*Expert meeting on EEA assessments on losses from climate-related extremes in Europe*

*19 September 2019, EEA, Copenhagen*

# Background document

## 1. Introduction

### 1.1 Monitoring economic damage in Europe

**In the EEA member countries (EEA-33) ([1]), based on an analysis of Munich Re NatCatService, economic losses from all natural disasters in the EEA member countries amounted to EUR 557 billion for the period 1980-2017** (in 2017 Euro values), mostly (EUR 453 billion or 81%) triggered by extreme weather and climate-related events whose frequencies and/or intensities are expected to increase as a result of human-induced climate change in many regions across Europe. A bulk (70%) of this damage was caused by relatively few (3%) low-probability/high-impact hazard events. These estimates mostly account for direct economic damages to assets only, which are tangible and relatively easy-to-measure.

The above estimates are produced by the European Environment Agency (EEA) to monitor impact of climate variability and change throughout Europe. Natural hazards are a major threat to sustainable development, resilience and social cohesion, financial and economic stability and growth. Effective support to climate change adaptation (CCA) and disaster risk reduction (DRR) measures require an economic assessment of costs caused by extreme weather and climate related events (hereafter climate extremes). However, the above estimates omit often significant economic losses generated by slow-onset hazards (e.g. land degradation), spill-over effects and indirect costs from the disruption of social networks, economic flows, and ecosystem services.

**Lack of loss data:** Despite the importance of quality-assured, systematically collected and thorough datasets on impacts of natural hazards, policy makers have little choice but to resort to empirical data collection. This is the result of neglected attention to disaster risk impacts in the past, and it is not easy or even possible to portray the spatial and temporal patterns of flood damage and losses with reasonable precision. This makes measurement of progress in reducing disaster risk difficult if not impractical.

### 1.2 Policy background

#### *1.2.1 Global level*

Systematic disaster damage data collection is compelled by 2015 multilateral frameworks and sustainable development goals, a part of which are the UNFCCC Paris agreement on climate change and the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030**.**

The **Paris Agreement** specifies a global adaptation goal focused on the ability to adapt to the adverse impacts of climate change and on climate resilience, both among the essential prerequisites of sustainable development.

The **SFDRR** advocates multi-hazard, inclusive, science-based and risk-informed decision-making, and lays down priorities for action and policy targets. Progress in achieving these targets is monitored

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([1]) EEA/EIONET member countries are EU-285 Member states plus EFTA countries (Iceland, Liechtenstein, Norway and Switzerland) and Turkey.

and assessed by means of 38 indicators formulated by the Open-ended Intergovernmental Expert Working Group, some of which are also used to report on the Sustainable Development Goals.

The launch of the **Sendai Monitor** in March 2018 has kicked-off the first reporting phase whereby member states submit data on progress in implementing the seven global targets of the SFDRR, as based on the Sendai Indicators. This information will be reported in the first Sendai Progress Report by the end of this year to reveal how far the strategy's objectives of measuring and reducing disaster risk have come to fruition. Yet, effective monitoring relies on the availability, accessibility, quality and applicability of relevant data. The Data Readiness Review launched by UNISDR to determine countries' existing gaps revealed that, while data is typically more available on physical damage and human impact, substantial improvements are needed to enhance data availability on direct disaster economic losses. Moreover, several underlying conceptual and structural issues already signal the limited utility offered by the indicators in supporting data collection on disaster losses and providing an overview of the physical and social geography of current and future risks. This may erode opportunity in bringing about transformative change within the global disaster risk agenda ([2]), and confronting the linked challenges of climate change and sustainable development.

### *1.2.2 European level*

The **EU Adaptation Strategy** (2013) refers to the economic losses due to weather and climate related hazards in the past and likely to increase in future. Information on damage and adaptation costs and benefits were recognized as a key knowledge gap, and one of the main reasons why EEA regularly updates assessments on losses from climate-related extremes.

