



CONHAZ
Costs of Natural Hazards

**The intangible effects of Natural Hazards
CONHAZ Report**



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Abstract

The “intangible” effects are defined as the costs of natural hazards which are not, or at least not easily measurable in monetary terms. In this context, this background paper reviews and analyzes the cost-assessment of the human health and the environmental effects of the natural hazards. This Work-package aims at compiling and analyzing the methods for the assessment of the intangible effects and at providing recommendations for their most effective application. The compilation and the analysis of the cost-assessment methods is based on a state-of-the-art literature review and will consist the basis for the hazard background papers and the hazard workshops to be carried out in ConHaz. Summarizing the content of the WP3 background paper it presents the physical context of health and environmental impacts caused by the four different natural hazard types analyzed under the ConHaz project. Also it presents and compiles the cost-assessment methods of the intangible effects by providing in detail their application context. Furthermore, the data availability and use process is evaluated. Eventually, this background paper analyzes in a qualitative way the application of the cost-assessment methods and provides preliminary recommendations.

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Introduction

In general, damages, which can be easily specified in monetary terms, such as damages on assets, loss of production etc. are called tangible damages. The current practice of disaster risk assessment mainly focuses on these damages (Smith & Ward 1998, Penning-Rowsell et al. 2003). More precisely, many damage evaluation approaches applied in different European countries focus on damage to assets, like the physical destruction of buildings and inventories (Meyer & Messner 2005). Most of these approaches calculate the expected damages or the degree of damage based on the market values of assets (Messner et al. 2007).

Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as “intangibles” or “non-market”. Hence, the “intangible” effects incur costs of natural hazards which are not, or at least not easily measurable in monetary terms. Intangible effects are often not included in costs assessments of natural hazards leading to an incomplete and biased cost assessment. However, several methods exist which try to estimate these effects in a non-monetary or monetary form. In this context, this background paper reviews and analyzes cost-assessments of mainly human health and the environmental effects of the four types of hazards (floods, droughts, coastal and alpine hazards) analyzed under the ConHaz project. It also provides a valuation framework of the complex issue of estimating these intangible effects. In addition, cultural heritage costs of natural hazards are also briefly summarized, although no cost-estimations are provided since they are not available.

In contrast to impacts of natural hazards on human beings and economic assets, environmental impacts are more difficult to assess. Natural hazards may have negative and positive effects on ecosystems, depending on the extent of a hazard and the specific spatial and temporal scales. In this report, we are focusing on the negative effects or the costs of the natural hazards. Only few examples exist for an ex-post estimation of environmental and health costs of natural hazards (Post-Disaster Needs Assessment, <http://www.recoveryplatform.org/pdna/>). Also, for ex-ante estimations the intangible costs are currently rarely considered (for exceptions see Turner et al. 1995 or Hartje et al., 2001). On that basis, an optimised allocation and design of damage reduction measures cannot be ensured. Hence, for an integrated assessment and management of natural hazards it would be necessary to consider also the intangible impacts and their costs.

Particularly, the objectives of this work package are:

- To compile and analyze the methods, data and terminology for the assessment of health and environmental effects caused by natural hazards.
- To provide recommendations on the cost-assessment methods and to identify research needs, knowledge gaps and potentials for their application.

In order to conduct this background paper (BP), we first carried out a literature review to compile the state-of-art of the methods applied for the cost-assessment of intangible effects. Additionally, the lead partners of the hazard work-packages 5-8 contributed by providing a state-of-art concerning the cost-assessment of intangible effects in their natural hazard communities (floods, droughts, coastal and alpine hazards). In this context, a questionnaire was answered by the WP5-8 partners providing information on cost-assessment methods, data used for the application of the methods, terminologies, the physical context as well as relevant recommendations. The present background paper together with BP's 1,2 and 4 provided the basis for the hazard background papers and the hazard workshops organised with the ConHaz activities. Based on the feedback from the hazard stakeholder workshops, the present report has incorporated more detailed recommendations on methods and research needs regarding the intangible effects.

The WP3 background paper on the intangible effects is structured as follows: The first chapter presents the physical context of health and environmental impacts caused by the four different natural hazard types analyzed under the ConHaz project. Also it provides a literature review concerning the terminologies and the available glossaries used by the scientific community. The second chapter is the core of this background paper, presenting and compiling the cost-assessment methods of the intangible effects which can be found in literature. In this context, it illustrates a general theoretical basis for the estimation of the intangible effects and analytically presents the cost-assessment methods that are applied or could potentially be applied. The application context of the cost-assessment methods is analyzed specifically in the field of the natural hazards, while relevant case-studies are provided in most methods. In order to compile the cost-assessment methods they are classified as revealed preferences, stated preferences and integrative decision-making processes. The third chapter analyses the data availability and evaluation process for the application of the cost-assessment methods. The available databases for the intangible effects are identified and the data used are evaluated under certain criteria in a comparable way for each cost-assessment method. The fourth chapter evaluates the cost-assessment methods with regard to their applicability in a qualitative way by providing an analysis and comparison using various criteria. Finally, the fifth chapter presents the preliminary conclusions concerning policy recommendations, research needs, knowledge gaps and potentials.

1. The intangible effects of the natural hazards

In general, damages, which can be easily specified in monetary terms, such as damages on assets, loss of production etc. are called tangible damages. Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as intangibles (FLOODsite, 2007)¹. In this context 'intangibles' is anything which is not currently considered to be a tangible loss (i.e. one which can currently be evaluated in economic terms). Following this definition of the intangible impacts, ConHaz is mainly analysing the environmental and health impacts of natural hazards. We start by presenting the natural process for each one of the four types of natural hazards considered in this project (floods, droughts, coastal, alpine) to circumscribe the variety and complexity of damage producing processes following the occurrence of natural hazards.

This chapter provides the basic knowledge on the intangible effects induced by floods, droughts, coastal and alpine hazards. The main intangible effects of natural hazards are summarised in Table 1.1 These effects are differentiated for the severity of the hazardous event and the types of the four natural hazards included in our analysis. (++: important impacts, +: minor impacts)

Table 1.1 The intangible effects of natural hazards

	Intangible costs effects	Types of hazards
Environment	Biodiversity loss	Droughts (++) floods (+)
	Loss of wetlands	Droughts (++)
	Soil contamination & pollution	Floods & coastal (++) alpine (+)
	Water pollution	Floods (++) coastal (+)
	Water depletion	Droughts (++)
	Loss of soil nutrients	Droughts (++) floods (+)
	Soil erosion	Floods (++) droughts, coastal (+)
	Aesthetic environment impacts	All (minor)
Health	Fatalities / injuries	All
	Infectious diseases	Floods (++) coastal (+)
	Mental illnesses e.g post-traumatic stress, depression	All
	Malnutrition	Droughts (++) floods (+)
Others	Damages to cultural heritage	Floods (++) coastal (+) alpine (+) All

¹ For other definitions of „intangibles“, see section 1.2

The first and second section summarize, consequently, the physical context of the environmental and health impacts caused by the four types of natural hazards analyzed in the ConHaz project. The third section briefly presents the cultural heritage costs, and the fourth part regards the various terminologies and glossaries used by the hazard communities concerning intangible impacts.

1.2 The physical context of the environmental effects

The environmental effects differ for each of the four types of natural hazards. These main effects are presented separately regarding each type of hazard.

Floods

In regard to the environmental impacts of floods, the focus has been almost exclusively upon the environmental harm potentially caused by extreme flood events. When flooding is a frequent event, then ecosystems will usually have adapted to that 'natural variability' in their resistance to and intake or storage of excess water. Therefore, the critical questions about flooding and the effects of flooding are: frequency and seasonal timing. For example if an area is frequently flooded during the growing season, a wetland will develop: plant species which are well adapted to and require saturated soils during the growing season.

Additional potential environmental problems of floods are:

- Sediment load deposited by the flood

Rivers vary dramatically in both the quantity of sediment carried and the nature of the sediment which is carried. That sediment can be characterised in terms of the standard soil types and the standard fertility expectations of those types used. In gross terms, the primary difference is then between silts and sands, with the deposition of silt being broadly good and the deposition of sand being bad. Some floods have deposited many centimetres, even metres, layers of sand and this is very destructive of soil fertility. But that generalisation should be modified by consideration of the chemical structure of the deposited material: a heavy load of aluminium or iron or salts would generally be undesirable. What needs to be considered is the soil type of the area, which is generating the sediment and the soil type of the area to which that material is being exported.

- Any pollutants carried on the flood causing contamination.

Floods can release a variety of pollutants, notably agricultural chemicals and oil in the form of heating oil, diesel and petrol. Areas where the concentrations are high will be harmed (Euripidou and Murray 2004, Förstner, 2004).

A good example is the 1997 floods that emerged in the Oder, Morava and Danube and influenced Poland, Germany and Czech Republic causing series of environmen-

tal impacts. These ecological impacts included increased nutrient and pollutant concentrations in the Oder estuary. Heavy metals, mineral oils and organic trace substances were carried by the floodwater. Destruction of forest and river wetlands engineering of mountain streams and rivers destruction of waterside vegetation and removal of natural water-retention features have reduced water-absorption capacity. (EEA, 2001)

Another case-study of 2006 on extreme floods in the Danube River regarding the species composition of phytoplankton in a shallow flood plain lake, Lake Sakadas, indicate a change in the ecological state of the lake. Extremely low phytoplankton abundance and biomass, high nutrient concentration and high Chla (Chlorophyll) concentration characterize the clear state. The long-lasting inundation caused a high stress environment for phytoplankton development in the lake which became the deepest part of a single large shallow water body. The results demonstrate that the occurrence of extreme flooding could be a stress or high enough for the transition from a turbid to a clear state of a floodplain lake (Adis and Junk,m 2002).

In the Elbe floodplain grasslands, the hydrological parameters are also key factors determining the structure of vegetation, mollusk, and ground beetle communities with soil and other abiotic factors contributing less to the variation (Follner and Henle 2006). Thus it was expected the 2002 Elbe summer flood to have a significant influence on the vegetation, mollusk, and ground beetle communities. Surprisingly, the vegetation structure hardly changed. The high resistance of the vegetation is a instructive example of range of morphological and life-history adaptations displayed by most floodplain plants, such as the development of aerated root tissue, shoot elongation, or timing of reproduction (Blom and Voesenek 1996). The adaptations displayed by the terrestrial and aquatic mollusks to cope with the dynamics of floodplain ecosystems, not only enabled them to survive the extreme flood event but also to benefit from them. In contrast, carabid beetle populations were seriously decimated by the flood, Hence the effects of the 2002 flood as well as the response to this event (i.e., resistance/resilience) varied widely among the different taxonomic groups according to the resilience capacity and the vulnerability of each group. Nevertheless, it can be difficult to quantify the effects of a single extreme event in regard to the long-term variation patterns of the observed communities and taxonomical groups. The quantification of the ecological effects can be achieved by a long-term monitoring of floodplain ecosystems with standardized methods.

Concerning flood events in industrial regions, extreme high waters may cause severe contamination of inundated areas with organic and inorganic pollutants, as it was observed during the flood event of the Rivers Elbe and Mulde (Germany) in August 2002 [Krüger et al. 2005].

Droughts

According to the EEA (2001), water resources experience under drought periods a dramatic depletion. In this case, the main priority is drinking water supply of acceptable quality. Differently from floods or other temporal extreme events, we therefore almost by definition experience a depletion of natural resources under droughts. River water entering a reservoir under low-flow conditions tends to be of low quality because the dilution of wastewater in the river is less than under normal-flow conditions. In terms of supply management, water supply problems are often alleviated by adequate groundwater and reservoir storage. Water quality deterioration affects also natural ecosystems related to the water bodies affected. Low flow in a river means poor dilution of the discharged pollutants and thus a risk of harming aquatic life.

In this context, droughts induce several intangible impacts. The environmental impacts from droughts embrace various ecological damages to wildlife and fish habitat, animal disease, loss of biodiversity, loss of wetlands, deteriorated water and air quality (e.g. salt concentration, ph, dissolved oxygen, dust, pollutants), soil erosion, reduced quality or loss of recreational sites, and aesthetic impacts.

The environmental impacts of the droughts can also be summarized with the following categories (European Commission, 2008)

- mortality of fish species
- impacts on river banks and biodiversity (flora)
- loss of biodiversity in terrestrial areas depending on the aquatic system
- impacts on wetlands (Natura 2000 sites)
- forest fires risk
- ecological status

Coastal hazards

According to the LIFE Environment Project 2003-2006 'RESPONSE', the environmental effects of the coastal hazards are the following: The ecological impacts of the coastal hazards is a significant attribute of natural hazards, though difficult to quantify since natural hazards in the coastal environment promote natural coastal evolution (e.g. injection new sediment volumes), which can also be seen as a benefit. Hence, in order to be addressed as a cost, it implies vulnerability/damage to an ecological asset of a specified value. There is a wealth of ecologically valuable land along the coastline, and in some of these areas a change to a rare or unique habitat can be highly significant. An example of this is the phenomenon of 'coastal squeeze' affecting low-lying saltmarshes backed by hard coastal defences or rising ground.

An example of the coastal hazards' intangible impacts is presented at Brown et al. (2007). This case-study analyzes the intangible costs of Hurricane Katrina. During Hurricane Katrina, a 250,000 barrel storage tank was dislodged and damaged in

flooding, releasing 25,110 barrels of oil. The contamination of polyaromatic hydrocarbons, diesel and arsenic has impacted 1,700 homes in adjacent neighborhoods and several canals, and the damage to offshore oil infrastructure has led to several million gallons of spilled oil scattered throughout southeastern Louisiana.

Alpine hazards

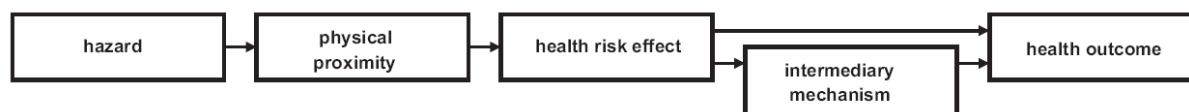
ConHaz, and more particularly WP8, covers selected alpine risks: floods and hydro-meteorological processes (heavy rain, flash floods, flooding, debris and mud flows), geologic mass movements (torrents, rock fall, rock- and landslides) and avalanches in alpine regions (countries: mountainous parts of Italy, France, Switzerland, Liechtenstein, Germany, Austria, Slovenia, Romania). These risks are characterised by multiple or “cascade” effects and therefore (in most cases) by strong relief energy due to the steep topography, hence total different loss characteristics compared to e.g. plain floods can be observed. Also, for instance, heavy precipitation rates during the August 2005 flood triggered rock falls, debris flows and sedimentation / till accumulation.

The most important environmental impacts of the alpine hazards include: leakages and relating contaminations due to floating oil tanks in flooded cellars, flooded garbage dumps and again contaminations of the water bodies, washed vehicles, interiors and resulting pollutants in waters. However, avalanches and landslides do not trigger environmental effects, apart from the direct affection of possible polluters (oil tanks, gas stations, etc.)

1.2 The physical context of the health effects

The health effects of natural hazards range from direct impacts on human life (eg loss of life, injuries) to risks regarding infectious diseases and mental illnesses. The human health vulnerability in natural hazards is a combination both of physical vulnerability (the likelihood of physical exposure to the hazard) and social vulnerability (susceptibility to its impacts) (Brooks, 2003; Cutter, 2006). In terms of health risk, social vulnerability can be shaped by people’s ability to avoid infection as well as by the ability of health systems to continue functioning during hazard events. In this context, ‘susceptibility’ refers to the capacity to experience harm but ‘modulated by physiologic factors only’ (Makri, 2005). Figure 1.1 presents a simple generic overview pathway for health of climatic hazards (Few, 2007). It commences with a hazard related to weather extremes that has the potential to pose risks to people and society. That hazard has to come into physical proximity to people (impinge on people’s environment and lives) to then create a health risk effect. A health risk effect can constitute a direct threat to human physical and mental health via a range of intermediary mechanisms that produce a pathophysiological impact on the body. This process can then lead to a range of health outcomes on individuals.

Figure 1.1. Generalized health impact pathway for climatic hazards.



Source: Few, 2007

Floods

Floodplain community structures are driven by short-term to extreme hydrological events, such as floods and droughts (Adis and Junk 2002). Extreme flood events can cause a range of negative impacts on human health from minor injuries to death including short and medium-term psychological distress. Similarly, we find minor or major, short and long-term disturbances of environmental bodies such as surface waters, wetlands or coast lines (for example). On the contrary, sometimes floods may also affect the environment in a positive way by “re-naturalizing” ecosystem functions suppressed by human usage of natural resources. This Work-package is restricted to examine the negative impacts on human health and the environment, illustrating the intangible costs due to natural hazards. Health impacts of floods are influenced by the interactions between physical, social and other vulnerabilities, pre-existing health conditions, and flood characteristics including the speed of onset, depth, and extent (Meusel and Kirch 2005). In this context Bourdieu (1986) underlines that the vulnerability and resilience of those impacted by floods might be influenced by the socio-economic and demographic characteristics, the personality characteristics and life experience as well as of the social context. The particularly vulnerable groups identified include the elderly, disabled, children, women, ethnic minorities, and those with low incomes (Hajat, Ebi et al. 2005). Health impacts of floods are a very complex issue, and often it is difficult to quantify these and to attribute them specifically to the flood (Ebi 2006; Fewtrell and Kay 2008). A variety of factors emerge that might have health consequences such as bacteria, viruses, helminths, protozoa, as well as immuno-suppressive effects of stress.. Therefore, an identified health effect cannot necessarily be traced back to its specific ‘natural’ cause. In turn, health effects may potentially be detected in a variety of ways at multiple levels from self-report through visits to medical doctors, to statistics, including also the study of death certificates. In all the above-mentioned cases, difficulties occur concerning the identification of the floods’ health impacts, including the reliance upon official statistics of doctor’s or hospital visits or excess deaths.

