in the home and in the community;
8. loss of community and/or cultural heritage;
9. loss of landscape and nature as an aesthetic value; and
10. reduced quality of life (Markantonis et al. 2011)[[12]](#footnote-12)

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Case study** | Markantonis et al. (2011)ECLAC (2003)DEFRA (2004)[[13]](#footnote-13) |  |

*Environmental losses* arise as a result of temporal or permanent compromise of ecosystem quality and/or ecosystem service supply, and as biodiversity losses. For instance, during the drought spells the minimal environmental flows may not be maintained, often because the anthropic water uses, notably domestic water supply, are assigned higher priority. Floods often trigger industrial accidents and pollution spills with lasting consequences.

Ecosystem functions - regulatory, habitat provision, production and information related - refer to the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly (de Groot et al. 2002)[[14]](#footnote-14). The maintenance of the optimal life conditions depends on a delicate balance between several ecological processes in which biotic and abiotic factors are combined to offer the large amount of goods and services under evolution and control mechanisms. Ecological and socio-cultural values are of great significance for the function of ecosystems (de Groot et al. 2002)[[15]](#footnote-15). The former refer to the level of integrity of regulation and habitat functions analysed considering ecosystem parameters as complexity, diversity and rarity. The latter refer to natural ecosystems as a crucial source of non-material well-being. In synthesis, high relevance is assigned to the different aspects of ecosystem functions impacting on mental health, education, cultural diversity and identity, freedom and spiritual values. In Meyer et al (2012, 2013) the environmental costs are fully integrated in the intangible losses category.

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Case study** | De Groot et al. (2002)1, section 3 p. 402Green et al. (2011), Ch. 3 p. 20[[16]](#footnote-16)DEFRA (2004), Ch. 2, p. 5Meyer et al (2013)5 |  |

A separate category of losses relates to recovery and risk mitigation costs. These are associated with planning (e.g., developing appropriate processes including key stakeholders), risk prevention and preparedness, recovery (e.g., emergency disaster responses, rehabilitation, and reconstruction), and implementation of risk mitigation measures (IPCC 2012a)[[17]](#footnote-17). Risk mitigation costs are characterized by the benefits generated in terms of avoided losses.

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| **Further reading** | **Where in the Guidance documents**  | **Note** |
| **Types of impacts** | Messner et al, F. (2007)[[18]](#footnote-18) – Ch. 2 p. 9 – 10Bouwer et al. (2011) |  |

[Page] **Methodologies for estimating the costs of natural hazards**

There is wide range of assessment techniques available for assessing the effects of natural hazards. Depending on the available data and the scope of the assessment, the different assessment techniques may yield partly diverging results. It is important therefore to understand the strengths and limitation of the existing techniques and chose those which are best suited for the intended purpose.

The methodologies under consideration have been described in the table below. For each of the methodologies an assessment of the main characteristics has been provided. The characteristics taken into consideration are: background knowledge requirement for the application of the specific methodology; complexity of the methodological tools; and extent of data requirements or availability. The assessment results have been expressed through a “traffic light” representation where: red corresponds to the maximum, yellow to the medium and green for the lower level.

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| Methodology’s characteristics | Degree |
| Background Knowledge requirement |  | Low |
| Degree of Complexity of the methodological tool |  | Medium |
| Extent of data requirements or availability |  | High |
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For instance, a methodology characterised by a low background knowledge requirement, a large complexity, and a high data requirement will be reported with a green light in the first row and two red lights in the second and third rows. A “green light” methodology could be easier to be applied, but, in most cases, a methodology requiring deeper background knowledge and more data, and characterized by a larger complexity, could provide more accurate results.

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| **Methodology** | **Description** | **Where in the Guidance documents**  | **Note** |
| **Reduced-form impacts attribution statistical model** | Statistical methodologies aimed at assessing flood direct impacts in proportion of the physical characteristics of the flood event.  | PREEMPT (2013) – Chapter 2, pages 15 – 16Messner et al (2007) – Chapter 3 pages 22 – 33Bubeck et al. (2011) – Chapter, pages 10 – 16Przyluski et al. 2011, Ch. 2 p. 9  |

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| **Geo-referenced analysis and Spatial Coupled hydrological-economic modelling applied to flood** | Combination of spatial (GIS) geo-referenced analysis of the flood characteristics combined with appropriate land use data and damage functions for direct impact assessment. | PREEMPT (2013) – Chapter 2, pages 16 – 17Messner et al (2007) – Annex 2.1 pages 19 – 21Messner et al (2007) – Chapter 3 pages 33 – 60IPCC (1994) – Chapter 7 page 30 |

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| **Different instruments for different scale of impact** | For micro-scale analysis, the high data accuracy and the scarce uncertainty linked to the assessment procedure could be favourable for the use of econometric methodologies, while for meso- and macro-scale analyses model based approaches could be more suitable | Messner et al (2007) – Chapter 3 pages 29 – 31 and 98 – 99Przyluski et al. (2011), Chapter 2 pages 24 – 25IPCC (1994) – Chapter 4 page 9 |