The evaluation of the Adaptation Strategy in 2018 has an Annex on the economic costs of climate change based on modelling. At the time of the formulation of the Strategy, the economic, environmental and social costs of not adapting to climate change were estimated to range from EUR 100 billion a year in 2020 to EUR 250 billion a year in 2050 for the EU as a whole. Recent studies confirm that the frequency and economic costs of extreme events are continuing to rise for specific sectors. As from 2020, a **new EU Adaptation Strategy** will be prepared. Here the knowledge about loss data for different key sectors and over time will remain of high importance to evaluate the efficiency and effectivness of adaptation strategies, plans and measures. In addition, there is an increasing attention to sustainable finance. EEA is actively involved, e.g. via the Technical Expert Group set up by the European Commission. These activities on sustainable finance include, inter alia, an adaptation taxonomy (closely related to reducing risk from climate-related hazards) and climate-related disclosure guidelines (including data needs) to ensure the Taxonomy can support investment decisions.

The **EU Action Plan** on SFDRR acknowledged that a coherent realisation of the objectives laid down in the Framework could not only boost resilience, but also spur innovation and growth in the context of sustainable development. The EU's Civil Protection Mechanism compels the EU member states to conduct risk assessments, where possible also in economic terms, at national or appropriate sub-national level. For both purposes, the Joint Research Centre (JRC) developed loss indicators that should be part of operational disaster loss databases ([3]). **Disaster risk assessments should build upon a systematically collected, re-assessed, and possibly open-access database on past disaster events**.

([2]) Wahlström, M., 2015, New Sendai Framework Strengthens Focus on Reducing Disaster Risk, *Int. J. Disaster Risk Sci* (6): 200-201, DOI 10.1007/s13753-015-0057-2.
([3]) see http://publications.jrc.ec.europa.eu/repository/handle/JRC92458

In 2017 the Commission proposed a reform of the Mechanism (rescEU) which accentuates coherence between CCA, disaster prevention and disaster response.

An implementing act "Reporting on national adaptation actions" is under preparation and includes the elements on adaptation as described in the **Regulation on the Governance of the Energy Union and Climate Action** (Governance Regulation) and as agreed in Paris rulebook. As for rescEU, the planned reporting includes descriptions on observed impacts of hazards and potential future impacts but little or no quantitative aspects.

Eurostat created a European entry point for information on the **Sustainable Development Goals** (SDGs). This includes a yearly monitoring report on progress towards the SDGs in an EU context. SDG13 – Climate Action includes an indicator on Climate-related economic losses, being an adaptated version for the EU-28 countries of the EEA indicator based on NatCatService. Both short-term (past 5 years) and long-term (past 15 years) trend are not given and the indicator has no official and quantified EU policy target.

**Economic growth and stability**. A better understanding of natural hazard risk and ensuing economic losses is important also for coordinating responses to shocks and crises within the European Economic and Monetary Union, especially in countries that have suffered most and have not yet fully recovered from the recent economic, financial and sovereign debt crises. In the absence of financial protection tools for coping with disasters, the incidence of major disasters in several EU member states may exacerbate economic imbalances and deteriorate credit ratings ([4]). A recent debt sustainability analysis showed that marginal changes in nominal GDP growth and interest rates can lead to a much greater debt-to-GDP ratio than the one projected as a baseline.

**State liability.** Economic assessment of natural hazard risks is also important for understanding implicit and explicit governments' liabilities and State Aid conferred in the post-disaster recovery. State Aid on a selective basis that distorts (or threatens to distort) free-market competition is incompatible with the EU internal (single) market, except for cases in which the aid is to make good of the damage caused by natural disasters.

**Social cohesion.** Natural hazards impair economic, social and territorial cohesion, and some European countries and regions are more vulnerable to hazards than others. The **European Solidarity Fund** was set up as a way to provide countries with financial assistance after a natural disaster. However, the solidarity aid needed reform, and in May 2014, the European Council and the European Parliament agreed to implemented clearer thresholds to trigger the fund ([5]).