The mitigation of the floods’ health impacts is mainly coping with the attention to post-traumatic stress disorder which is extremely valuable. Treatment options are being explored which may identify how to mitigate the long-term impacts of disasters on individuals directly and indirectly affected by extreme floods. Better understanding

and treatments for anxiety, depression, grief, loss, cognitive or social dysfunction and coping deficits are needed to establish the physical basis of a comprehensive costing of impacts.

In a review conducted by the Tyndall Centre for Climate Change Research (2004) the major health effects of floods include: injuries, diarrhoeal diseases, vector-borne diseases, rodent-borne diseases and effects on mental health. Globally, the greatest impact on mortality is occurring in developing countries. This is mostly due to different degrees of awareness among private and public actors, and consequently differing degrees of individual and structural protection against natural hazards in developing versus developed countries. In other words, different social vulnerabilities and coping capacities drive the physical impact basis for economic losses. A small value given to human and environmental impact in protection is reflected in a larger number of casualties and greater physical loss to natural and human health assets.² Despite the relative greater importance in physical terms, the few epidemiological studies on natural hazard related deaths mostly focus on developed countries. In the context of identifying the health impacts, cholera has been reported after numerous flood events, but no controlled studies are known. Similarly, though some evidence exists for flood related outbreaks of rotavirus, hepatitis and polio, it is not particularly strong. In the case of vector-borne diseases the main focus in the literature has been on malaria and arboviruses. Flood-related malaria transmission was reported from Africa, Asia and Latin America (but no detailed epidemiological studies are available). Rodent-borne diseases (Leptospirosis) are observed to occur worldwide in urban and rural area, and in both developed and developing countries. The main mental health outcomes highlighted in this review were common mental health disorders (anxiety, depression, stress) and posttraumatic stress disorder, with the majority of studies arising in the USA and Europe. The review concluded that the potential health impacts of flooding are wide-ranging and context specific, and that few (rigorous) epidemiological studies exist.

In Few et al. (2004) the health effects of floods in different magnitudes are analyzed. According to this study, which based on epidemiological researches, infectious disease is a major flood-related health concern in the South, especially in settings where infectious disease transmission is an endemic public health problem. Infectious disease outbreaks have been reported following major flood events in developing countries, and these outbreaks vary in magnitude and rates of mortality. There is some evidence from India and Bangladesh that diarrheal disease increases after flooding. There is also good evidence of outbreaks of leptospirosis, but relatively weak evidence that flooding leads to outbreaks of other infectious diseases (e.g. cholera, hepatitis, vector-borne disease). Mental health studies relating to flood events, by contrast, come mainly from countries of the North. There is strong evi-

² Paradoxically, we could therefore see the economic damage staying the same despite large differences in physical impacts in developing versus developed countries

dence that flooding can have an adverse effect on common disorders such as anxiety and depressive illness, especially in the elderly. One study in the USA showed that an increase in such disorders was greatest in low-income groups. Only two studies addressed mental health impacts of flooding in developing countries. There was evidence that flooding in Bangladesh was associated with increased behavioural problems in children. The lack of research in developing countries may reflect low levels of mental health service provision as well as a shortage of research expertise on mental health epidemiology.

In a case study of the Buffalo Creek, West Virginia in 1972, flooding event, citizens are known to have suffered very important long-term health impacts. The result of this flood event was a collective trauma that lasted longer than the individual traumas caused by the original disaster. Of the 615 survivors examined by psychiatrists, 1½ years after the event, 93 per cent or 570 of them were suffering from emotional disturbance. Nearly everyone had a close encounter with death from the event (Grunfest, 1995).

The health impacts of floods, specifically in Europe, are summarized in the Table 1.2.

Table 1.2 Summary of the health impacts of flooding in Europe

Impact	Features
Mortality	Main cause is drowning, other causes inadequately studied and include heart attacks, hypothermia, trauma, and vehicle-related deaths. Mud and water rushing in also caused some deaths in camping sites.
Injuries	Mainly soft tissue injuries (contusions, lacerations, abrasions, cuts, bruises, sprains, strains, puncture wounds), minor in nature
Communicable diseases	No malaria or dengue, some arbo-virus disease, West Nile virus, leptospirosis. Oro-faecal infections include diarrhoeal diseases and gastroenteritis. General infections include ear, nose, and throat infections; conjunctivitis; skin irritations; skin rashes; and dermatitis. Respiratory symptoms reported include colds, coughs, flu, headaches, acute asthma, allergies to moulds, and pleurisy.
Chronic diseases	Asthma worsening, high blood pressure, cardiac arrest, heart attacks, kidney or other renal infections, joint stiffness, and erratic blood sugar levels
Mental health impacts	Anxiety, panic attacks, increased stress levels, mild/moderate/severe depression, irritability, nightmares, sleeplessness, PTSD, anger, tantrums, mood swings, increased tensions in relationships (e.g., arguing), difficulty in concentration, suicidal thoughts, alcohol dependence, and psychosomatic disorders. Aggression,
Miscellaneous	Carbon monoxide poisoning, toxic fungal spread, insect or animal bites, earache, lethargy, spontaneous abortions mainly due to mental and physical stress

Health systems impacts	Increased referrals more than double in flooded households for the year following the floods; system disruptions such as electricity, lack of standard operating procedures, lack of communication between relief and rescue workers and administrative authorities
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Source: Jakubika et al, 2010

Droughts

Health impacts from droughts primarily refer to an increased risk of diseases as well as malnutrition and famine due to food shortages, mainly in developing countries. Also, low flow in a river due to drought (EEA, 2001) means poor dilution of the discharged pollutants and thus a risk of harming aquatic life and sometimes it can even pose a risk to human health. Droughts also have other intangible impacts, such as a loss of human lives, migration (usually from rural to urban areas), social conflicts, increased crime rates, changes in income distribution, social welfare losses due to restrictions of water supply in households (e.g. prohibition of water use for swimming pools, gardens or car washing), and other kinds of social welfare.

Coastal hazards

According to the LIFE Environment Project 2003-2006 'RESPONSE' coastal hazards cause several health effects, including fatalities, injuries and mental health impacts. Fatalities are the highest cost and can be measured in real terms, but other health-related factors such as stress and depression, which may be related to risk, cannot be measured in the same way. Additionally, losses to social capital, damaging as they are to everyday quality of life, could hinder disaster recovery at the community as well as the individual level. At the individual level, recovery entails overcoming psychological and emotional responses including anxiety, depression and grief. When social networks are degraded or destroyed due to displacement, psychological and emotional problems are more likely to go unchecked making personal recovery more difficult. The effects of these problems may cascade beyond the individual or family causing secondary damage to social structures.

Alpine hazards

Health effects of the alpine hazards mainly refer to casualties, injuries and traumatic stress mental diseases. However, in the case of floods, debris flows and related hydro-meteorological processes the health effects (loss of life, injured) are neglectable in recent decades due to risk management strategies and technical mitigation measures, but (snow-) avalanches did occasionally cause major effects, like a relatively large number of casualties (e.g. 39 persons killed in the 1999 avalanches in the municipalities of Galtür and Ischgl, Austria).

1.3 The cultural heritage effects

The cultural heritage costs, likewise environmental and health ones, are also usually not included in cost estimations of natural hazards. Further, natural hazard risk analyses are often not included into cultural heritage management plans. However, in some cases extreme events have significantly affected cultural heritage assets.

Natural hazards, especially floods and secondary landslides, avalanches and coastal storms, can cause important damages to cultural heritage assets (Stovel, 1998) such as monuments, archeological sites, historic settlements, cultural landscapes etc. Taboroff (2000) identifies cultural heritage being a risk issue of natural hazards (including floods, landslides, avalanches and coastal storms), especially in the low-income countries due to the absence of adequate risk estimation and evaluation. In this context, ineffective risk management of cultural heritage assets is caused by the inadequate knowledge of the assets themselves, failure to estimate the true cost of loss damage and the difficulty to put a value on the non-market nature of many cultural heritage values. According to Meier and Will (2007), knowledge of natural hazards' impacts on cultural heritage is relatively scattered and there is need for further assessment of these impacts and their costs. Furthermore, Abhas (2010) recognizes the importance of the socioeconomic value of cultural heritage as a way to mitigate risk ex-ante.

Tarraguel (2011) analyses the risk vulnerability of 60 cultural heritage objects in Georgia caused by natural hazards, specifically landslides and avalanches. Metternicht et al (2005) analyze, among others, the impacts of landslides on cultural heritage in Switzerland. Also, Taboroff (2003) describes the significant impacts on cultural heritage of the extreme floods emerged in Central Europe as well as the cultural heritage impacts of floods and coastal hazards at the Mediterranean region. In the context of cost assessing the damages of natural hazards on cultural heritage the relevant risk management measures include protective actions and/or restoration of the affected sites. Regarding the former, Will and Lieske (2007) proposes flood protection measures to protect future flood damages to cultural heritage in Grimma (Germany), where urban cultural heritage was significantly affected by the 2002 floods. Palaeo-environmental sites and their value for coastal management have been assessed in the Central Southern England Study Area, one of the Coastal Study Areas assessed as part of this RESPONSE Project.

The Slovenian case study of “Franja Partisan Hospital”

The Franja Partisan hospital is one of the few preserved partisan hospitals, a famous monument from the Second World War. The Franja Partisan Hospital is a cultural monument of national importance, is entered in UNESCO's Tentative List of World Heritage, and bears the European Heritage Label. On September 2007 torrential waters swept away most of the buildings of the Partisan Hospital Franja. The total damages of this torrent was 3,36 mio € (cultural heritage 2,33 mio €, on the streams 1,03 mio €). After the disastrous flood that occurred in September 2007, the monument has been reconstructed almost in its entirety, and is reopened for visitors from May 2010. The costs of repairing the hospital, a project assumed by the Slovenian government in the immediate aftermath of the catastrophe in 2007, amounted to 4,59 mio €. The repairs did not only concern the conservation and restoration works of the monument (2,54 mio €), but also included restoration of torrent catchment Čerinščica (2,05 mio €) to ensure that a similar disaster will not happen again. The money was provided by the Slovenian Ministry of Culture and the Ministry of the Environment and Spatial Planning. (Source: M.Sc. Jože Papež, “Data on natural hazard losses and methods for event documentation and costs assessments in Slovenia”, Presentation at the ConHaz Workshop “Costs of Alpine Hazards”, Innsbruck 19-20 May 2011).

Figure 1.2. Before and after the restoration of the Franja Partisan Hospital



Photo: Spletni portal mesta Idrija (<http://www.idrija.ws/>)

1.4 The terminology of intangible effects

In the context of defining the intangible costs of natural hazards, a range of terminologies have been developed for each of the natural hazards types. The terminologies of the four natural hazards' types, which are analyzed in the ConHaz Project, are presented below:

Floods

Defra (2004, 1): The 'intangible' health effects induced by a disastrous occurrence, such as flooding, can include both physical and stress-related symptoms, for example loss of sleep, anxiety, a reduced immune system response and increased susceptibility to certain illnesses. Current guidance on economic appraisal for flood and coastal defence schemes is provided by FCDPAG3 (MAFF, 1999) which includes a section on the 'non-monetary impact on households', in which it is stated that "...impacts of flooding such as increased stress, health damage and loss of memorabilia can be far more important than the direct material damages to their homes and their contents...". Although this is acknowledged, it is also stated that "...there is currently no agreed method for evaluation of these indirect impacts..."; current methods only extend to the cost of renting alternative accommodation and/or the cost of the drying-out process (usually in the form of the cost of dehumidifiers). Given the possible acute and chronic health effects that can arise from a flooding incident, the costs attributed to these effects could be a major factor in flood risk decision-making.

Defra (2004, 9): There are also 'intangible' damages caused by flooding. These include stress-related health impacts and loss of, or damage to, irreplaceable personal possessions (e.g. family photos, diaries etc.) and manifest themselves as the value of lost utility because of restricted activities, pain and suffering, anxiety about the future and concern and inconvenience to family members and others. These costs are not reflected in actual markets and hence cannot be estimated using actual market data. Generating evidence that such costs exist and producing initial estimates of their magnitude have been the focus of this study.

FLOODSite (2007, 10): Tangible/intangible damages: damages, which can be easily specified in monetary terms, such as damages on assets, loss of production etc. are called tangible damages. Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as "intangibles".

WHO defines health impacts of the floods including to them: increases in suicide, alcoholism, psychological and behavioural disorders. Moreover, WWF defines pollution caused by floods as the main environmental impact defining them as: Soil and water pollution from sewage, pesticides, fertilisers, heavy metals from mining and hazardous industrial products.

Droughts

A frequently used classification of drought impacts includes economic, environmental, and social categories (Wilhite, 1992; Wilhite, 1997; Wilhite et al., 2007). Wilhite and Wood (1994) and the National Drought Mitigation Centre of the University of Nebraska – Lincoln (<http://drought.unl.edu/risk/impacts.htm>) present comprehensive

lists of impacts associated with droughts according to this classification. The term intangible cost is currently not being used in the literature on droughts. This category, as defined in the ConHaz project, is incorporated either within the notion of indirect impacts or environmental and social impacts of droughts, depending on the precise classification of drought impacts applied.

To determine the onset of a drought event (European Commission, 2008), operational definitions usually specify the degree of departure from average of the climatic variable under consideration over some time period. Operational definitions can also be used to analyse drought frequency, severity, and duration for a given historical period. Drought is caused by a deficiency of precipitation due to different natural causes including global climatic variability and high pressure resulting in lower relative humidity and less precipitation. Drought differs from other natural disasters in its slowness of onset and its commonly lengthy duration and possible spatial difference between the deficiency of precipitation itself and the occurrence of drought.

Coastal hazards

The flood definition of Penning-Rowse et al. (2003) and Smith & Ward (1998), is also used to define the intangible costs of the coastal floods which are classified in direct and indirect forms of damages:

Table 1.3. Typology of flood damages

		Intangible
Form of damage	Direct	Loss of life Health effects Loss of ecological goods Cultural losses and migration, including ethical aspects
	Indirect	Inconvenience of post-damage recovery Increased vulnerability of survivors Water shortages on mortality and morbidity Loss of social cohesion and inter-/intra-state conflict

Source: Penning-Rowse et al. 2003

Furthermore, in the context of defining the environmental costs of the coastal hazards these can either be positive or negative. Floods can have positive effects on coastal ecosystems, but can also destroy oligotrophic biotopes and cause pollution in the coastal zone by transporting toxic materials. Here the analogy with riverine flood-

ing is evident (see for example Penning-Rowell et al., 2003, Brouwer and Van Ek, 2004, Meyer et al., 2008). Storms produce open space in wood land that allows flowers, and insects to flourish and encourage the development of shrub habitats that will benefit birds and small mammals (Harmer et al., 2004). In coastal regions they endanger coastal wetlands, pollute lakes with saltwater and polluted floodwaters and pose other risks to natural habitats.

Additionally, coastal storm events can cause the loss of coastal land via erosion from increased wave energy, removal of coastal vegetation and saltwater intrusion into interior wetlands from storm surges. Global climate change is expected to increase coastal storm events (Michener et al., 1997), and these storms are often a cause of drastic changes in coastal landforms (Leatherman, 1982), where erosion is particularly prevalent in areas where vegetation has been diminished (Danielsen et al., 2005).

Alpine hazards

Mountain hazards are defined as the occurrence of potentially damaging processes resulting from movement of water, snow, ice, debris and rocks on the surface of the earth, which includes snow avalanches, floods, debris flows and landslides. These hazards are inherent in the nature of mountainous regions and may occur with a specific magnitude and frequency in a given region (United Nations Disaster Relief Organisation - UNDRO 1991). In a general appraisal context of the natural hazards' impacts, the Austrian and Swiss methods of risk management have adopted the definitions of several citations.

Glossaries

In general the glossaries concerning the intangible costs of the natural hazards have been developed in a limited and incomprehensive level. The so far known glossaries concern mainly floods and secondary coastal hazards. Concerning the intangible costs of the alpine hazards and the droughts, no specific glossaries have been developed in this field. Citations and references about the intangible effects are provided in the Annex.

2. Identification and description of the cost assessment methods applied to value intangible effects

2.1 Theoretical framework and classification of the methods

Usually the cost assessment of the natural hazards impacts covers mainly direct and in some case indirect costs. Characteristically, the EU-FLOODsite project (Meyer and Messner, 2005) reviews the cost-assessment methods for evaluating flood impacts in four countries (England, Netherlands, Czech Republic and Germany). In these countries only in England the health and environmental impacts of the floods are estimated at the regional level. In this context, an average value per household and year of 200 British Pounds is used as a basis for the calculation of the benefits of avoiding health impacts.

There are good economic reasons to value the intangible impacts on human, social and natural capital (Costanza and Farley, 2007). An economic system should allocate available resources in a way that best provides sustainability. Quantification and monetization (for the handling of trade-offs between different functions) of environmental goods and health functions therefore is a basic requirement for sustainability and for economic efficiency of public investment. In this context, the present chapter illustrates and analyzes the cost-methods that are used or could potentially be used to value the intangible costs (environmental and health) that emerge from the four different types of natural hazards being evaluated by the ConHaz project (floods, droughts, coastal and storms, alpine risks). Analytically, case studies of applying cost assessment methods are also provided when this is feasible.