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| **Econometric approaches for indirect impact assessment** | Linear programming models for the optimal allocation of the post event production capacity; post event economic surveys; econometric models reflecting historical trading patterns. | PREEMPT (2013) – Chapter 2, page 17Przyluski et al. (2011) – Chapter 2 page 23IPCC (1994) – Chapter 4 page 8-9 |

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| **Model based approaches for indirect impact assessment** | Input Output Models; Computable General Equilibrium Models: hybrid models. | PREEMPT (2013) – Chapter 2, page 17Przyluski et al. (2011) – Chapter 2 page 25IPCC (1994) – Chapter 4 pages 8 – 9EMA (2002) – Chapter 2 – Pages 5 – 10 |

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| **Revealed preference methods** | Cost-assessment methods estimating the intangible costs of natural hazards: Hedonic pricing method (HPM); Travel Cost Method (TCM); Cost of Illness Approach (COI); Replacement Cost Method (RCM); Production Function Approach (PFA). | Markantonis et al. (2011) – Chapter 2, pages 30 - 39 |

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| **Stated preference methods** | Cost-assessment methods estimating the intangible costs of natural hazards: Contingent Valuation Method (CVM); Choice Modeling Method (CMM); Life Satisfaction Analysis (LSA) | Markantonis et al. (2011) – Chapter 2, pages 39 - 53 |

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| **Benefit transfer methods** | Cost-assessment methods estimating the intangible costs of natural hazards: Benefit estimate transfer; benefit function transfer; and meta-analysis | PREEMPT (2013) – Chapter 2, page 18Markantonis et al. (2011) – Chapter 2, pages 55 - 56 |

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| **Cost-Benefit Analysis** | Cost-assessment method estimating the intangible costs of natural hazards: CBA is used to organise and present the costs and benefits, and inherent trade-offs, and finally estimate the efficiency of projects | DEFRA (2004) – Chapter 5 pages 81 – 90IPCC (1994) – Chapter 7 page 29Markantonis et al. (2011) – Chapter 2, pages 58 - 60 |

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| **Multi-criteria Analysis** | Cost-assessment method estimating the intangible costs of natural hazards: MCA is an approach that involves judging the expected performance of each development option against a number of criteria or objectives | Markantonis et al. (2011) – Chapter 2, pages 60 - 62 |

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| **Cost Effectiveness Analysis** | Cost-assessment method estimating the intangible costs of natural hazards: CEA is an economic approach that compares the relative costs and outcomes of two or more courses of action | Markantonis et al. (2011) – Chapter 2, page 63 |

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| **Biophysical Models** | Biophysical models are used to evaluate the physical interactions between climate and an exposure unit. Empirical-statistical models are based on the statistical relation; Process-based models are based on the physical relation. | IPCC (1994) – Chapter 4 page 8 |

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| **Uncertainty analysis** | Methods and techniques aimed at assessing and managing uncertainty derived from “errors” and “unknowns” in flood impact assessment. | IPCC (1994) – Chapter 7 page 31Government of Queensland (2002) – Chapter 7 – page 53Messner et al (2007) – Chapter 2 pages 14 – 18Conhaz (Bubeck et al. 2011) – Chapter, pages 21 - 23Green et al. (2011), Ch. 5 p. 76 |

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[Page] **Overview of the guidance documents**

The methodological analysis exposed above has been conducted taking into consideration the information provided by the Disaster Risk Reduction literature production in the recent past. Most of the manuscripts taken into consideration are represented by guidance documents. In this section, a sample of the most important guidance documents about natural hazard, and more specifically flood, risk and impact assessment is presented and described. The following guidance documents have been selected in base of the importance of their contribution for the topic under consideration. The analysis of these documents provided the background information for the development of this meta-guidance.

[Pull-down menu] ***Technical guidelines for assessing climate change impact and adaptation*** (IPCC 1994)

Definition of the problem; Selection of methods; Testing the methods; Selection of Scenarios; Assessment of biophysical and socio-economic impacts; Assessment of autonomous adjustments; Evaluation of adaptation strategies.

An updated version of these guidelines is currently under development. The new guidance will be available in the last days of 2013 or the first days of 2014.

*Ref: IPCC. (1994). IPCC technical guidelines for assessing climate change impact and adaptation.*

[Pull-down menu]**Handbook for Estimating the Socio-economic and Environmental Effects of Disasters** (ECLAC 2003)

This new version of the ECLAC Handbook describes the methods required to assess the social, economic and environmental effects of disasters, breaking them down into direct damages and indirect losses and into overall and macroeconomic effects.

The Handbook focuses on the conceptual and methodological aspects of measuring or estimating the damage caused by disasters to capital stocks and losses in the production flows of goods and services, as well as any temporary effects on the main macroeconomic variables. This new edition also contemplates both damage to and effects on living conditions, economic performance and the environment.