**Risk financing.** Improved modelling of economic costs of natural hazards notion has implications for risk prevention and risk transfer policies. For example, the G20 finance ministers invited the OECD to develop a voluntary framework helping governments to develop financial strategies for managing disaster risk. The ensuing methodological guide defines risk financing as *strategies and instruments used to manage the financial impact of disasters, ensuring adequate capacity to manage and mitigate the costs of disaster risk, thereby reducing the financial burden and economic costs of disasters and enabling rapid recovery in economic activity*. In 2014, OECD Council adopted recommendations for

([4]) See e.g. Standard & Poor's Rating Services https://www.agefi.com/uploads/media/S_P_The_Heat_Is_On_How_Climate_Change_Can_Impact_Sovereign_Ratings_25-11-2015.pdf

([5]) The reform of the Fund has made a clearer definition of the terms under which the solidarity aid can be provided for regional natural disasters, causing damage below these thresholds but disproportionally affecting the regional economies. By choosing to reinstall the absolute damage threshold criterion of 3 billion Euro in 2011 instead of 2002 prices, the legislator made it easier for the largest (six) EU economies to access the post-disaster solidarity aid.

dealing with critical risks that include, among others, collection and analysis of damage and losses from disasters and development of 'location-based inventories of exposed populations, assets, and infrastructures' as a part of better appreciation of disaster risk. The recommendations also addressed the transparency of risk related information that includes an 'honest and realistic dialog' on risk among the stakeholders, and public access to risk information.

## 2. EEA indicator on Economic losses from climate-related extremes in Europe

### 2.1 Origin of the indicator

As information on damage and adaptation costs and benefits were recognized as a key knowledge gap in the EU Adaptation Strategy (see section 1.2.2), EEA collects European information to regularly updates the indicator on economic losses from weather and climate related hazards and to contribute to specific assessments (e.g. on floods).

The climate state and impact indicator "Economic losses from climate-related extremes in Europe", was first published in 2004, as a part of the first Climate change, impacts and vulnerability report, updated in 2008, 2012 and 2016. The early assessments of the indicator were performed by Munich RE, since 2012 the online edition of the indicator is updated annually as a part of the work programme of the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA).

The **EEA report 'Climate change adaptation and disaster risk reduction in Europe**: enhancing coherence of the knowledge base, policies and practices' (and a related journal article) addressed the policy coherence between the DRR and CCA, and identified best practice examples , including the disaster damage and loss databases.

### 2.2 Data used for the assessment

Since the very beginning the assessment was based on the NatCatSERVICE data of the Munich Reinsurance Company (Munich RE). The NatCatSERVICE is one of the most comprehensive databases on disaster loss data. This was the main reason EEA selected NatCatSERVICE as the data source for the indicator on economic losses. Part of the information of NatCatSERVICE is publicly available, however not all details needed for the EEA assessment. Therefore, the data is provided under institutional agreement and strict confidentiality rules: only the EEA staff members and ETC/CCA experts directly working on the indicator update can access the data.

The data is provided for all 33 EEA member countries. Every record refers to a unique damaging event or a country-portion of such an event, when a single event causes damage in more than one country. The data is structured according to the category of hazard (4 categories: geophysical, meteorological, hydrological and climatologic ones) and several/many sub-categories of hazard (individual perils). The NatCatSERVICE data are subjected to changes and in some cases the classification of the hazard type or sub-type may change posteriori. Each record contains total and insured loss in current USD and fatalities. Furthermore, a short description of the event indicates the geographic areas affected and the dynamic of the event. All events without thresholds are recorded, but in the case of small events the damage is grouped to categories (e.g. small events with damage equal or less to 0.5 million USD). The records of countries that underwent geopolitical transformation are retrospectively adjusted and are attributed to new countries when the initial country split into more states (as for example Yugoslavia or Czechoslovakia).