Cost assessment of intangible costs of natural hazards is following the main principles of welfare and environmental economics. According to environmental economics, individuals derive values from non-market goods, especially environmental goods, through many more ways than just direct consumption (Pearce and Turner, 1990). More specifically, they refer to the importance of considering the Total Economic Value (TEV) of an environmental good or resource. TEV recognizes two basic distinctions between the value that individuals derive from environmental good and services, one from using them i.e. use values, and the value that individuals derive from the environmental resource even if they themselves do not use it, i.e. non-use values. Use values can be further classified into three broad categories: Direct use values, indirect use values, and option values. The non-use values are further classified to existence and bequest values.

- Direct Use Value

'Direct' or 'primary use-values' include all outputs resulting from direct consumption and application of resources.

- Indirect Use Value

The second component of Use Values is represented primarily by indirect environmental function.

➤ Option Value

The Option Value contains the potential use of certain resources, even if they are not used at the present. The Option Value is to assure the future availability of a resource and can be seen as a kind of insurance premium.

➤ Existence Value

The Existence Value, taken separately, represents the value of the 'pure pleasure in something's existence' (OECD, 2000, p. 26). According to this definition, something's existence alone is not sufficient for its valuation. At least the awareness and appreciation of that environmental asset in the minds of individuals has to be assured.

➤ Bequest Value

Bequest Values represent the individual's desire to maintain resources in order to ensure their transmission for potential use by future generations (Loker, 1992; OECD, 2000).

In this context, the concept of total economic value (TEV) helps to identify the different market (tangible) and non-market (intangible) values that might be damaged in a natural hazard event (OECD, 2000). According to each type of (non-)use, a different valuation method is proposed that fulfils the specific valuation criteria and pre-requisites (Table 2.1).

Table 2.1. Components of Total Economic Value (Loker, 1992)

Total Economic Value				
Use Values			Non-use Values	
Direct Use	Indirect Use	Option Use	Bequest	Existence
<i>examples:</i>	<i>examples:</i>	<i>examples:</i>	<i>examples:</i>	<i>examples:</i>
<ul style="list-style-type: none"> • Recreation • Food • Health • Forestry • Landscape 	<ul style="list-style-type: none"> • Storm, Flood protection • Impact on climate change • Conservation of water resources (natural resources) 	<ul style="list-style-type: none"> • Future utilization • Conserved habitat • Biodiversity 	<ul style="list-style-type: none"> • Natural assets retained for future generations • Irreversible changes 	<ul style="list-style-type: none"> • Objects of intrinsic value (uniqueness of certain natural assets) • Endangered species
<i>possible valuation methods:</i>	<i>possible valuation methods:</i>	<i>possible valuation methods:</i>	<i>possible valuation methods:</i>	<i>possible valuation methods:</i>
<ul style="list-style-type: none"> ▪ Travel-Cost-Method ▪ Hedonic-Price-Method ▪ Contingent-Valuation 	<ul style="list-style-type: none"> ▪ Replacement cost method 	<ul style="list-style-type: none"> ▪ Contingent Valuation Method 	<ul style="list-style-type: none"> ▪ Contingent Valuation Method ▪ Choice Modeling 	<ul style="list-style-type: none"> ▪ Contingent Valuation Method ▪ Choice Modeling

- Method
- Production
Function
Method
- Cost of illness

Alternatively to the Total Economic Value theory, The Economics of Ecosystems and Biodiversity provides particularly a framework for the valuation of the ecosystems services (TEEB, 2010). Additionally, the Millennium Ecosystem Assessment (MA, 2005) defines four categories of ecosystem services that contribute to human well-being: provisional services, regulating services, cultural services, supporting services.

The cost assessment methods for estimating the intangible effects of natural hazards are categorized into indirect (revealed preference) and direct (stated preference) valuation methods. Revealed preference methods, such as avoidance cost and hedonic studies, have the advantage of producing estimates of the value for a particular good based on an actual market behaviour. In contrast, stated preferences methods (contingent valuation and choice modeling) create a hypothetical or contingent market, and analyze choices.

The revealed preference methods, also known as indirect valuation methods, look for related markets in which the environmental good is implicitly traded (Lancaster, 1966). Information derived from observed behaviour in the surrogate markets is used to estimate willingness to pay (WTP), which represents individual's valuation of, or the benefits derived from, the environmental resource. The two most popular methods prevalent in environmental economics literature are the hedonic pricing and the travel cost methods. In the context of estimating intangible costs of natural hazards, both methods have been applied. For example, Hamilton (2007) uses property prices in Schleswig Holstein to derive estimates of the value people attach to different coastal attributes that are at stake if flood events increase as a result of climate change. In another study (Hartje et al, 2001) the Travel Cost Method and Contingent Valuation Method are applied to estimate the recreational value of the island of Sylt and the impact of more frequent storm surges on the recreational value and the value of the German Wadden Sea. For the valuation of the environmental goods or services also, the replacement cost as well as the production function methods are used and analyzed in this report. In Leschine et al (1997) the Replacement Cost method has been applied to estimate the economic value of wetlands' flood protection capacity in Western Washington. Moreover, another method, considered as revealed preference one, which has a wide practical implementation concerning the health impacts of natural hazards is the cost of illness approach. The cost of illness has been applied in the DEFRA (2007) study to estimate the health costs of the 2007 floods in UK. In this case health costs were estimated on working days lost due to ill

health induced by flooding used data on work absences at a national level and at average wage rates.

The stated preference methods have been developed to value environmental goods that are not traded in any related market (Birol et al, 2006). Stated preference methods are survey-based approaches that elicit people's preferences directly by using one of the following measures: willingness to pay (WTP) to obtain an environmental improvement or to avoid an environmental deterioration, or willingness to accept (WTA) compensation for relinquishing an environmental deterioration or to forgo an environmental improvement. The methods bypass the need of markets for environmental assets by presenting individuals with a hypothetical market in which they have the opportunity to buy (WTP) or sell (WTA) the environmental good in question. People's actions are contingent on the hypothetical situation described to them, and elicited WTP and WTA bids are close to the value that would be revealed if an actual market existed (Cummings et al, 1986, Garrod and Willis, 1999 and Mitchell and Carson, 1989). The main advantage of stated preference methods is that they are the only methods capable of estimating both use and non-use values. In this context, they are very important in order to estimate the natural hazards intangible costs and so far they have been applied in many cases for this purpose. Both WTP and WTA measures are an important supplement to the revealed preferences method, since they measure welfare effects of damage and can thus be integrated in cost-benefit decisions (Pearce and Smale, 2005). Typical approaches for estimating the environmental and health goods or services are: 1) Contingent Valuation (CVM), in which respondents are directly asked about their willingness to pay for a certain improvement, 2) Choice Modelling (CM), in which respondents are presented with different bundles of goods at a certain price among which they are asked to make a choice and, 3) Life Satisfaction Analysis that correlates the degree of public goods with individuals' reported subjective well-being and evaluates them directly in terms of life satisfaction.

The above mentioned stated preferences methods have been applied in several cases to estimate the intangible effects of natural hazards. Messner et al. (2007) presents some examples for applications of CVM, describes how monetisation of environmental goods can be accomplished and - based mainly on Arrow et al. (1993) - gives some recommendations on how CVM techniques should be applied. In another study Daun and Clark (2000) are using a CVM to estimate the WTP for the maintenance of status quo flooding risk levels and/or corresponding ecological improvements to the watersheds. Also, in the study by Birol et al (2006) a CVM valuation survey has been used to estimate the non-use values affected by the droughts of the Cheimaditida wetland in Greece. In Hensher et al (2006) choice experiments were applied in Canberra, Australia in order to estimate households' and businesses' willingness to pay (WTP) to avoid drought water restrictions. Finally, in the study of Carroll et al. (2009) a fixed-effects model for Australia matching rainfall data with individ-

ual life satisfaction was used to estimate, the total cost of the 2002 drought, the costs of drought among residents in rural and urban areas, and the potential costs of a doubling in the frequency of spring droughts.

Additionally, the benefit-transfer method is based on transferring results of previously applied stated or revealed preferences methods in order to value the intangible costs. In the study of Martin-Ortega and Markandya (2009) the benefit transfer approach has been applied, based on public's willingness to pay for the estimation of the environmental costs of droughts' events, through a value transfer exercise. The estimates for the valuation of the droughts' environmental costs in this case were transferred from a choice experiment that was applied by the AquaMoney project in four river basins in Southern Europe.

Besides the stated and revealed preferences methods, and BTM, integrative decision-making methods are used to estimate intangible costs: Cost-Benefit Analysis, (CBA) Multicriteria Analysis (MCA) and Cost-Effectiveness Analysis (CEA). CBA and MCA are both approaches which are (mainly) used for the assessment of management options. Intangible costs or change in intangible costs compared to a baseline option are hereby included either as costs/benefits or as non-monetary evaluation criteria. Multicriteria analysis provides a non-monetary evaluation of the intangible costs and acts complementary to cost benefit analysis, which may include monetary estimations of the intangible impacts. The advantages and disadvantages of the main valuation methods are presented in the Table 2.2. A more analytical comparison of the cost-assessment methods, used exclusively for valuing the intangible costs of natural hazards, is provided in chapter 4 of this report.

Table 2.2. Advantages and disadvantages of the economic valuation methods

Method	Advantages	Disadvantages
Hedonic pricing method (HPM)	Based on observable and readily available data from actual behaviour and choices.	Difficulty in detecting small effects of environmental quality factors on property prices. Connection between implicit prices and value measures is technically complex and sometimes empirically unobtainable. Ex post valuation. (i.e. conducted after the change in environmental quality or quantity has occurred). Does not measure non-use values.
Travel cost method (TCM)	Based on observable data from actual behaviour and choices behaviour. Relatively inexpensive.	Limited to in situ resource use situations including travel. Limited to assessment of the current situation. Possible sample selection problems. Ex post valuation. Does not measure non-use values.

Replacement cost method (RCM)	Based on observable data from actual behaviour and choices. Relatively inexpensive. Provides a lower bound WTP if certain assumptions are met.	Estimates do not capture full losses from environmental degradation. Several key assumptions must be met to obtain reliable estimates. Limited to assessment of current situation. Ex post valuation. Does not measure non-use values.
Production function method (PFM)	Based on observable data from firms using water as an input. Firmly grounded in microeconomic theory. Relatively inexpensive.	Underestimates WTP. Ex post valuation. Does not measure non-use values.
Cost-of-illness approach (COI)	Relatively inexpensive.	Understates WTP because it overlooks averting costs. Limited to assessment of the current situation. Ex post valuation.
Contingent valuation method (CVM)	It can be used to measure the value of anything without need for observable behaviour (data). It can measure non-use values. Technique is not generally difficult to understand. Enables ex ante and ex post valuation.	Subject to various biases (e.g., interviewing bias, starting point bias, non-response bias, strategic bias, yea-saying bias, insensitivity to scope or embedding bias, payment vehicle bias, information bias, hypothetical bias). Expensive due to the need for thorough survey development and pre-testing. Controversial for non-use value applications.
Choice modelling method (CMM)	It can be used to measure the value of any environmental resource without need for observable behaviour (data), as well as the values of their multiple attributes. It can measure non-use values. Eliminates several biases of CVM. Enables ex-ante and ex-post valuation.	Technique can be difficult to understand. Expensive due to the need for thorough survey development and pre-testing. Controversial for non-use value applications.

(CGER, 1997)

Following the above-mentioned classification of the cost-assessment methods, this report analyses the application of revealed, stated and integrative valuation methods, providing a methodological framework for the estimation of the intangible costs induced by floods, droughts, coastal hazards and alpine hazards. Following, each cost assessment is briefly described, including their application advantages and disadvantages, their implications in valuing intangible costs of natural hazards, while ex-

amples are illustrated. The cost-assessment methods that are analyzed in this report are presented in the Table 2.3.

Table 2.3. Cost-assessment methods estimating the intangible costs of natural hazards

Loss estimation methods		Integrative Decision-Making Methods
Revealed Preferences Methods	Stated Preferences Methods	
Hedonic Pricing Method (HPM)	Contingent Valuation Method (CVM)	Cost-Benefit Analysis (CBA)
Travel Cost Method (TCM)	Choice Modeling Method (CMM)	Multicriteria Analysis (MCA)
Cost of Illness Approach (COI)	Life Satisfaction Analysis (LSA)	Cost Effectiveness Analysis (CEA)
Replacement Cost (or restoration cost) Method (RCM)		
Production Function Approach (PFA)		
	Benefit Transfer Method (BTM)	

2.2 Intangible costs under comprehensive frameworks: Environmental Liability & PDNA's

Environmental liability

In a general appraisal framework the Environmental Liability Directive (2004/35/EC) could set the basis for estimating the natural hazards' environmental costs. The Environmental Liability Directive seeks to achieve the prevention and remedying of environmental damage - specifically, damage to habitats and species protected by EC law, damage to species or habitats on a site of special scientific interest for which the site has been notified, damage to water resources and land contamination which presents a threat to human health. In this context, it reinforces the "polluter pays" principle - making operators financially liable for threats of or actual damage. The implementation of the Environmental Liability Directive in Germany is described below and could be expanded to the policy-framework for the cost assessment of the natural hazards' environmental costs.

Environmental liability in Germany

Kokott, J., Klaphake, A. & Marr, S. (2005): Key elements of a Liability Regime Taking into Account Ecological Damages. *Journal for European Environmental and Planning Law* 2(4): 269-286.

Klaphake, A. (2005): The Assessment and Restoration of Biodiversity Damages. Remarks on Environmental Damages under the Directive 2004/35. *Journal for European Environmental and Planning Law* 2(4): 268-276.

Brief Explanation: The report is related to the cost calculation of environmental damages and the resultant compensation charges.

As there are many different methods of appraisal as well as the fact that the federal states of Germany have only less or even no guidelines concerning liability regulations there is still a non-unified compensation charge system in Germany. Furthermore, there are also differences in between the federal states. Indeed 14 of the 16 federal states established compensation charges in their edicts only 6 of them have already adopted these methods.

In Baden-Württemberg, Rhineland-Palatinate and Saarland the monetary assessment is ascertained due to each specific case. There are rates concerning the construction of towers or the excavation of soil as well as for the size of the detracting landscape area.

In Hessen indeed the environmental damage is compared directly to the value of the affected biotope based on the "list including the potential value of all types of biotopes". Each value is allotted to a particular amount of money which has to be paid in case of liability regulations.

In Saxony a hybrid type including skeleton rates as well as a similar concept like the one used in Hessen is applied. Regulated via skeleton rates a method measuring the values of each habitat is adopted to determine the compensation charges. Whereas in Thuringia those charges are calculated by using an overview of the potential costs concerning the construction of biotopes.

Post- Disaster Needs Assessment

The Post- Disaster Needs Assessment (PDNA) is a national government-led exercise, with integrated support from the United Nations, the European Commission, the World Bank and other national and international actors (<http://www.recoveryplatform.org/pdna>). A PDNA pulls together information into a single, consolidated report, information on the physical impacts of a disaster, the economic value of the damages and losses, the human impacts as experienced by the affected population, and the resulting early and long-term recovery needs and priorities. A Post-Disaster Needs Assessment (PDNA) encompasses two perspectives: (i) the valuation of physical damages and economic losses; and, (ii) the identification of human recovery needs based on information obtained from the affected population. These perspectives are integrated into a single assessment process to

support the identification and selection of response options covering recovery interventions from early- to long-term recovery in a Recovery Framework (RF).

The PDNAs are elaborated as soon as possible after the disaster onset, ideally within the first weeks. Needs identified by the PDNA beyond national capacity may be used as an evidence base for the mobilization of further international resources in support of recovery, e.g. in connection with an international donor conference in response to the disaster. The project outputs include:

- development of protocols of cooperation between the United Nations, the World Bank and the European Commission;
- the Guide to Multi-Stakeholder Post-Disaster Needs Assessment (PDNA) and the Recovery Framework (RF);
- field testing of the Guide in disaster response as well as joint support of recovery management capacity development in high disaster risk countries.

The Damage Assessment and Loss Assessment (DALA) is the methodology for estimating damages and losses under the application of the PDNAs. DALA has been developed by the UN Economic Commission for Latin America and the Caribbean (UNECLAC) and is used to estimate the effects and impact of natural hazards. DALA was developed in the 1970s and since then has been customized for application in different areas of the world. DALA bases the assessment of disaster impacts on the overall economy of the affected country as well as on household level. This provides a basis for defining the needs for recovery and reconstruction following any disaster.

DALA estimates:

- The replacement value of totally or partially destroyed physical assets that must be included in the reconstruction program
- Losses in the flows of the economy that arise from the temporary absence of the damaged assets
- The resulting impact on post-disaster economic performance, with special reference to economic growth, the government's fiscal position and the balance of payments.

PDNA includes the estimation of the following categories of costs:

- Infrastructure (Housing, Transport, Power, Telecommunications, Water Supply and Sanitation, Urban and Municipal Infrastructure, Embankments and Water Control Structures)
- Social Sectors (Education, Health and Nutrition)
- Productive Sectors (Agriculture: Crops, Livestock, and Fisheries, Industry, Commerce, and Tourism)
- Crosscutting Issues (Environment)
- Economic and Social Impacts (Macroeconomic Impact, Impact on Livelihoods and Income)

In this context, PDNAs are estimating the intangible effects of natural hazards, particularly environmental and health costs. The following table 2.4 summarizes the cost estimation of intangible effects within the framework of PDNAs' applications in several countries.