*Ref: ECLAC. (2003). Handbook for Estimating the Socio-economic and Environmental Effects of Disasters.*

[Pull-down menu]**Evaluating flood damages: guidance and recommendations on principles and methods** (Messner et al 2007)

Provide fundamental standard knowledge, specify key principles for economic evaluation of damages and reveal the sources of uncertainty that need to be considered. Hence, to help preventing errors in flood damage studies (chapter 2).

Chapter 3 describes the state-of-the-art in evaluating direct, tangible flood damages.

Chapter 4 reveals the principal rules and the procedure of building up a proper flood damage data base in order to ensure a consistent set of flood damage data.

Chapter 5 outlines the approaches to evaluate flood effects on industrial production.

Chapter 6 indicates possible procedures to include social flood effects. Environmental flood effects and methods of their evaluation are described in chapter 7.

Chapter 8 focuses on damage reducing effects of flood warning in order to support specific decisions on flood warning systems.

Chapter 9 gives an overview of flood damage categories which have not been considered in more detail in these guidelines and indicates relevant literature sources for further reading.

*Ref: Messner et al, F. (2007). Evaluating flood damages: guidance and recommendations on principles and methods. FLOODsite consortium, 2007. Integrated Flood Risk Analysis and Management Methodologies.*

[Pull-down menu]**Current knowledge on relevant methodologies and data requirements as well as lessons learned and gaps identified at different levels, in assessing the risk of loss and damage associated with the adverse effects of climate change** (UNFCCC 2012)

Chapter 3 outlines the different aspects of loss and damage in order to discuss different conceptual frameworks currently applied to the assessment of the risk of loss and damage, thereby setting the scene for an overview of relevant methods and tools;

Chapter 4 investigates selected approaches and the applicability of selected methods and tools in the context of loss and damage risks. The focus is on developing countries, with detailed descriptions of some of the most relevant methodologies and a specific assessment of information needs, capacity requirements and their relevance for decision makers;

Chapter 5 summarizes the findings and indicates lessons learned and gaps, and points to possible issues for further discussion under the work programme on loss and damage.

*Ref: UNFCCC. (2012). Current knowledge on relevant methodologies and data requirements as well as lessons learned and gaps identified at different levels , in assessing the risk of loss and damage associated with the adverse effects of climate change Technical paper, (May).*

[Pull-down menu]**The appraisal of human related intangible impacts of flooding** (DEFRA 2004)

The degree of health impact was associated with a wide range of factors including socio-demographic factors (especially prior health and age), flood characteristics (especially flood depth) and post flood events (especially problems with insurers in settling claims for flood damage which emerged as the most important factor).

*Ref: DEFRA. (2004). The appraisal of human related intangible impacts of flooding.*

[Pull-down menu]**Disaster Loss Assessment Guidelines** (EMA 2002)

Chapters 1 and 2 set out the framework within which a loss assessment would be carried out. Chapter 3 sets out the process to follow in assessing loss from hypothetical or actual hazard events and includes checklists to follow in progressively developing an overall loss assessment for a typical inundation loss.

*Ref: EMA. (2002). Disaster Loss Assessment Guidelines.*

[Pull-down menu]**Guidance on the Assessment of Tangible Flood Damages** (Government of Queensland 2002)

The purpose of this bulletin is to assist applicants to the Regional Flood Mitigation Program to assess tangible flood damages (i.e. those that can be estimated in dollars). The focus is on how to estimate the value of potential1 physical damage caused to property and infrastructure exposed to flood inundation within an urban environment. The common methods and approaches adopted for estimating flood damages, and the conversion of those estimates to an average annual damage figure necessary for cost/benefit calculations, are explained.

*Ref: Government of Queensland. (2002). Guidance on the Assessment of Tangible Flood Damages.*

[Pull-down menu]**ConHaz Synthesis Reports** (Coordination Action project funded by the EU 7th Framework Programme. Contract no 244159)

ConHaz synthesises current cost assessment methods and strengthens the role of cost assessments in the development of integrated natural hazard management and adaptation planning.

[Pull-down menu]Natural Hazards: direct costs and losses due to the disruption of production processes (Bubeck et al. 2011)

Indirect Costs of Natural Hazards (Przyluski et al.2011)

The intangible effects of Natural Hazards (Markantonis et al. 2011)

Methodology report on costs of mitigation (Bouwer et al. 2011)

Methods of Assessment of the Costs of Droughts (Logaret al. 2011)

Guidance for assessing flood losses (Green et al. 2011)

Methods for Estimating the Costs of Coastal Hazards (Lequeux et al. 2011)

Costs of Alpine Hazards Costs of Alpine Hazards (Pfurtscheller et al. 2011)

Synthesis and Overview (Meyer et al. 2012, 2013)

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