### 2.3 How the analysis for the EEA indicator is performed

The damage data for the purpose of the analysis below is stored in relational database system MS Access but any other open access/source alternative such as MySQL is possible. The data is first screened for completeness and to identify problematic cases (such as incomplete data or data errors - when a fast-onset event is registered over a period exceeding reasonably expected time). Damage estimates are converted from USD to EUR using EUROSTAT conversion rates, and then deflated using the GDP-related price indices. The deflated damage aggregated by countries is used to estimate comparable indices such as the per capita or per sq.km damage. To this end we use EUROSTAT population, GDP and land area data (see Table 1 for the definition of the EUROSTAT data used). The EUROSTAT data and the analysis is performed in R environment. Access to Eurostat database is facilitated by a dedicated API and Eurostat R package. Analysis and visualisation of the results is also managed in R using tmap package.

**Table 1** Eurostat data used for the analysis

| Eurostat statistics | Purpose within the CLIM039 assessment |
|---|---|
| conv_ert_bil_eur_m | conversion from USD to EUR, value_at_the_end-of-period, monthly |
| nama10_gdp | GDP, price indices |
| demo_gind, demo_r_3d_area | population and area |

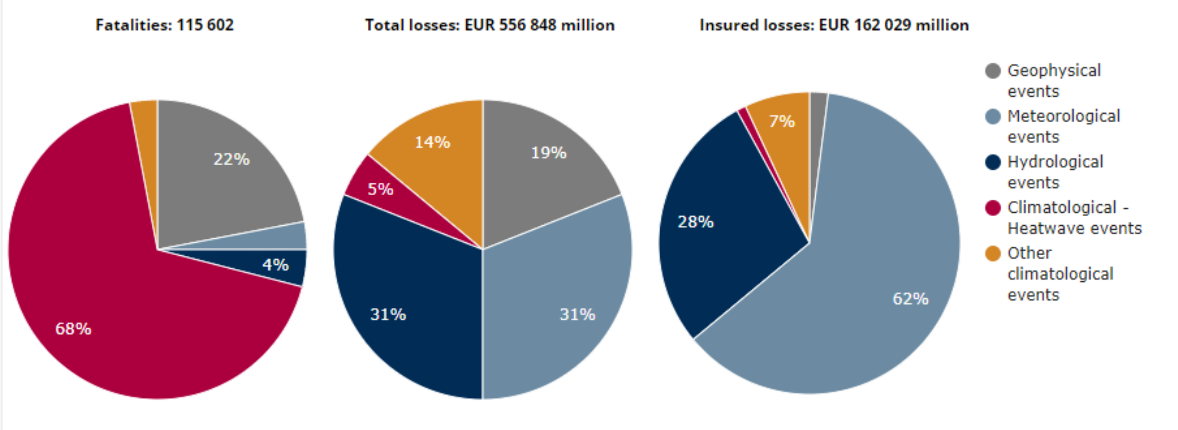
### 2.4 Choices made for the analysis

- First, some of the recorded impacts, especially climatologic events (such as droughts or forest fires) span over weeks, months or even years. The records are attributed to the **begin of the time period** over which the damage was recorded. For example, if an event lasted for two or more years, the damage is attributed to the first year. This choice has a limited impact on the results (aggregated damage over time).
- Second, the conversion of the USD damage value to EUR is performed using the conversion rate at-the-end-of-the-period. Eurostat provides monthly, quarterly and annual data, and for the period chosen either the average or at-the-end-of-the-period value. We use the latter for monthly data. In practical terms this means that the damage originally expressed in USD is converted to EUR using rates corresponding to the end-of-the-first-month of the period over which it was recorded.
- Third, EUROSTAT provides relevant data for all countries starting from 1996. There are several reasons for the missing data for the earlier periods (e.g. 1980s). For example, the countries of former Czechoslovakia and Yugoslavia did not exist before 1991. Or the inflation rates (price indices) in the non-market economies have been determined by political choices rather than observed economic performance. The missing data has been completed from various international sources including, in the order of importance, the Annual Macro-Economic Database of the European Commission (AMECO), the International Monetary Fund's (IMF) World Economic Outlook (WEO), the Total Economy Database (TED) and the World Bank database. Finally, Lichtenstein data on inflation is derived from Swiss data and the GDP estimates, not immediately available from Eurostat, is obtained from the National Statistical Office (NSO).