Table 2.4 PDNAs: Estimations of intangible costs for natural hazards related to ConHaz

Country	Year of PDNA	Natural hazard event	Environmental costs	Health costs
Bangladesh	2008	Cyclone Sidr	5.9 millions US\$	14.6 millions US\$
India	2010	Flood Bihat Kosi river	no estimation	16.6 millions US\$
Moldova	2010	Floods Prut and Nistru rivers	2.23 millions US\$	0.30 millions US\$
Madagascar	2008	Cyclone Fame, Ivan and Jokwe	0.50 millions US\$	10.2 millions US\$
Namibia	2009	Floods Chobe, Kunene, Kavango and Zambezi rivers	1.33 millions US\$	0.8 millions US\$
Pakistan	2010	Floods	11.67 millions US\$ (damage) 209 millions US\$ (recovery)	49.67 millions US\$ (damage) 48.84 millions US\$ (recovery)
Samoa	2009	Earthquake and Tsunami	0.24 millions US\$	3.7 millions US\$
Yemen	2008	Tropical Storm and Floods	13.7 millions US\$	30.4 millions US\$

Source: <http://www.recoveryplatform.org/pdna>

2.3 Revealed Preferences Methods

2.3.1 The Hedonic Pricing Method (HPM)

The hedonic pricing method (HPM) is based on Lancaster's characteristics theory of value (Lancaster, 1966) and was further developed by Rosen (1974). The basic theory of HPM states that any good can be described as a bundle of characteristics and the levels these take, and that the price of the good depends on these characteristics and their respective levels. The value that consumers attach to the characteristics will be reflected in the price of the differentiated product. The price of an individual characteristic is called the implicit or hedonic price. In this context, the method has been

extensively used for housing and in particular the valuation of environmental amenities in this context. As the price of a house will also reflect its relevant characteristics i.e., number of bedrooms, number of bathrooms, size, etc., the local environmental resources such as ambient air quality, noise levels, aesthetic views, water quantity or quality are marginal additional factors for house prices. It follows that an implicit price exists for each of the characteristics and an implicit marginal WTP, which represents an individual's valuation of the incremental unit of the environmental resource can be identified statistically. A limitation of the HPM is that it only measures direct use values of ecological resources as perceived by the consumers' of the good in which it is implicitly traded. Services such as flood control, water quality improvement, habitat provision for species, and groundwater recharge may provide values that benefit individuals far away, beyond the consumers of the good, which the HPM is unable to capture (Boyer and Polasky, 2004).

Addressing the question if the house pricing is affected in a floodplain location, the US Army Corps of Engineers (1998) conducted a study using hedonic pricing models. This study reviewed existing academic literature on hedonic price models of the floodplain real estate market. In addition, two hedonic price model cases were studied to answer some of the questions raised in the literature review. The hedonic price models were used to empirically measure a discount due to primary flood damages, separate from the discount for the floodplain location. However, the discount for the floodplain location does not necessarily equate to discount for primary flood damages since the location discount represents the net effect of all attributes, positive and negative alike, associated with floodplain location which affect property value.

To apply the hedonic pricing method, the following information must be collected (US EPA, 2002):

- A measure or index of the environmental amenity of interest.
- Cross-section and/or time-series data on property values and property and household characteristics for a well-defined market area that includes homes with different levels of environmental quality, or different distances to an environmental amenity, such as open space or the coastline.

Analyzing more the different categories of data needed for the conduction of a HPM they may include:

- selling prices and locations of residential properties
- property characteristics that affect selling prices, such as lot size, number and size of rooms, and number of bathrooms
- neighborhood characteristics that affect selling prices, such as property taxes, crime rates, and quality of schools
- accessibility characteristics that affect prices, such as distances to work and shopping centers, and availability of public transportation
- environmental characteristics that affect prices

The process of using the hedonic price model to estimate willingness to pay for natural hazards reduction benefits can be thought of as a two stage process (Shabman et al, 1998). During the first stage, a hedonic model is specified and statistically estimated to determine the characteristics that affect property prices. This stage estimates the implicit monetary contribution of reduced risk to the total price of the property. In the second stage, the estimated value of reduced risk from the land price equation is then multiplied by the amount of the risk control project, which is expected to reduce that risk to arrive at a total benefit measure.

In general the method is versatile, and can be adapted to consider several possible interactions between market goods and environmental quality including the cost assessment of the natural hazards environmental impacts. The advantages of the hedonic price method are based on the fact that the values estimates are derived from real estate markets. Analytically, the advantages of HPM (US EPA, 2002) can be summarized as following:

- The method's main strength is that it can be used to estimate values based on actual choices.
- Property markets are relatively efficient in responding to information, so can be good indications of value.
- Property records are typically very reliable.
- Data on property sales and characteristics are readily available through many sources, and can be related to other secondary data sources to obtain descriptive variables for the analysis.

Yet, the fact that the hedonic method relies exclusively on the subjective assessments of flood risk by land traders to generate values estimates introduces several potential problems (Shabman et al, 1998):

- The hedonic price method fails to provide any insights into the individual's risk attitudes, personal discount rate, or information and understanding about the natural hazards.
- Several technical assumptions and data constraints limit the ability of hedonic price analysis to accurately separate property attributes in the hedonic price equation, and to generate theoretically valid value estimates.
- It can estimate only intangible impacts that have a use value, excluding for example the non-use environmental assets influences by natural hazards.

Cost assessment method: HPM, Hazard: Coastal, Sector: Environment

Hamilton M.J. (2007), Coastal landscape and the hedonic price of accommodation, *Ecological Economics*, 62: 594-602.

Brief Explanation: This implementation of the hedonic pricing explores the role that coastal and other landscape features have on the attractiveness to tourists. The average price of accommodation in the coastal districts of Schleswig-Holstein, Germany is explained using landscape and other characteristics of these districts. Flooding of low-lying areas is a particular problem in Schleswig-Holstein, which will be exacerbated with sea-level rise and an increase in storminess. This study provides a way of estimating the value that tourists attach to different coastal attributes. The results show that the type of coastal landscape has an effect on the price of tourist accommodations. Sea level rise will have an impact on the coastal landscape, whether through erosion or land loss. Districts with open coast accrue higher accommodation prices than districts with other coastal types. The hedonic prices of the different coastal types produced from this study can be used along with other tourism data to compare the impact on revenue caused by changes in the attractiveness of the coast through adaptation measures to sea-level rise.

Objective of the approach: Evaluation of the coastal hazards

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Nature, coastal landscape, Fragmented

Size of study area: Local

Spatial resolution: Coastal ecosystems in local level

Time: Mid-term

Effort and resources required: Low/Moderate

Expected precision: Moderate precision for use values

Ability to deal with the dynamics of risk: Moderate

Skills required for application: Scientific

Validity/Reliability: Valid and reliable

How are the results of the applied methods being used: Used by insurance companies and policy makers

2.3.2 The Travel Cost Method (TCM)

The basic principle of the travel cost method (TCM) is the estimation of the consumer surplus based on the Marshallian demand curve. The consumer surplus estimate is considered as a good approximation of a welfare measure (Shresta et al., 2002). In the context of TCM the consumer surplus is the difference between the price visitors are willing to pay and the actual price paid to visit the recreational site (Lansdell and Gangadharan, 2003).

The travel cost method (TCM) is used to estimate use values associated with ecosystems or sites (such as forests, wetlands, parks, and beaches) that are used for

recreation to which people travel for hunting, fishing, hiking, or watching wildlife (Birol et al 2006). The basic premise of the TCM is that the time and travel cost expenses that people incur to visit a site represent the “price” of access to the site. Thus, peoples' WTP to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples' WTP for a marketed good based on the quantity demanded at different prices. The TCM encompasses a variety of models, ranging from the simple single-site TCM to regional and generalized models that incorporate quality indices and account for substitute sites (CGER, 1997).

The method can be used to estimate the economic benefits or costs resulting from changes in access costs for a recreational site, elimination of an existing recreational site, addition of a new recreational site and changes in environmental quality at a recreational site. In this context, TCM can be used to value the intangible costs of natural hazards, by correlating environmental impacts of natural hazards to losses in travel expenditures. There are however several limitations to TCM. This approach yields information on the value of characteristics in addition to the value of the site as a whole. TCM however can only be used to value goods consumed in situ and, similar to HPM, it cannot capture the non-use values of environmental resources. Moreover, other disadvantages of TCM is the value of traveling time, the substitutes, the multi-purpose or multi-destination trips, the length of visit and the components of the travel costs (Clawson and Knetsch, 1966).

Cost assessment method: TCM, Hazard: Coastal, Sector: Recreation (& Environment)

Hartje, V.; Meyer, I.; Meyerhoff, J., 2001: Kosten einer möglichen Klimaänderung auf Sylt. In: Daschkeit, A.; Schottes, P. (Hrsg.): Sylt - Klimafolgen für Mensch und Küste. Berlin.

Brief Explanation: The study tries to estimate the economic impacts of climate change to the island of Sylt. Climate change and increasing frequency of storm surges threatens the island by coastal erosion and potential loss of land and asset values but also by the loss of environmental and landscape qualities and therefore also the recreational value. The study applies different economic costing approaches: a CVM to estimate the value of the Wadden Sea around Sylt and a TCM in order to estimate the recreational value of the island and the impact of more frequent storm surges on that recreational value.

In interviews tourists were asked several questions (point of origin, age, income, means of travel, how long they stay etc.). Based on travel distance and means of travel typical travel costs per distance zone were estimated. Furthermore a visiting rate per distance zone was calculated. Based on this information a demand curve was calculated by means of regression analysis and finally the resulting consumer surplus per visitor and visiting day (18 DM per day). Visitors were also asked how "strong wind" events would affect their recreation in terms of lost visiting or recreation days. Based on these statements the impacts of increased frequency of storm events due to climate change could be estimated.

Objective of the approach: Evaluation of the impacts of climate change and appropriate adaptation strategies

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Recreation, Nature, Coastal landscape, Asset values

Size of study area: Local to Regional (island & surrounding Wadden Sea)

Spatial resolution: Recreational value of the island as a whole

Time: mid-term

Effort and resources required: Moderate

Expected precision: rough estimate of recreational value and its change due to climate change

Ability to deal with the dynamics of risk: Yes?

Skills required for application: Scientific

Validity/Reliability: Valid and reliable

How are the results of the applied methods being used: Used by insurance companies and policy makers

2.3.3 The Cost of Illness Approach (COI)

The cost of illness (COI) approach focuses on the health impacts that are most easily measured – medical costs and lost wages due to illness (Mc Donald, 2001). In the case of estimating the health impacts of natural hazards, the COI can estimate health costs for treating the illness caused by the natural hazards or wages/income being lost while recovering from illness. The health expenditures portion of the COI estimate is referred to as the direct cost of illness, while forgone earnings are referred to

as the indirect costs of illness. Hence, direct costs measure the opportunity cost of resources used for treating a particular illness, whereas indirect costs measure the value of resources lost due to a particular illness (Segel, 2006).

According to Kenkel (1994), the COI approach is easy to be applied due to its simplicity, accuracy and validity, since it estimates in a clear way medical expenditures and lost wages due to illness. Recent contributions to the approach include placing aggregate medical expenditures on an “individual per-case” and “per-day spent ill” basis, which may be more useful in evaluating policy. Also due to its advantages it is generally accepted by the health professionals and economists as a way of estimating health costs, including natural hazards’ health costs. Due to its advantages, COI has been commonly implemented to value the health impacts of the natural hazards.

However COI has some disadvantages:

- It does not take into account the benefits of reduced pain and suffering associated with health improvements.
- COI estimates do not reflect many types of additional indirect costs such as the value of the time an individual may spent studying and learning about an illness, the value of lifestyle changes that an individual may have to make, or the value of potential adverse side effects from the medications an individual may have to take to treat his illness.
- It places little value on non-market activities, since it considers only lost wages.
- There is a general consensus that cost of illness estimates are lower comparing to willingness-to-pay values for a given change in illness. In this context, average WTP for a reduction in symptoms of illness is typically three to four times higher than cost of illness estimates (Cropper and Oates, 1992).
- Two more important limitations of this approach is that it does not consider the actual disutility of those who are ill, nor does it account for the defensive or averting expenditures that individuals may have taken to protect themselves (CGER, 1997).

In the study of Volker and Messner (2005), COI has been applied to estimate the health impacts of floods. A statistical analysis of data from a medical insurance company for the years 2000-2004 has been carried out to determine which diseases have occurred significantly more often during or after the 2002 floods. In a second step, the societal costs of these diseases are monetised. Medical experts are asked in a survey, which therapy is provided for each of the relevant diseases and what amount of therapy costs are likely to arise. Based on the survey results the average therapy costs are estimated in monetary terms. However, the results of this study are not yet published. Another? interesting application of the COI in estimating the health costs of the floods is following.

Cost assessment method: CVM and COI, Hazard: Floods, Sector: Health

DEFRA (2007), The costs of the summer 2007 floods in England, Project: SC070039/R1

Brief Explanation: Measuring the health impacts of the 2007 floods two methods were considered: one based on willingness to pay to avoid health impacts (stress and anxiety effects) of flooding and one based on days away from work due to ill health. The results of the CV study suggested that households were, on average, willing pay £200 per year to avoid the negative intangible, mainly health related impacts of flooding. The health costs estimated on working days lost due to ill health induced by flooding used data on work absences at a national level and at average wage rates. Assuming one day lost per flooded household due to ill health results in 32 years of loss of production associated with paid employment, equivalent to about £0.5 million.

Approach: Applied method

Who applies the method: Scientists

Impacted sector: Health sector

Size of study area: Impacted areas of the 2007 floods in UK

Spatial resolution: Health costs at the local level

Time: Valuation of the short-term health costs

Effort and resources required: Low resources.

Expected precision: High

Ability to deal with the dynamics of risk: Yes

Skills required for application: Scientific

Validity, reliability: High validity

How are the results of the applied methods being used: Used by health agencies and insurance companies.

2.3.4 The Replacement Cost (or restoration cost) Method (RCM)

The replacement cost method (RCM) is a valuation method based on cost estimates. The cost of a man-made substitute, that provides the same services and goods as the ecosystem, is estimated to derive the economic value of that ecosystem service (US EPA, 2002). It is often argued that the replacement cost method is easy to apply and less time consuming than other valuation methods. The examination of the replacement cost method is based on the validity conditions established by Shabman and Batie (1978). The main focus is on applications to value ecosystem goods and services, but also other fields are included.

The method is based on the possibility of finding perfect substitutes to ecosystem services. However, the validity of the method does not only depend on the possibility of finding perfect substitutes. Replacement costs can be a valid measure of economic value only if certain conditions are met. Shabman and Batie (1978) define the conditions as also discussed in Leschine et al. (1997), in Bocksteal et al. (2000) and in Freeman (2003). This method is particularly applicable where there is a standard that must be met, such as a certain level of water quality (Markandya et al., 2002).

Furthermore, RCM defines the cost of a potential or an actual replacement in order to derive a value of a change in environmental quality. The cost of replacing an ecosystem service with a man-made substitute is used in the RCM as a measure of the economic value of the ecosystem service. Consequently, it must be possible to identify a substitute for the ecosystem service. The cost of investment and the maintenance cost should both be included in the replacement cost. The method could for example be applied to value the flood protection capacity of wetlands by estimating the cost of replacing this capacity with the use of a human made protection, i.e. some kind of artificial coastal defense such as breakwaters or sea walls. In this context, RCM can be used to value ecological costs of the natural hazards, as a part of the revealed preferences methods.

Cost assessment method: RCM, Hazard: Floods, Sector: Environment

Leschine, T. M., Wellman, K. & Green, T.H. (1997). The economic value of wetlands - wetlands' role in flood protection in western Washington. Washington State Department of Ecology. Ecology publication No. 97-100

Brief Explanation: In this case study the replacement cost method has been applied to estimate the economic value of wetlands' flood protection capacity in Western Washington. The city has proposed to enhance flood flow reduction through projects that would enhance the ability of the existing wetland to lower flood flows. The enhancement is accomplished via construction of a channel, which works as an interconnection between the wetland and a detention pond. Cost estimates of the engineered system are used to establish an economic value of the flood protection currently provided by the wetland. The cost estimation is based on the assumption that each acre of the wetland has an equal effect in reducing flood flows. To establish a value of the flood protection service provided by the existing wetland the cost of enhancement per percent reduction effect is multiplied by the existing reduction effect per acres of existing wetland.

Objective of the approach: The report was prepared for Washington State Department of Ecology, USA. This study claims that RCM could be used to derive an approximate value of the flood protection services provided by many wetlands.

Impacted sectors: Environmental services of the wetlands affected by the floods

Scale: North Scriber Creek Wetlands that are situated northeast of the City of Lynnwood, Washington.; time scale: mid-term

Effort and resources required: low

Expected precision: high, but it is applied only in use values

Validity: high validity .

Is the method able to deal with the dynamics of risk? Moderate

Skills required: Scientific, Technical, Local

2.2.5 The Production Function Approach (PFA)

The Production Function approach (PFA) is another revealed preferences method that can be used to value non-marketed goods and services that serve as an input to the production of marketed goods. The approach relates the output of particular marketed goods or services (e.g. agricultural production, timber, fish catch) to the inputs necessary to produce them (Birol et al, 2002). These include marketed inputs such as labour, capital, and land, as well as non-marketed goods and services such as soil stability, air quality, or water quality and quantity. For example, the implicit value of water can also be calculated by measuring the contribution of water to the profit in cases where water is an important component of a production process and the producer's cost structure is known.

In this context, PFA can be used for the cost-assessment of those environmental assets being influenced by natural hazards and that have a use-value as a source of producing market goods. However, it has not yet been applied for the cost-assessment of the natural hazards intangible costs.

2.4 Stated Preferences Methods

2.4.1 The Contingent Valuation Method (CVM)

The basic approach of the Contingent Valuation Method (CVM) is to simply ask people what they are willing to pay to either receive a given increment or to avoid a given decrement of a particular non-market good. The CVM has received wide application in valuing a variety of nonmarket goods such as, wildlife (Stephenson and Taylor 1989; Reaves 1993; Boyle *et. al.* 1994), air quality (Rowe *et. al.* 1980), water quality (Strand *et. al.*, 1985), scenic views (Boyle and Bishop 1988), risk (Krupnick and Cropper 1992), and the value of recreational sites (Loomis 1989; Boyle, Welsh, and Bishop 1993).

CVM is used to estimate economic values for ecosystem and environmental services. It can be used to estimate both use and non-use values, and it is the most widely used method for when non-use values are at stake (Bateman et al, 2002). It is also the most controversial of the non-market valuation methods. Moreover, CVM is referred to as a “stated preference” method, because it asks people to directly state their values, rather than inferring values from actual choices, as the “revealed preference” methods do. The fact that CVM is based on what people say they would do, as opposed to what people are observed to do, is the source of its greatest strengths and its greatest weaknesses.

The purpose of CVM in this context is to elicit individuals' preferences, in monetary terms, for changes in the quantity or quality of non-market environmental goods. In the context of CVM, the valuation is dependent or 'contingent' upon a constructed scenario where a sample of the population is interviewed and individuals are asked to state their maximum willingness to pay (WTP) or minimum willingness to accept (WTA) for an increase, or decrease, in the level of environmental quantity or quality (Cummings et al, 1986). Because it creates a hypothetical marketplace in which no actual transactions are made, contingent valuation has been successfully used for commodities that are not exchanged in regular markets, or when it is difficult to observe market transactions under the desired conditions.

The conceptual, empirical, and practical problems associated with monetary estimates of economic value on the basis of how people respond to hypothetical questions about hypothetical market situations are debated at length in the economics literature. In this context, much dialogue refers to the use of CV concerning possible biases, protest bids, free-riders etc (Carson, 2001). Additionally, the conduction of a CV requires special attention on the design and implementation of the survey. The most important parameter of the survey design is the selection of the sample, the pre-testing of the survey, the consultation with relevant experts, the selection of the appropriate payment vehicle, the mean for conducting the interviews (in-person, via mail or via telephone surveys) and the WTP elicitation format (Hoevenagel, 1994). Decisions need to be taken regarding how to conduct the interviews (in-person, via mail or via telephone surveys); what the most appropriate payment bid vehicle is (e.g., an increase in annual taxes, a single-one-off payment, a contribution to a conservation fund, among others); as well as the WTP elicitation format (see Hanemann, 1994; Bateman et al., 2003). Ultimately, the mean WTP bids that have been obtained from the sample can then be extrapolated across the population to obtain the aggregate WTP or value of the environmental resource (Mitchell and Carson, 1989).

As aforementioned, a questionnaire is designed to elicit an individual's willingness to pay for the nonmarket good of interest. A CVM questionnaire is administered either through a mail survey, telephone interview, or personal interview. A hypothetical market, or contingent scenario, is created for the non-market good and the individual is asked to value the good within that context. The contingent scenario is made up of three components: 1) the description of the commodity to be valued, 2) a description of the contingent market, and 3) the payment vehicle. First, the respondent is given a description of the nonmarket commodity to be valued. The change in the commodity must be clearly defined and consistent with what the analyst is attempting to measure. The description of the contingent market follows. The contingent market defines the market participants, the rights and obligations of the participants, and the terms and conditions under which the commodity is provided. The payment vehicle defines how the commodity or commodity change is going to be paid for. Examples of potential payment vehicles include a tax, private preservation fund, user fees, or license.

After the complete contingent scenario is provided the survey respondent then is asked what he or she is willing to pay for the proposed commodity or commodity change just described. This is called a “WTP ‘bid’”. The willingness to pay question can be asked in three general formats: open-ended, payment card, or dichotomous choice. An open-ended question simply asks the respondent how much he would be willing to pay for the given commodity. The payment card method presents the respondent with a range of possible WTP bids and then the respondent is asked to pick from the range of values. Finally, the dichotomous choice format asks the respondent whether they would be willing to pay X amount of dollars for a given commodity. The respondent is confronted with one WTP bid, selected at random, and answers with a “yes” or “no” response

Another point that should be kept in mind is that the values of WTP and WTA are always significantly different from each other (Associated Programme on Flood Management - 2007). In many cases WTP measures are much lower than WTA for the same change in environmental quality. This is partly caused by the different wealth positions attached to WTP and WTP, partly it was also observed that people tend to value losses more highly than the equivalent amount of gains. The reliability of CVM results can be checked by repeating the same survey on a different sample, drawn in the same manner as earlier from the same population after a month or two. This is called the test–retest procedure. Another method could be the convergent validity check.

There are several advantages of using the CVM to value nonmarket commodities, like health and environmental impacts of natural hazards (Shabman, 1998). The CVM is conceptually able to capture non property as well as property costs of natural hazards. Furthermore, the CVM is not confined to measurement of hazard costs to only the residents of the impacted areas. Also, the CVM does not impose any assumptions about an individual's risk attitudes, personal discount rates, or level of flood risk knowledge. Additionally, the CVM can overcome the potential lack of any information a citizen may have about the probability and impacts of the natural hazards. In the description of the contingent market, the CVM provides information to the survey respondent about the nature of the good being valued. While there is no guarantee the individual will interpret this information in an “objective” manner, it does guarantee the individual is not ignorant about the impacts of the natural hazards.

However, there are numerous limitations associated with the CVM. These are referred to as sources of biases in the CVM literature. In general, the biases associated with CVM can be grouped into two general categories, survey biases and motivational biases. Each of these biases can result in changes in willingness to pay without changing the commodity being valued. One group of biases, survey biases, is related to the structure of the survey itself. Biases can occur with any of the three compo-

nents of the contingent scenario described above. The quantity and quality of information provided in the commodity description has been found by some researchers to significantly influence respondent's WTP bids (Bergstrom and Stoll 1987; Boyle 1989). In addition, how the WTP question is asked could alter the value a respondent places on the commodity (Kealy and Turner 1993). Finally, the selection of the format of the survey itself, either mail, telephone, or personal interview, may affect WTP bids (Mitchell and Carson 1989).

Besides the biases surrounding the survey itself, motivation biases deal with the disposition of the respondent prior to or during the interview process. The most important forms of motivational bias are hypothetical and strategic bias. Hypothetical bias can be a problem whenever the respondent is unfamiliar with the contingent scenario or does not believe the contingent scenario will occur. Under either of these circumstances, the respondent may not be motivated to seriously consider the CVM scenario and give a thoughtful bid. This bias implies that people do not react to the survey the same way they would to an actual market situation (Bishop and Heberlein 1986). Strategic bias occurs when a respondent states a false bid in an attempt to influence the outcome of the contingent value survey (Cummings *et al.*, 1986). Respondents may behave in a strategic manner whenever they believe their bid will affect whether or not the commodity will be provided and/or the price at which the commodity is offered. Because the possibility of strategic behaviour is likely to increase as the contingent scenario becomes more realistic and believable, the potential for a tradeoff between hypothetical and strategic bias exists.

Being the most commonly used method in valuating non-market goods and services, CVM has been applied in many cases for the cost assessment of the natural hazards intangible costs. The Floodsite-Report (Messner *et al.* 2007), based mainly on the study by Arrow *et al.* (1993) presents some examples for applications of CV, describes how monetisation of environmental goods can be accomplished, and gives some recommendations on how CVM techniques can be applied. Some important applications of CVM, in the context of estimating the intangible costs of natural hazards, are illustrated below.

Cost assessment method: CVM, Hazard: Droughts, Sector: Agriculture & Environment

Pattanayak, S.K., Kramer, R.A. (2001). Pricing ecological services: Willingness to pay for drought mitigation from watershed protection in eastern Indonesia. *Water Resources Research*, 37: 771-78

Brief Explanation: A survey conducted in eastern Indonesia (500 face-to-face interviews with local farmers) to estimate the economic value of an ecosystem service of drought mitigation provided by tropical forest watersheds in Ruteng Park protected area to local agrarian communities. The mean (median) annual stated WTP through an annual fee is \$2.79 (\$1.64) per household, which aggregates to a total annual value of \$27.000.

Cost types addressed: intangible costs - loss of local farmers' welfare (well-being) due to decreased agricultural production

Objective of the approach: The survey is part of a larger project on the economic analysis of protected areas. The study intends to provide signals to watershed managers and policy makers regarding the economic magnitude and spatial distribution of the local economic value of watershed protection.

Impacted sectors: agriculture (services provided by protected watershed primarily contribute as inputs to agricultural production)

Scale: Ruteng Park, Indonesia; survey on the household level; time scale: N/A

Effort and resources required: high (design and administration of a survey)

Expected precision: moderate. Applying the CV method to a hardly measurable ecological service in a developing country setting includes a high risk of commodity and context misspecification despite a good practice in survey design and administration. The authors themselves point out that because of the imprecision in their economic data, indices of ecological attributes, and household opinions they do not recommend using the estimates to predict precise values of drought mitigation services.

Validity: the main problem in assessing the validity of the WTP estimates is the absence of actual values against which to compare the results. However, validity of the WTP can be tested by comparing the result with those from other valuation studies using other methods, the findings of cross-study analyses (e.g. meta-analyses or benefits transfer exercises), or simulated markets. Such comparisons often showed that CVM is likely to slightly overestimate the actual value due to its hypothetical nature. Validity can also be evaluated by examining consistency of CVM estimates with theoretical expectations derived from economic theory. For example, when the price of a good increases, consumption of that good declines. Moreover, a positive relationship between stated values and the respondent's disposable income is expected.

Is the method able to deal with the dynamics of risk? Yes, but because in long-term hypothetical situations the answers have a low validity.

Skills required: empirical methods of social science - focus groups (optionally), questionnaire design and econometric analysis, particularly regarding the WTP questions.

Cost assessment method: CVM, Hazard: Alpine, Sector: Health

CBA for torrents, avalanches and floods: Leiter, A. & G. Pruckner (2007): Dying in an Avalanche: Current risks and Valuation, working paper, University of Innsbruck.

Brief Explanation: This paper discusses the influence of the risk events on WTP for a prevention of a risk increase. The CV study conducted in the Austrian federal state of Tyrol individuals were asked in a double-bounded dichotomous choice format to state their WTP for the prevention of an increase in the risk to die in an avalanche.

Objective: evaluating the WTP as an input for CBA for the evaluation of protection measures

Approach: scientific

Impacted sector: human beings/population

Scale (study area, spatial resolution, time scale): regional scale, no spatial resolution, no adherence of dynamic effects

Effort and resources: high effort und resources, because of the high number of questionnaires

Precision: quite high, based on an exact methodological approach

Skills: very high: deep knowledge in multivariate regression, statistics and evaluation of non-use goods

Validity, reliability: high, due to the sufficient datasets, but validity only for alpine areas with similar economic structure as the federal state of Tyrol, Austria

How are the results of the applied methods being used: only scientific advance, no implementation for real CBA or risk management strategies so far.

Cost assessment method: CVM, Hazard: Floods, Sector: Environment

Daun C.M and D. Clark (2000), Flood Risk and Contingent Valuation Willingness to Pay Studies: A Methodological Review and Applied Analysis, Institute for Urban Environmental Risk Management, Marquette University, Milwaukee, WI.

Brief Explanation: This study uses a CV survey conducted in November, 1999 – May, 2000 to estimate the WTP for the maintenance of status quo flooding risk levels and/or corresponding ecological improvements to the watersheds for residents of two metropolitan Milwaukee watersheds: the Menomonee River and Oak Creek watersheds.

During the implementation period, eight focus groups were conducted by the University of Wisconsin Survey Center in order to explore residents' feelings and thoughts about local flooding and the ecological quality of the rivers.

The final survey was constructed with three separate question paths:

Path A: "Flood Path," Menomonee River residents only, asked about WTP for flood risk only

Path B: "Environment Path," Menomonee River and Oak Creek residents, asked about WTP for improvements to the ecological health of the river only

Path C: "Combined Path," Menomonee River residents only, asked about WTP for both flood risk and ecological improvements.

The Mean WTP per person and year of this survey is: 83,56\$

Objective of the approach: Assessment of the flood risk and the environmental costs of floods.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Environmental impacts of floods

Size of study area: Local

Spatial resolution: Ecological impacts of the Menomonee River and Oak Creek watersheds (watershed as a whole)

Time: Short-term

Effort and resources required: As any large scale CV survey it demands many human and financial resources.

Expected precision: Moderate precision

Ability to deal with the dynamics of risk: Yes, since it values the flood risks

Skills required for application: Scientific, local.

Validity/Reliability: Low/Moderate

How are the results of the applied methods being used:

Cost assessment method: CVM, Hazard: Droughts, Sector: Environment

Birol E., Karousakis K. and P. Koundouri (2006) Using economic valuation techniques to inform water resources management: A survey and critical appraisal of available techniques and an application, *Science of the Total Environment* 365: 105–122

Brief Explanation: During the last century, several lakes in Greece were drained to generate hydroelectric power or to expand agricultural land, resulting in biodiversity loss. Also, a drought period between 1987 and 1993 diminished both water quantity and quality in rivers and lakes. The aim of this case study is to estimate the non-use values affected by the droughts of the Cheimaditida wetland in Greece using the CVM method. Based on expert consultations, literature review and focus groups, four environmental assets are valued (a) biodiversity, (b) open water surface area, (c) inherent research and educational values that can be extracted from the wetland and (d) values associated with environmentally friendly employment opportunities.

Objective of the approach: These non-use values can be combined with use values of the Cheimaditida wetland to obtain its TEV which can then be used for CBA of management strategies for this wetland, including drought management strategies. In general these values can be included in decision-making processes for the development of efficient and effective strategies for sustainable drought management.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Ecological assets, It is not a part of a comprehensive cost-assessment

Size of study area: Local

Spatial resolution: Cheimaditida wetland

Time: Mid term

Effort and resources required: Increased human and funding resources required

Expected precision: Moderate

Ability to deal with the dynamics of risk: Yes

Skills required for application: Scientific, local knowledge

Validity/Reliability: Moderate

How are the results of the applied methods being used:

Cost assessment method: CVM, Hazard: Floods, Sector: Health

DEFRA - Environment Agency Flood and Coastal Defense (2004), The Appraisal of Human - Related Intangible Impacts of Flooding, R&D Technical Report FD2005/TR

Brief Explanation: The aim of this Defra/Environment Agency study is to develop a robust methodology to assess the human health and well-being benefits of flood risk reduction measures. To achieve that, the Choice Modeling method, and particularly a Choice Experiment has been developed and applied. The survey addresses the WTP of the respondents to avoid health related impacts, particularly stress impacts, caused by floods. The main survey involved 1,510 (983 flooded and 527 at risk respondents) face-to-face interviews in 30 locations across England and Wales that had suffered fluvial or surface water flooding to varying degrees since January 1998. The results demonstrate that flooding causes short-term physical effects and, more significantly, short- and long-term psychological effects. Also, more than 60% of flooded and at risk respondents expressed a willingness-to-pay (WTP) to avoid the health impacts associated with flooding and the overall mean WTP values for flooded and at risk respondents were about £200 and £150 per household per year respectively.

Objective of the approach: This approach should be incorporated to the economic instruments of flood risk and impacts assessment and hence to influence the policy making.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Health-people, Fragmented

Size of study area: National

Spatial resolution:

Time: Short term

Effort and resources required: High human and financial resources

Expected precision: Moderate

Ability to deal with the dynamics of risk: No

Skills required for application: Scientific

Validity/Reliability: Moderate

How are the results of the applied methods being used: Average WTP is incorporated in CBA for project appraisals for flood risk management.

Cost assessment method: CVM, Hazard: Droughts, Sector: Environment

Zhongmin X, Guodong C, Zhiqiang Z, Zhiyong S. and John Loomis (2003), Applying contingent valuation in China to measure the total economic value of restoring ecosystem services in Ejina region, *Ecological Economics*, 44: 345-358

Brief Explanation: The CVM was used to obtain estimates of willingness to pay for restoring Ejina ecosystem services. The Ejina region has an extreme and harsh natural environment and the area's climate is characterized by frequent and severe droughts. This study is valuating to WTP for restoring the ecological services of the Ejina region after the severe droughts occurred in 2000. The mean WTP is 19.37\$ per household and year.

Objective of the approach: The objective is to influence the Chinese policy making in evaluating the ecological impacts of the droughts.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Ecological impacts of droughts, Non-comprehensive

Size of study area: Regional

Spatial resolution: Ecosystems of Ejina region as a whole

Time: Short-term

Effort and resources required: High human and financial resources

Expected precision: Moderate

Ability to deal with the dynamics of risk: moderate-high

Skills required for application: Scientific, local

Validity/Reliability: Moderate

Cost assessment method: CVM, Hazard: Coastal, Sector: Environment

Turner K.R., Doktor P. and N. Adger (1993), Key issues in the economics of sea level rise, CSERGE Working Paper: 93-04.