### 2.5 Presentation of the indicator data

The indicator is presented in tabular and graphical form, both for EEA-33 and EU-28 subset. The tables include total and insured damage and fatalities by country (and year) and derived statistics, such as damage per sq.km, '000 population or in relative terms (percentage of deflated GDP). Graphical form includes bar diagram for annual damage by hazard categories and pie diagrams for fatalities, total and insured damage over the whole times series since 1980 and by hazard category and with an additional split between heatwaves and all other climatological events. Assessment of the indicator includes a brief description of the context (data used and how it was transformed) and literature review/updates.

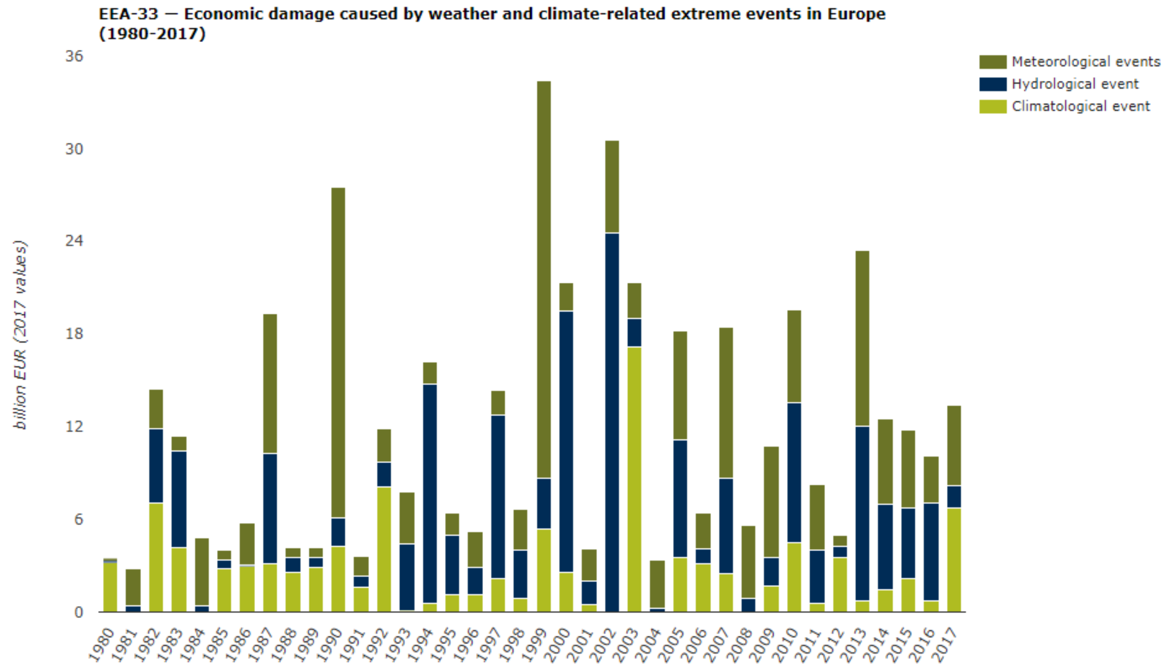
EEA-33




**Note:**

Geophysical events: earthquakes, tsunamis, volcanic eruptions
Meteorological events: storms
Hydrological events: floods, mass movements
Climatological events: cold waves, droughts, forest fires
Climatological events (heatwaves)

For the period 1980-2017, total values for losses and insured losses in EUR million (in 2017 prices), based on the damage records from the NatCatSERVICE of Munich Re and the EUROSTAT structural indicators.