Brief Explanation: Broadland is a coastal area in East England, where coastal erosion and flooding emerge and due to sea level rise these natural hazards are expected to be more intense and frequent. Contingent Valuation has been applied in order to estimate the use values (Recreation and Amenity) of the Broadland ecosystem. The payment question frames the willingness to conserve Broadland in its present condition. In this case study various WTP elicitation methods and according to these methods the WTP range from 67£ to 140£ per household, per annum.

Objective of the approach: To influence policy making

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Nature, Fragmented

Size of study area: Regional

Spatial resolution: Ecosystem of Broadland

Time: Short-term

Effort and resources required: Moderate

Expected precision: Moderate because different elicitation methods were tested.

Ability to deal with the dynamics of risk: Yes

Skills required for application: Scientific, local

Validity/Reliability: Moderate

2.4.2 The Choice Modeling Method (CMM)

A relatively new Stated Preferences Method is the Choice Modeling Method (CMM), which is theoretically grounded in Lancaster's characteristics theory of value (Lancaster, 1966) and based on random utility models (RUMs) (McFadden, 1974). RUMs are discrete choice econometric models, which assume that the respondent has a perfect discrimination capability, whereas the analyst has incomplete information and must therefore take account of uncertainty. CMM is a highly 'structured method of data generation' (Hanley et al., 1998), relying on carefully designed tasks or "experiments" to reveal the factors that influence choice. The non-market goods or services (including mainly ecological and health ones) are defined in terms of its attributes and levels these attributes would take with and without sustainable management of the resource. For example, one attribute that can be used to describe the quality of coastal waters is bathing water quality. The levels of this attribute could be high, medium, and low.

One of the attributes is a monetary one, which enables estimation of WTP. Profiles of the resource in terms of its attributes and attribute levels is constructed using experimental design theory, a statistical design theory which combines the level of attributes into different scenarios to be presented to respondents. Two or three alternative profiles are then assembled in choice sets and presented to respondents, who are asked to state their preference (Hanley et al., 1998; Bateman et al., 2003). By choosing the respondents a choice set, they are also choosing a payment amount, defining in this way their willingness to pay. Similar to CVM, CMM can estimate economic values for any environmental resource, and can be used to estimate non-use as well as use values. CMM however, enables estimation not only of the value of the environmental resource as a whole, but also of the implicit value of its attributes, their implied ranking and the value of changing more than one attribute at once (Hanley et al., 1998; Bateman et al., 2003). Another advantage of CMM over CVM is that respondents are more familiar with the choice rather than the payment approach. Moreover, CMM can solve for some of the biases that are present in CVM; the strategic bias is minimized in the CMM since the prices of the resources are already defined in the choice sets. Finally, the risk of insensitivity to scope (or embedding effect) in CEM is reduced. If the choice sets offered to respondents are complete and carefully designed, the respondent would not mistake the scale of the resource or its attributes for something else that it could be embedded in (Bateman et al., 2003).

The CMM encompasses a range of stated preferences techniques, which take a similar approach to valuing non-market goods (Batemann et al, 2003) including:

- Choice experiments
- Contingent ranking
- Contingent rating
- Paired comparisons

In a choice experiment, respondents are presented with a series of alternatives and are asked to choose their most preferred one. A baseline alternative that illustrates the current status is usually included in each choice set and must be used in order to produce welfare-consistent estimates. In a contingent ranking experiment respondents are asked to rank a set of alternative options. Each alternative is characterized by a number of attributes, which are offered at different levels across options and then respondents are asked to rank the different options. In a contingent rating experiment respondents are presented with a series of scenarios, one at a time, and are asked to rate each one individually on a semantic or numerical scale. Finally, in a paired comparison exercise, respondents are asked to choose their preferred alternative out of a set of two choices and to indicate the strength of their preferences in a numeric or semantic scale. Martin-Ortega et al (2011) have applied a choice experiment in the Guadalquivir River Basin (Spain) in order to estimate ecological value of household water provision under scarcity conditions.

A version of the Choice Modelling Method used in health impacts is the quality-adjusted life years (QALY). QALY has been used extensively in the medical and health economics fields. The technique originally developed by the 1976 paper of Zeckhauser and Shepard, who viewed the individual as “choosing among alternative lotteries on quality and quantity of life”. The QALY method attempts to value health based on individuals’ preferences towards various possible symptoms, as well as levels of pain and impairment. Individuals are asked, in a hypothetical context, to rate different health states that are described in a questionnaire. The health state may be described by several attributes, such as mobility, physical activity, social activity, and symptom/problem complex (Kaplan, Bush and Berry, 1976). An individual is asked to rate a particular health state along a scale that runs from “zero” for death (or less than zero for outcomes that may be viewed as worse than death, such as severe brain damage) to “one” for perfect health. The difference between two health states along the scale is then taken to represent the individual’s difference in utility of those two health states.

Cost assessment method: CMM, Hazard: Droughts, Sector: Social welfare

Hensher, D., Shore, N., Train, K. (2006). Water supply security and willingness to pay to avoid drought restrictions. *The Economic Record*, 82: 56-66

Brief Explanation: Stated choice experiments were applied in Canberra, Australia in order to estimate households' and businesses' willingness to pay (WTP) to avoid drought water restrictions. A total of 211 residential respondents and 205 business respondents completed the choice experiments. Respondents seem to be unwilling to pay to avoid low-level restrictions that are not in place every day, and all year. They are willing to adjust their watering schedules or tolerate high-level restrictions for limited periods each year, compared with paying higher water bills. Households are on average willing to pay \$239 to move from a situation with continuous restrictions on level 3 (medium restriction measures) to a situation with virtually no risk of restrictions. An average WTP of business customers for the same change in conditions equals \$1.104 and the median is \$239.

Cost types addressed: intangible costs (social welfare loss due to restrictions of water supply)

Objective of the approach: The study was commissioned by the region's water service provider in response to a request by the Independent Competition and Regulatory Commission for information on customers' valuation of service attributes in order to assess whether the existing service levels provided by the water company were appropriate.

Impacted sectors: water supply service

Scale: Canberra, Australia; survey on the household level (residential respondents) and company level (business respondents); time scale: the method is able to estimate short, mid, and long-term effects (long-term effects refer to a period of 20-30 years)

Effort and resources required: high (focus groups and survey)

Expected precision/Validity: good. Most of analyses of CE validity (although there are relatively few) show results in favour of external validity of the choice experiments method. However, like contingent valuation, it is a hypothetical method and its precision depends mainly on the design of the experiment, which involves definition of attributes, attribute levels, context of the experiment, and questionnaire development. The choice sets selected for the experiment also have an important impact on the results. Furthermore, the questions in choice experiment survey are conceptually difficult for respondents and require considerable cognitive efforts. As a result, responses may be biased (McFadden et al., 2005).

Is the method able to deal with the dynamics of risk? No. It is only able to estimate the approximate costs of water supply restrictions due to drought based on various simulated water restriction levels and frequencies. *However, also scenarios for future drought risk developments could be included.*

Skills required: social science skills (focus groups; questionnaire design, especially concerning choice experiments; econometric analysis)

Cost assessment method: Choice experiment, Hazard: Floods, Sector: Health

Daun CM, Clark D (2000) Flood Risk and Contingent Valuation Willingness to Pay Studies: A Methodological Review and Applied Analysis, Institute for Urban Environmental Risk Management, Marquette University, Milwaukee, WI.

Brief Explanation: This study uses a CV survey conducted in November, 1999 – May, 2000 to estimate the WTP for the maintenance of status quo flooding risk levels and/or corresponding ecological improvements to the watersheds for residents of two metropolitan Milwaukee watersheds: the Menomonee River and Oak Creek watersheds.

During the implementation period, eight focus groups were conducted by the University of Wisconsin Survey Center in order to explore residents' feelings and thoughts about local flooding and the ecological quality of the rivers.

The final survey was constructed with three separate question paths:

Path A: "Flood Path," Menomonee River residents only, asked about WTP for flood risk only

Path B: "Environment Path," Menomonee River and Oak Creek residents, asked about WTP for improvements to the ecological health of the river only

Path C: "Combined Path," Menomonee River residents only, asked about WTP for both flood risk and ecological improvements.

The Mean WTP per person and year of this survey is: 83,56\$

Objective of the approach: Assessment of the flood risk and the environmental costs of floods.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Environmental impacts of floods

Size of study area: Local

Spatial resolution: Ecological impacts of the Menomonee River and Oak Creek watersheds (watershed as a whole)

Time: Short-term

Effort and resources required: As any large scale CV survey it demands many human and financial resources.

Expected precision: Moderate precision

Ability to deal with the dynamics of risk: Yes, since it values the flood risks

Skills required for application: Scientific, local.

Validity/Reliability: Low/Moderate

2.4.3 The Life Satisfaction Analysis (LSA)

Life satisfaction analysis (LSA) is a methodological tool that correlates the degree of public goods with individuals' reported subjective well-being and evaluates them directly in terms of life satisfaction, as well as relative to the effect of income (Bruno et al, 2004). In this context, LSA can be applied to evaluate public non-market goods like health and environmental assets influenced by natural hazards. As it is not based on observed behaviour, the underlying assumptions are less restrictive and non-use values can be estimated. Furthermore, individuals are not asked to value intangibles directly, but to evaluate their general subjective well-being, life satisfaction or happiness. This is presumably a cognitively less demanding task that does not evoke answers considered desirable by the persons asked, and there is no reason to expect strategic behaviour.

There are two different ways for implementing the LSA (Bruno et al, 2004). Firstly, an indirect utility function with income and other arguments of a representative individual can be studied. In the empirical analysis, a micro-econometric happiness function is estimated, in which an individual's utility is approximated by reported subjective well-being. The variables of this utility function include the (household) income, socio-demographic and socioeconomic characteristics, as well as societal, economic and institutional conditions. Secondly, aggregate data can be analyzed. Usually, simple cross-country analyses are conducted, with the average happiness levels as the dependent variable, and economic, social and institutional indicators as explanatory variables.

LSA has some advantages compared to other revealed preference methods and stated preferences methods. Comparing to other revealed preferences methods, life satisfaction approach is not based on observed behaviour, and thus the underlying assumptions are less restrictive and non-use values can be measured. On the other hand, the stated preferences methods may entail unreliable results and strategic behaviour. However, LSA overcomes these problems since individuals are not asked to value the public good directly but to evaluate their general life satisfaction. Then the respondents' reported life satisfaction can be correlated with the specific environmental or health assets.

Cost assessment method: LSA, Hazard: Droughts, Sector: Health

Carroll, N., Frijters, P., Shields, M.A. (2009). Quantifying the costs of drought: new evidence from life satisfaction data. *Journal of Population Economics*, 22: 445-61.

Brief Explanation: A fixed-effects model for Australia matching rainfall data with individual life satisfaction (a sample of 15,561 adults) was used to estimate (1) the total cost of the 2002 drought, (2) the costs of drought among residents in rural and urban areas, and (3) the potential costs of a doubling in the frequency of spring droughts, as predicted by the Australian Commonwealth Scientific and Industrial Research Organization. The total cost of dry spring across Australia in 2002 was equivalent to the lowering of national income by AUD \$5.4 billion. The loss in life satisfaction for residents of rural areas was equivalent to a fall in average annual household income of AUD \$18,000 or around 35%, while no evidence of a loss of life satisfaction from drought was found for urban communities. A doubling of spring drought episodes would lead to the equivalent loss in life satisfaction of AUD \$7.4 billion per year, or just over 1% of Australia's GDP.

Cost types addressed: intangible costs (psychological costs of drought that may be associated with a drop in expected future income or other factors related to very low rainfall)

Objective of the approach: taking into account psychological costs of drought, apart from its direct economic costs

Impacted sectors: households (social welfare)

Scale: Australia; methodological data correspond to the postcode level, life satisfaction and demographic data used are at the individual level; time scale: mid-term effects (period 2001-2004, including a particularly severe drought in 2002)

Effort and resources required: moderate if meteorological and life satisfaction data is available, otherwise high (survey needed)

Expected precision/Validity: good. Generally, in order to have a precise estimate by using information on life satisfaction it is of crucial importance that respondents are able to express accurately their degree of satisfaction and that all respondents interpret the satisfaction scale equivalently. Data used in this study is "Australian Unity Wellbeing Index", which is being collected quarterly and is expected to be reliable. Coefficients from the model are then applied to calculate the income-equivalence changes due to a fall in self-reported life satisfaction, which is a crucial step for determining precision of the approach and depends primarily on the quality of the model. Data available for this study does not allow distinguishing between farmers and non-farmers or others directly connected to agricultural production, which means that it cannot determine the precise transmission mechanisms of drought on life satisfaction, even though it might provide a correct average effect. Regarding the estimated potential costs of a predicted doubling in the frequency of droughts, more information would be needed on the various ways in which individuals could adapt to a greater drought frequency to be more certain about the costs of changes in future climate risks.

Is the method able to deal with the dynamics of risk? no.

Skills required: empirical methods of social science (econometric modelling if data is available, otherwise also questionnaire design)

Reliability: depends largely on the quality of the data used. The authors have conducted a series of robustness checks using several different definitions of drought and found that the results are quite robust.

2.5 The Benefit Transfer Method (BTM)

It is costly to use the revealed and stated preference valuation methods. First, the travel cost and hedonic pricing method require location-specific data sets. A single study would be feasible in the time allotted, but a number of studies, as required to assess the environmental benefits of several natural hazards mitigation projects, is not feasible due to time constraints. Second, using a single revealed preference method will exclude large classes of environmental values from the benefits assessment. Also the stated preferences methods like CVM require mail, telephone, or in-person survey that elicits the willingness to pay for changes in governmental policy that leads to environmental change. In the context of hazard mitigation, the survey would describe mitigation policies that limit environmental damage from natural hazards and determine the value of those policies. The entire CVM survey and reporting process would require a significant amount of time.

Hence, the BTM was developed for situations in which time and/or money costs of primary data collection are prohibitive. Environmental benefit estimates from other case studies are spatially and/or temporally transferred to the policy case study. There are three types of benefit transfer: benefit estimate transfer (Boyle and Bergstrom 1992), benefit function transfer (Kirchhoff et al. 1997), and meta-analysis (Smith and Pattanayak 2002). Researchers simply obtain a benefit estimate from a similar study conducted elsewhere and use it for the current policy analysis case study. Benefit function transfer uses the statistical model to transfer benefits. Characteristics of the current policy situation or case study (e.g., population demographics, site characteristics) are substituted into the statistical model from the transfer case study to develop benefit estimates that are more suitable for the current policy situation than the directly transferred benefit estimates. Meta-analysis requires the collection of a large number of studies related to the policy situation. A data set is constructed with measures of the environmental benefits as the dependent variable and characteristics of the individual studies as the independent variables. Regression models are developed which are used to relate the study characteristics to environmental benefits. These regression models are used as benefit function transfer models where the characteristics from the case study are inserted and environmental benefits related to the case study are developed.

Most often, the benefit function transfer method is typically the preferred of the three methods given time constraints. The benefit transfer method does not consider differences between case studies. This can potentially lead to errors in benefit estimation. A meta-analysis requires significant resources devoted to literature review and interpretation. In contrast, the benefit function transfer method can be used to quickly transfer benefit estimates from one case study to another and develop those estimates around the particular parameters of the case study of interest.

The study of Whitehead and Rose (2009) summarizes the application of results Benefit Transfer methods (BTM) for the estimation of the environmental benefits emerged by the flood mitigation policies. In general, this study attempts to evaluate the environmental benefits of U.S. Federal Emergency Management Agency natural hazards mitigation grants. Categories of benefits include water quality for recreational and commercial fishing, drinking water, outdoor recreation, hazardous waste, wetlands and aesthetic, health and safety benefits.

Cost assessment method: BTM, Hazard: Droughts, Sector: Environment

Martin-Ortega J. and A. Markandya (2009), "The costs of drought: the exceptional 2007-2008 case of Barcelona", BC3 Working Paper Series 2009:09.

Brief Explanation: This study is part of the 7th EU Framework Program Project XEROCHORE: An Exercise to Assess Research Needs and Policy Choices in Areas of Drought, a support action to the European Union aimed at contributing to the design of a road map towards a European Drought Policy by identifying research gaps. XEROCHORE project puts existing knowledge together and not on primary field research. The information presented here comes from different available sources and is analyzed and interpreted in the context of the socio-economic costs of drought in Europe. Direct, indirect and intangible costs of the 2007-2008 droughts in Barcelona are under valuation. In this context, benefit transfer approach has been applied, based on public's willingness to pay for the estimation of the environmental costs of the drought event, through a value transfer exercise. The estimates for the valuation of the droughts' environmental costs in this case were transferred from a choice experiment that was applied by the AquaMoney project in four river basins in Southern Europe: the Serpis, Guadalquivir and Tajo river basins in Spain, the Po River basin in Italy and the Lesvos Island in Greece. The research concluded to the following aggregate estimates: Environmental costs of the droughts in Barcelona (million €): 127.89 - 207.61. Total non-market costs due to the drought (million €): 722.09 - 801.81

Objective of the approach: The aim of this study is to contribute to further research on the estimation of the costs of drought (especially at the European level) that needs to be embedded into the assessment of the costs of adaptation to climate change.

Approach: Applied method

Who applies the method: Scientists

Impacted sector: The non-market welfare losses occurred as a consequence of the drought, including: a) those related to the decrease of the ecological status of the river basin due to the lowering of water flows (reduction of the provisioning of ecosystem services) and b) those related to the social welfare losses due to the restrictions of water supply in the households for secondary uses (outdoor use, use of washing machines, etc.).

Size of study area: Region of Catalonia

Spatial resolution: Environmental costs at the regional level

Time: Valuation of the short-term environmental costs

Effort and resources required: Comparing to other valuation methods, low resources are required.

Expected precision: Low/Moderate precision

Ability to deal with the dynamics of risk: No

Skills required for application: Scientific skills mainly and local knowledge

Validity, reliability: Since the choice modeling valuation exercise was not explicitly designed for the Barcelona droughts, the estimates are expected to be subject to significant transfer errors, due to the differences on the environmental conditions of the policy and study site and the socio-demographic differences of the involved population.

How are the results of the applied methods being used: This research is made aiming that the results will be used by the EU and Catalanian River Basin Agency.

2.6 Integrative Decision-Making Methods

2.6.1 Cost-Benefit Analysis (CBA)

Cost-Benefit Analysis (CBA) is a main economic project appraisal technique, commonly used by governments and public authorities for public investments and the appraisal of projects. CBA has its origins in the rate-of return assessment/financial appraisal methods undertaken in business operations to assess whether investments are profitable or not. However, CBA takes a wider point of view and aims at estimating the profit for society. It is used to organise and present the costs and benefits, and inherent tradeoffs, and finally estimate the efficiency of projects (Turner et al, 2007). The basic idea of CBA is to evaluate and compare all the costs and benefits of an investment accruing over time. In this context CBA is a widely accepted and often used framework for decision-making. Simplifying matters, CBA can be utilized as a method for identifying a 'decision rule' for choosing a preferred alternative, or as a component of a comprehensive policy analysis. The roots of CBA are based in welfare theory, which is conducted by aggregating the total costs and benefits of a project or policy over both space and time (Hanley and Spash, 1995). A project or policy represents a welfare improvement only if the present value of benefits exceeds the present value of costs. Different management options will yield different net benefits and the option with the highest net benefits is the preferred or optimal one. In order to compare the benefits and costs occurring at different time scales, discounting is needed to express future costs or benefits at present equivalent value. Controversy over discounting lies at the heart of the debate on CBA, in that the choice of discount rate can often determine whether net benefits are found to be positive or negative.

A CBA of a policy or project with environmental impacts is complicated because many environmental resources are public goods (Biol et al, 2006). Public goods are not traded in markets as private goods are, and are thus often underproduced or exploited by the market. Other causes of market failure include insufficient or non-existent property rights, externalities, the lack of perfect competition and lack of perfect information.

The increasing importance of social and environmental concerns of natural hazards has expanded the use of CBA in integrated natural hazard management projects aiming to put monetary values to social and environmental concerns. Therefore, monetisation methods have to be carried out. Concerning the application of CBA in the context of natural hazards risk management, it is used to evaluate ex-ante projects for risk reduction, including cost estimates of intangible impacts. The methodology of applying CBA for natural hazards risk management projects is described analytically in Reinhard Mechler's study (2005) or for floods in Schanze et al. 2008.

Cost assessment method: CBA, Hazard: Alpine, Sector: Environment

CBA for torrents, avalanches and floods: BMLFUW (2008): Richtlinien für die Wirtschaftlichkeitsuntersuchung und Priorisierung von Maßnahmen der Wildbach- und Lawinenverbauung gemäß § 3 Abs. 2 Z 3 Wasserbautenförderungsgesetz 1985, Vienna.

CBA for floods receiving streams: BMLFUW (2008): Kosten-Nutzen-Untersuchungen im Schutzwasserbau Richtlinie, KNU gemäß § 3 Abs. 2 Ziffer 3 WBFVG, Vienna.

Brief Explanation: In Austria the TAC (Torrent and avalanche control, part of public administration) and the public flood control carry out CBA for mitigation measures. Due to the different institutions responsible for natural hazard management in alpine areas in Austria, the methods and categories used are varying, especially in the case of loss of life (“endangered people”) and intangible effects (environmental effects). The main objective is the identification of the best cost-benefit ratio for different mitigation measures.

Effort and resources: medium, qualitative and quantitative judgement

Precision: low, due to the simple counting of potential affected people and subjective judgement on environmental effects

Skills: necessary knowledge in natural hazard and risk management, legal framework of hazard mapping and modelling, basic knowledge in pragmatic CBA approaches

Validity, reliability: medium, because of traceable results, usage of research, but high uncertainties

How are the results of the applied methods being used: as CBA for mitigation measures

Cost assessment method: CBA, Hazard: Droughts, Sector: Environment

Turner R.K., Burgess D., D. Hadley D., Coombes E., and Jackson N. (2007) A cost–benefit appraisal of coastal managed realignment policy, *Global Environmental Change* 17: 397–407.

Brief Explanation: The study evaluates the economic efficiency, using cost–benefit analysis, of various managed realignment scenarios compared to a strategy of holding-the-line within the Humber estuary in North-east England. In the context of this study the environmental impacts of the coastal degradation are assessed.

Objective of the approach: In this study. CBA is viewed as one component of a wider policy appraisal process within integrated coastal management, which contributes to an efficient decision making.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Nature

Size of study area: Local

Spatial resolution: Ecosystems of the Humber estuary

Time: Long term

Effort and resources required: Moderate

Expected precision: Moderate

Ability to deal with the dynamics of risk: Yes

Skills required for application: Scientific, local

Validity/Reliability: Moderate

How are the results of the applied methods being used: Tool for decision making

2.6.2 Multicriteria Analysis (MCA)

Multicriteria Analysis is a complementary integrative approach that involves judging the expected performance of each development option against a number of criteria or objectives (Belton and Stewart, 2002). In contrast to CBA also non-monetary criteria can be included. These techniques can deal with complex situations, involving uncertainty as well as the preferences of many stakeholders. This is particularly recommended when the problem presents conflicting objectives and when these objectives cannot be easily expressed in monetary terms, like in our case the mitigation of health and environmental risks of natural hazards.

The process of MCA can be divided into different steps (Munda 1995, Rauschmayer 2000):

1. Problem Definition: What is the problem to be solved and which objectives can be formulated to solve the problem?
2. Evaluation Criteria: By which evaluation criteria can these objectives be measured?
3. Alternatives: Which are the alternative options to solve the problem?
4. Criteria Evaluation / Decision Matrix: How do the different alternative perform in the different evaluation criteria?
5. Criterion Weights: Which relative importance is given to the different evaluation criteria by the decision maker(s)?
6. Decision Rules: How is this information (performance of the alternatives in the different criteria & weights assigned to the criteria) aggregated for the final assessment?
7. Sensitivity / Uncertainty: How could uncertainties in the criteria values or weights influence the final assessment?
8. Ranking / Recommendation: Which are the most preferable options, given the above described conditions?

In this context, MCA can be used for an inclusion of the natural hazards' intangible costs in non-monetary and monetary terms. Multi-criteria analysis can be useful in ranking options, short-listing a limited number of options for subsequent detailed appraisal or simply separating acceptable from unacceptable options. Moreover, it can be applied complementary to CBA securing overall better evaluation of projects evaluating the natural hazards impacts.

While MCA in the context of hazard management is mainly used for the evaluation of management options (see examples below, but also RPA 2004, Bana E Costa et al. 2004, Akter & Simonovic 2005), Meyer et al (2007, FLOODsite report T10-07-06, 2009) are analysing the potential of the Multicriteria Analysis to map flood risks, including a non-monetary evaluation of the social and environmental impacts. In this context, a GIS-based multicriteria flood risk assessment and mapping approach has

been developed. This approach has been tested at the River Mulde in Saxony, Germany, where a GIS-dataset of economic as well as social and environmental risk criteria was applied. As criteria for social risk 1) the annual affected population and 2) the probability of susceptible community locations like hospitals, kindergardens etc. were analysed. As environmental flood risk criteria the probability of susceptible biotops of being flooded as well as the erosion & accumulation potential of polluted material were used.

Cost assessment method: MCA and CBA, Hazard: Floods, Sector: Environment, society

Brouwer R. and R. van Ek (2004), Integrated ecological, economic and social impact assessment of alternative flood control policies in the Netherlands, *Ecological Economics*, 50: 1-21.

Brief Explanation: In this study an integrated cost-assessment framework is applied in order to evaluate the land use and floodplain restoration measures after the 1993 and 1995 extreme flood events in the Netherlands. In this context using CBA and MCA, the environmental, social and economic impacts of the floods are evaluated. Particularly, the ecological impacts of these floods were first assessed by an Environmental Impact Assessment study. The results from the CBA indicate that traditional flood control policy (building higher and stronger dikes) is the most cost-effective option to protect one of the most densely populated and economically most important areas in the Netherlands. The MCA has been implemented as an important alternative integrated assessment method to CBA. The MCA are based on an equal weighting procedure of the predicted ecological benefits and economic costs. According to the results of the MCA, a land use change and floodplain restoration is to be preferred over and above traditional dike strengthening. The results based on these two different methods are not comparable for a number of reasons since the outcome of CBA can be interpreted in terms of the effect of a single alternative on overall economic welfare, whereas the outcome of MCA cannot. CBA can be applied to one project (alternative) only, while MCA requires at least two alternatives.

Objective of the approach: The objective of this approach is to provide an alternative flood policy control methodological framework that would influence the policy-makers and would increase the participation of the various stakeholders in the decision-making process.

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Nature, Society, It is a comprehensive cost-assessment method

Size of study area: Regional (Western Netherlands)

Spatial resolution: Ecosystems in the affected zone

Time: Long term

Effort and resources required: Moderate/High

Expected precision: Good precision because it combines different methods

Ability to deal with the dynamics of risk: Yes

Skills required for application: Scientific, local knowledge

Validity/Reliability: Moderate

How are the results of the applied methods being used: The Dutch Ministry of Economic Affairs and the Ministry of Transport, Public Works and Water Management have published a manual CBA, in which CBA is promoted as the most appropriate framework to assess the impacts of large infrastructure projects, including flood management.

Cost assessment method: MCA, Hazard: Floods, Sector: Environment

Kenyon W. (2007), Evaluating flood risk management options in Scotland: A participant-led multi-criteria approach, *Ecological Economics*, 64: 70-81

Brief Explanation: This study analyses the application of the MCA as a tool for flood risk management. It evaluates the flood mitigation alternatives after the 2005 flood events in Scotland. Two of the criteria included in this MCA application are the environmental goods and services of the flooded areas and the human safety as well. Stakeholders that participated in three workshops evaluated the criteria and the different options. This MCA case study in Scotland provided some notable results: that participants preferred regeneration or planting of native woodland to other flood management options, and least preferred building flood walls and embankments.

Objective of the approach: decision support for flood risk management

Approach: Scientific

Who applies the method: Scientists

Impacted sector: Environmental impacts of floods , Fragmented

Size of study area: National

Spatial resolution:

Time: Mid-term

Effort and resources required: Low human and financial resources

Expected precision: Low precision

Ability to deal with the dynamics of risk: Moderate

Skills required for application: Scientific

Validity/Reliability: Low

How are the results of the applied methods being used: By policy-makers for decision making

Cost method: Full Cost Assessment, Hazard: Coastal, Sector: Health & Environment

In this study (Gaddis B.E., Miles B., Morse S. and D. Lewis (2007)), a full-cost accounting for coastal disasters, like hurricane Katrina, is described. An initial framework is illustrated to conduct such an exercise based on losses to built, human, natural and social capital stocks and services provided from each during disaster relief and recovery. According to the analysis a full-cost accounting requires careful analysis of intangible, pecuniary and indirect effects and close attention to spatial and temporal scale. The role of such a full-cost accounting of coastal disasters could inform local and national policy. Particularly, examination of the full-costs of coastal disasters demands a more proactive approach to disaster mitigation through investment in natural capital (coastal wetlands) and built capital (strong infrastructure) as well as better disaster preparedness achieved through community development (social capital) and disaster planning (human capital). Moreover, a full-cost accounting is required in order to make appropriate decisions about the optimal investment during recovery in built, human, natural and social capital.

2.6.3 Cost Effectiveness Analysis (CEA)

Cost-effectiveness analysis (CEA) is an economic approach that compares the relative costs and outcomes (effects) of two or more courses of action. CEA compares the cost of an intervention to its effectiveness as measured in natural health outcomes (e.g., "cases prevented" or "years of life saved"). Cost-effectiveness analysis is often used in the field of health services, where it may be inappropriate to monetize health effect. Typically the CEA is expressed in terms of a ratio where the denominator is a gain in health from a measure (years of life, premature births averted and years gained) and the numerator is the cost associated with the health gain. The applications of the CEA are restricted to comparisons between programmes that produce directly comparable outputs measured in the same natural unit like life years saved (Birch and Gafni, 1992).

Decision-makers are often faced with the challenges of resource allocation, which therefore, they must be allocated judiciously. In this context, CEA is used to identify the most cost-effective strategies from a set of options that have similar results. CEA differs from cost benefit analysis because it expresses outcomes in natural units (e.g., "cases prevented" or "number of lives saved"). Also comparing to CBA, it is less time- and resource-intensive, easier to understand, and more readily suited to decision making. Though, its value is limited when the programs have different outcomes since CEA uses a particular outcome measure that must be common among the programs being considered. Although it could be used for the estimation of the intangible costs of the natural hazards, no relative applications are so far recorded.

3. Data for estimating the intangible effects

The applicability of the cost-assessment methods as well as the quality of their results is strongly dependent on the data used in each particular method. In this context, this chapter is presenting the data used for the cost estimation of intangible impacts of natural hazards. A brief presentation of the relevant databases is developed in the first section. Moreover, the types and the sources of data for each cost-assessment method are presented. The second section is analyzing the data compilation process, setting issues concerning: Who collects the data and how? Are the data derived ex-post or ex-ante? Is there a quality assurance process? Additionally, in a qualitative way all these criteria are illustrated in a table for each cost-assessment method.

3.1 Data sources

In general, due to the nature of the intangible impacts not many studies have been elaborated to estimate its costs and hence the existing relevant databases are very limited. Also the majority of the databases are providing data concerning the health impacts, excluding data for the environmental costs. The most important database, providing data for the cost-assessment of the natural hazards' health impacts, is the EM-DAT International Disaster Database [www.cred.be/emdat/]. EM-DAT is maintained by the US Office of Foreign Disaster Assistance (OFDA) and the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED). EM-DAT is the largest database on the occurrence and immediate health effects of all disasters in the world, including natural hazards (floods, droughts, storms etc). The database is compiled from various sources, including United Nations agencies, nongovernmental organizations, insurance companies, research institutes and press agencies. For a disaster to be included in the database, at least one of the following criteria has to be fulfilled: 10 or more people reported killed, 100 or more people reported affected, a call for international assistance, or the declaration of a state of emergency. The date and location of each event are provided, as well as the numbers of people killed and injured where such information is available.

The Swiss flood and landslide damage database, maintained by the Swiss Federal Research Institute (WSL), collects data related to the above-mentioned two types of natural hazards since 1972. The main source of information is approximately 3000 Swiss newspapers and magazines, which are scanned by a media-monitoring company. In some cases insurance companies, official sites or the internet are also consulted (Hilker et al, 2009). This database, among other direct costs, provides useful data on health impacts since the number of dead, injured and evacuated people are in some cases included and hence they can be used for the cost-assessment of the health impacts. Another database (Dlugolecki, 2007) related to the intangible impacts is the NatCatSERVICE database from Munich Re (see e.g. Munich Re Group 2009). This is a global database, listing from 1950 on several "major natural hazards. The data for each natural hazard included, deaths, insured cost, total economic cost etc. Finally, the database maintained by the Emergency Management Australia (EMA) provides data series about the direct and indirect health costs in Australia (Gentle et al, 2001). More specific, the EMA database provides data for floods, storms, cyclones, tsunamis, bushfires and landslides for the period 1967-1999, including cost data for fatalities and injuries.

The types of data needed for the application of the different cost-assessment methods, as described in chapter 2, depend on the type of the method. The revealed preference methods are using real market data as well as socio-economic and demographic ones. The sources of these data are usually the statistics offices and the relevant market agencies. Concerning the data used for the stated preferences data;

these are stated preferences including willingness to pay (WTP) and other relevant socio-economic opinions and information. For these data there are no open databases and in each case a survey has to be elaborated. More complicated are the types of data used for the application of the integrative cost-assessment methods. With regards to CBA, the types of data may be stated preferences or market prices, depending on the cost-method applied to estimate the intangible impacts. Hence, the sources of data for the application of CBA may include statistics offices, surveys or market agencies. Concerning MCA, the types of data may include quantitative or/and qualitative socio-economic and environmental data, which are provided from statistics offices, references, studies, market and state agencies. Moreover, in the case of the benefit transfer method, the types of data are the results of previous stated or revealed preferences methods provided by the relevant references. More analytically, the types and the sources of data for each cost-assessment method are illustrated in the Table 3.1.

3.2 The analysis and compilation process of the data

In analyzing the available data for the application of the methods for the estimation of the intangible impacts, it is very important to identify who collects them, how they are collected, if they are derived ex-post or ex-ante and if quality is assured. Similarly to the types and sources of data, the compilation process of the data differs according to each type of cost-assessment method. The data for the revealed preferences methods are usually derived ex-post to the natural hazard event and ensure a high quality assurance since they are based on real market prices and socio-economic data. On the contrary, the data for the stated preferences methods can be derived both ex-post and ex-ante but the quality assurance is usually problematic, even though these methods are evolved and are getting more standardized. Analytically the analysis and the data compilation process is presented in the Table 3.1

Table 3.1 Analysis of the data for the cost-assessment of the natural hazards' intangible effects

	Types of data	Data sources	Who collects the data?	How are data collected?	Data derived ex-ante or ex-post	Quality assurance
Revealed Preferences Methods						
Hedonic Pricing Method (HPM)	Property prices, property, neighborhood, accessibility and environmental characteristics that affect selling prices.	Statistics offices, Real estate markets	Experts on properties prices. Administrative officers.	Internet archives, Statistic offices archives	Ex-post	Moderate quality assurance
Travel Cost Method (TCM)	Travel expenses (accommodation, transport etc)	Statistics offices, Tourism agencies	Experts on travel costs. Administrative officers.	Internet archives, Statistic offices archives	Ex-post	Efficient quality assurance (based on real data and market prices)
Cost of Illness Approach (COI)	Medical costs, Loss of income, Affected population	Insurance agencies, Statistics offices, Natural Hazards Agencies	Administrative officers. Insurance agencies' experts Scientists	Internet archives. Statistic offices archives. Archives of the insurance agencies.	Ex-post	Efficient quality assurance (based on real data and market prices)
Replacement Cost (or restoration cost) Method (RCM)	Market prices for construction works.	Construction companies-agencies. Statistics offices.	Technical Scientists. Administrative officers.	Internet. Statistic offices. References	Ex-ante and ex-post	Efficient quality assurance (based on real data and market prices)
Production Function	Market prices for production	Statistics offices.	Administrative offic-	Internet.	Ex-ante and ex-	Efficient quality as-

Approach (PFA)	inputs such as labour, capital, and land.	Databases on market prices.	ers.	Statistic offices. References	post	urance (based on real data and market prices)
Stated Preferences Methods						
Contingent Valuation Method (CVM)	WTP preferences, Socio-economic preferences.	Questionnaire	Scientists	Surveys on the field	Ex- ante and ex-post	Moderate. Quality assurance varies according how accurate is the implementation of the method. CVM generally is a highly standardized and tested method.
Choice Modeling Method (CMM)	WTP preferences, Socio-economic preferences.	Questionnaire	Scientists	Surveys on the field	Ex- ante and ex-post	Moderate. Quality assurance varies according how accurate is the implementation of the method. This method is still under development.
Life Satisfaction Analysis (LSA)	Preferences, Income, socio-demographic and socioeconomic characteristics. Meteorological data.	Questionnaire Statistics offices. References.	Scientists.	Surveys on the field Statistics offices	Ex- ante and ex-post	Moderate. Quality assurance varies according how accurate is the implementation of the method.
Benefit Transfer	Data from previous stated	References,	Scientists.	Internet.	Ex-post	Low quality assur-

Method (BTM)	or revealed preferences methods.	Previous studies		References.		ance
Integrative Decision Making Methods						
Cost-Benefit Analysis (CBA)	WTP preferences or market prices according to which method is used for the estimation of the intangible costs.	References. Questionnaire. Statistic offices.	Scientists. Administrative staff and experts.	Internet. References. Statistic offices. Surveys.	Ex- ante	Low to high. Quality assurance varies according to the method used for the estimation of the intangible impacts and costs.
Multicriteria Analysis (MCA)	Qualitative or Quantitative, non-monetary data for the intangible costs	References, Health and environmental market or state agencies, studies and statistics.	Scientists. Field experts. Stakeholders.	Internet. Interviews. References.	Ex-ante	Quality depends on the input data for each criteria and the design of the participatory process in which decision makers and stakeholders are asked to assign weights on the different criteria
Cost Effectiveness Analysis (CEA)	Health data	Health agencies and statistics.	Scientists	Internet. References. Statistic offices.	Ex- ante	Moderate to high. Quality assurance varies according how accurately is the method applied

4. Analysis of the cost-assessment methods

Following the presentation of the cost-assessment methods this chapter aims to compile and analyze the cost-assessment methods in a qualitative way. The comparison of the various cost-assessment methods is achieved by using certain criteria. The aim of using certain criteria to evaluate the various methods is to provide a tool for decision makers and practitioners that would assist them to select the most appropriate method or methods in each case of cost-assessing the intangible effects of natural hazards. Each criterion is evaluated in a qualitative scale of predefined graded answers. The judgment for weighting each method under their criteria is based on the state-of-the-art review as well as on the outcome of the four workshops organized in the context of the ConHaz project. During the workshops, which concerned the cost assessment of natural hazards, stakeholders (scientists, decision-makers and practitioners) analyzed and evaluated the application of the natural hazards cost-assessment methods, including those for estimating the intangible effects. This approach of comparing and analyzing the cost assessment methods is presented in the Table 4.1. The criteria used and their gradation regard:

1. Scope. This criterion regards the comprehensiveness of the methods in the decision making system and examines if the method deals with certain types of costs or if it provides a comprehensive approach.
Gradation: 1: Sectoral, 2: Intersectoral, 3: Both
2. Spatial scale. The spatial implementation dimension of the methods is analyzed under this criterion.
Gradation: (1: local, 2: regional, 3: national, 4: global)
3. Time scale. Likely the spatial scale, the time scale is also analyzed concerning the time period that each method is covering when applied
Gradation: (1: short-term (on the spot), 2: mid-term (< 3 years), 3: long term (3-50 years), 4: Very long-term (> 50 yrs))
4. Data availability and quality. This criterion concerns the availability and the quality assurance of the data necessary for the application of each cost-assessment method.
Gradation: (1: low, 2: moderate, 3: high)
5. Effort required. The financial and the human resources that are demanded for the application of each method are compared under this criterion.
Gradation: (1: low, 2: moderate, 3: high)
6. Expected precision. It describes the precision of the results produced.
Gradation: (1: low, 2: moderate, 3: high)
7. Scientific or practice approach. This criterion illustrates the application context of the approaches by classified them into the scientific or the practical fields.
Gradation: (1: Scientific, 2: Scientific and Practical, 3: Practical)
8. Skills required. It is analyzing the knowledge skills required for the application of the methods.

Gradation: (Scientific, Practical, Decision Making, Local knowledge)

9. Ability to deal with the dynamics of risk. This criterion deals with the ability of the methods to deal with the dynamics of risks and to be implemented in future risk scenarios, mainly linked to climate change.

Gradation: (1: low, 2: moderate, 3: high)

10. Implemented ex-ante or ex-post: It deals with the ability of the methods to be applied ex ante in a hypothetical or laboratory setting or ex-post based on market observations..

Gradation: (1: ex-ante, 2: ex post, 3 : ex-ante and ex-post)

Table 4.1 Analysis of the methods for estimating the intangible costs of the natural hazards (floods, droughts, coastal, alpine)

	Scope	Spatial scale	Time scale	Data availability (AV) and quality (QU)	Effort required	Expected precision	Scientific or practice approach	Skills required	Ability to deal with the dynamics of risk	Implemented ex-ante or ex-post
Revealed Preferences Methods										
Hedonic Pricing Method (HPM)	Both	Local Regional	Mid-term	AV: Low-High QU: Low-Moderate	Low	Moderate	Scientific	Scientific	Low-Moderate	Ex-post
Travel Cost Method (TCM)	Sectoral	Local Regional	Short-term (Mid-term)	AV: Moderate-High QU: Moderate-High	Low-Moderate	Moderate-High	Scientific	Scientific	Low-Moderate	Ex-post
Cost of Illness Approach (COI)	Sectoral	Local Regional National	Short-term Mid-term	AV: Moderate-High QU: Moderate-High	Low	Moderate-High	Scientific	Scientific	Low-Moderate	Ex-post
Replacement Cost Method (RCM)	Sectoral	Local Regional (National)	Short-term (Mid-term)	AV: Moderate QU: Moderate	Low	Moderate-High	Scientific	Scientific	Low-Moderate	Ex-post
Production Function Ap-	Both	Local	Short-term	AV: Moder-	Low-	Moderate	Scientific	Scientific	Low-	Ex-post

proach (PFA)		Regional National	Mid-term	ate-High QU: High	Moderate				Moderate	
Stated Preferences Methods										
Contingent Valuation Method (CVM)	Both	Local Regional National (GLOBAL)	Short-term Mid-term Long-term (Very long)	AV: Moder- ate-High QU: Low	Moderate- High	Low-High	Scientific	Scientific	Moderate- High	Ex-ante and Ex-post
Choice Modelling Method (CMM)	Both	Local Regional National (GLOBAL)	Short-term Mid-term Long-term (Very long)	AV: Moder- ate-High QU: Low	Moderate- High	Low-High	Scientific	Scientific	Moderate- High	Ex-ante and Ex-post
Life Satisfaction Analysis (LSA)	Both	Local Regional National (GLOBAL)	Short-term Mid-term Long-term (Very long)	AV: Moder- ate-High QU: Low	Moderate- High	Low-High	Scientific	Scientific	Moderate- High	Ex-ante and Ex-post
Benefit Transfer Method (BTM)	Both	Local Re- gional	Short-term Mid-term Long-term	AV: High QU: Mod- erate	Low- Moderate	Low- Mod- erate	Scientific	Scientific	Moderate	Ex-post
Integrative Decision Making Methods										
Cost-Benefit Analysis (CBA)	Intersectoral	Local Regional National	Short-term Mid-term Long-term	AV: Moder- ate-High QU: Low- Moderate	Moderate	Moderate- High	Scientific	Scientific Decision- Making	Moderate- High	Ex-ante
Multicriteria Analysis (MCA)	Intersectoral	Local Regional National	Short-term Mid-term Long-term	AV: Moder- ate-High QU: Low- Moderate	Moderate	Moderate- High	Scientific	Scientific Decision- Making Local Knowledge	Moderate	Ex-ante
Cost Effectiveness Analysis (CEA)	Sectoral	Local Regional	Short-term Mid-term	AV: Moder- ate-High	Moderate	Moderate- High	Scientific	Scientific Decision-	Moderate	Ex-ante



National

Long-term

QU: Low-
Moderate

Making

5: Recommendations and Knowledge Gaps

WP3 analyses the cost-assessment of intangible effects of natural hazards: those effects that have no market prices. Particularly, we are analyzing and compiling the methods used for the estimation of the environmental and health costs of natural hazards. This section summarizes the most important conclusions concerning the application of different cost-assessment methods used for the estimation of the natural hazards' intangible costs. More specifically, we explore the best or bad approaches and practices, identify which methods assure the highest quality of the produced cost estimations, identify the potential for knowledge transfer between the different hazard communities and seek for knowledge gaps that should be addressed by the scientific community. These conclusions are based both on the extensive literature review, as well as on the outcome of the four thematic workshops organized within the ConHaz project.

Knowledge gaps and problems

- Many uncertainties emerge in estimating the costs of the intangible effects due to their incomplete definition and absence of market prices. A strong uncertainty factor is the lack of knowledge on the physical impacts. More specific, only a few studies have been elaborated to define the ecological impacts of natural hazards. Moreover, some epidemiological studies have been elaborated towards defining the health impacts. Another uncertainty factor is the often low quality and quantity of the available data. The third uncertainty factor concerns the methodological problems that often occur when applying the cost-assessment approaches.
- The terminology used for intangible impacts is different between the hazard communities (flood, droughts, coastal, alpine). There is consequently a lack of common understanding and, hence, difficulties in communication between the communities. (e.g. floods community uses the terms "Tangible & intangible costs" while the droughts community use the terms "Market & non-market costs")
- Out of the four natural hazards types investigated in the ConHaz project, the most experiences regarding cost-assessment of the intangible effects have been gathered in the context of floods. This occurs due to the generally more research efforts taken place to estimate the economic losses caused by floods. On the contrary, the assessment of environmental effects is largely missing in the case of natural disaster risk management in the field of the alpine hazards. Moreover, the intangible costs of droughts are more difficult to estimate and usually are underestimated, because droughts are occurred in a long term and slow process that creates uncertainties in defining the effects.

- In contrast to the estimation of direct tangible damages, only few cost-estimation studies have been applied to the valuation of intangible effects so far. These cost-estimations are often fragmented, and are not integrated into planning procedures and integrated cost estimations like cost-benefit analysis or multicriteria analysis.
- The data for the revealed preferences methods are usually derived ex-post to the natural hazard event and ensure a high quality assurance since they are based on real market prices and socio-economic data. On the contrary the data for stated preferences methods can be derived both ex-post and ex-ante but the quality assurance depends on how well-standardized methods are applied.
- The estimation of health and environmental costs of the natural hazards is often done separately. Although the impact assessment of the health and environmental effects are often quite different, cost-estimation approaches and processes could be the same.
- The health estimation approaches are mainly limited to human health and injury by using direct and standardized health values. Hence, they should be expanded into estimating the whole range of health effects like mental illness, post-traumatic stress, transmitted diseases etc. Stronger cooperation between health and natural hazard economists would enhance this process.

Best/good practice approaches

- There is no real “good” or “bad” practice. The accuracy and effectiveness of the cost-assessment methods depend on the data availability and quality, the available resources and the decision made in each case in order to select the most appropriate method for estimating the intangible effects.
- While in general, revealed preference methods provide more precise and reliable results compared to the stated preference methods, there are serious distortions in the markets in reflecting the risk of natural hazards (e.g. missing signals, owner-tenant-relationships, etc.).
- Stated preference methods are the most common in valuing intangible costs because they can estimate both use and non-use values
- Revealed preference techniques require less financial and human resources comparing to the stated preference and the integrated methods.
- Stated preference techniques can be used for long-term and global effects but are more uncertain under these conditions comparing when applied for local and short-term cost-estimations. When estimating intangible impacts at large areas and for longer time frameworks, revealed preferences methods are more precise and effective.

- Among the stated preference methods, the Contingent Valuation Method is the most commonly applied technique for the estimation of the intangible costs. It is preferred by the scientific community and few policy makers because it is more established and it is highly standardized. Though, the choice modeling method (CMM) could be further applied in this field since it can eliminate many of the biases emerged in the CVM.
- A general recommendation for the choice between the methods for estimating intangible costs is impossible. CVM and choice experiments (CMM) can be seen as alternative, substitute methods for eliciting individuals' willingness to pay and are expected to arrive at similar estimates. More recently, CMM has become more popular due to several advantages compared to CVM. These include the ease of estimating values of single attributes of an environmental resource, avoidance of part-whole bias problem since different levels of the good can be easily built into the experimental design, and avoidance of yeah-saying in the case of double-bounded dichotomous choice in CVM. However, there are also some drawbacks to CMM. They are much more demanding for respondents to answer, preferences may be inconsistent throughout the experiment, the design of a CMM experiment is a non-trivial task, and its incentive properties are unclear.
- The Benefit-Transfer method could be a good low-demanding resources approach, which however appears some important difficulties. In this case, valuation studies with very similar characteristics should be used and the simulation to the needs of the new case-study should be done precisely.

Potential for knowledge transfer between the different hazard communities

- A first step to a more effective cost-assessment of the intangible costs would be to develop a common terminology and definition of the various health and environmental impacts, providing this way a commonly accepted scientific basis. A common definition and terminology of the intangible costs prerequisites a close cooperation and knowledge transfer among the different hazards communities.
- The development of large scale and open-access databases prerequisites the knowledge transfer among the different hazard communities.
- In providing an integrated cost-assessment of the intangible effects scientists from various disciplines (ecologists, economists, health practitioners etc) and expertise in different natural hazards should establish those dialogue and collaboration structures that will enable knowledge transfer and learning capacity.
- There must be a better communication of the "intangibles" best-practices including gained knowledge about effects, costs and valuation methods. Furthermore, it is important to better prioritize and classify the intangible effects.

Recommendations and Research opportunities

- There is a need for a systematic definition and estimation of the physical impacts of the natural hazards on human health and the environment. In this context, health scientists and ecologists should cooperate closely. Hence, more effort and resources should be allocated for the cost-assessment of the intangible effects caused by floods, droughts, coastal and the alpine hazards.
- The cost estimations of the intangible effects should be based initially on accurate definitions (if possible quantified) of the impacts. Furthermore the cost estimations should be used in wider risk and land use management plans.
- The current cost-assessment approaches are mainly valuating the short term impacts of the intangible effects. However, an important scientific challenge of the cost-assessment process would be the intense exploration of the dynamics of risks in systems under the threat of climate and socio-economic change.
- Additionally to human health and environmental effects, more intangible effects may occur related to social distribution issues like the disruption of the social cohesion in an affected area. Within this framework social scientists can also contribute to a more efficient estimation of the intangible impacts. Nevertheless, these effects are off topic in this background paper, which deals exclusively with the negative environmental and health impacts of the four types of hazards (floods, droughts, coastal and alpine hazards). A systemic approach could include all the intangible effects.
- Stated preferences methods should be applied systematically in order to achieve more accurate results. In this context it is recommended that they the surveys should be applied in repeated time periods and under similar contexts, eliminating this way the various biases.
- Revealed preferences should use long time and verified data series in order to eliminate market price distortions, caused by other sources than natural hazards, and hence to provide more accurate results.
- Due to the complexity and uncertainty of the intangible effects, a combination of relevant methods would foster effectiveness and accuracy of the results. In this context, stated preferences and revealed preferences methods should be applied in parallel and complementary. However, such an option demands increased resources.
- More research could be undertaken in order to find ways to better integrate the results of aforementioned stated or revealed preference methods into decision support methods like Cost-benefit analysis or Multicriteria analysis.
- Finally, the complexity and uncertainty of valuating intangible effects fosters the integration of cost assessment into policy making and management in order to provide a more comprehensive evaluation. Hence, the limits of valuing the intangible effects and bridging policy-making with economics should be further investigated.

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ANNEX

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