**Source:** [https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-3/assessment-2](https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-3/assessment-2)

## 3. Ideas for improvement and further development of the EEA assessment

This chapter includes ideas to improve the data analysis and the assessment text of the indicator. At the same time, this chapter also includes ideas to further develop and expand the actual information to provide better answers on policy questions. The border in between the actual assessment and further development is not very strict and seen different amongst stakeholders. Therefore, all elements are brought together in one chapter and grouped under the following thematic headers ([6]):

- Data sources;
- Patterns (trends over time and geographically);
- Measuring impact differently;
- Modelled data;
- Europe in a global context.

Each and every item (and sub-item) below is presented to explain what additional knowledge it can bring and how the additional knowledge can contribute to answering policy questions. Nowadays, they are not part of the annual work EEA is doing and based on stakeholder needs and interest, resources and data available a prioritization will be made.

### 3.1 Data sources

Damage data repositories proliferated over the past years. These repositories offer empirical records and modelled damage and losses. Combining the data from multiple sources makes it possible to estimate the uncertainty bounds in the recorded damage. The combined data may be accompanied by econometric methods able to estimate the missing data in one database from the records of other databases.

#### *3.1.1.Overview of most relevant global and European data sources*

The insurance and re-insurance databases such as **NatCatSERVICE** (Munich Re) and **SIGMA Explorer** (Swiss Re) capture and record the financial damage, however the values associated with the "economic loss" are often scaled up value of uninsured vs. insured exposure, which often does not characterise infrastructure, public sector damage or indirect losses.

**EMDAT** Emergency Database is both comprehensive and publicly accessible, and most frequently used and referred to by the disaster risk reduction literature. However, the records are not complete and while most records include details about fatalities, missing and impacted people, about 70% of the records include no information about the damage. The **CATDAT** Natural Hazards Loss Database (Daniell, 2018) is another quality-assured database for natural perils covering over 60,000 events but is not publicly accessible.

UNDRR-sponsored disaster loss data initiative **DesInventar** assists states in construction of databases of damage and losses of disasters and centralizes the data collected into a single repository. For Europe, only a few databases exist and although being more detailed than other global databases, since built from local administrative unit damage data, often the total losses for a particular event are incomplete.

In addition, since 2011 the **Copernicus** **Emergency Management Services** (EMS) produces spatial analysis and the *geolocalisation of disasters* (e.g. flood extent) using remote sensing techniques for

([6]) The workshop agenda will follow the same 5 themes for discussion.

events for which the service is activated. The **Copernicus** **Climate Change Service** (C3S) has the potential to inform about climate-related hazards such as high-impact weather events.

The EC database of **notified state aid** (SA) records states' schemes to make good damage caused by natural hazards and to provide aid to economic operators adversely affected. Direct grants are the most frequent form of aid, followed by soft loans and interest subsidies, while debt write-off, tax deferment, reduction of social security contributions and guarantee represent relatively less preferred ways of aid provision. The database of the **EU Solidarity Fund** activations managed by the DG REGIO offers insights on the solidarity payments to disaster-stricken states and regions of the EU and the eligible partners' countries.

Existing **loss data systems are summarized** e.g. by JRC and OECD. EEA and ETC/CCA also summarized information in the research phase for a European flood impact database and on the significance of flood events. For floods only, the EEA gathered and harmonized flood impact records and produced the European past floods database that combines data reported by the EU Member States under the EU Floods Directive with additional data from ancillary sources such as Dartmouth Flood Observatory (DFO). Due to methodological problems, the database is not maintained after 2011.

#### *3.1.2.Experimental analysis of the data – combination of data sources*

As added to the project description in the institutional agreement between Munich Re and EEA and as an unpublished experiment, EEA tested several additional ways to obtain more insights from the data. Various ways were tested to compare NatCatSERVICE data with other disaster loss data such as EMDAT. However, many of the EMDAT (and other public access damage) records do not include any indication of economic value lost. To fill the gaps, we tested an econometric approach using the population affected or mortality to explain the variation of the damage. Regression models built in this way contribute to explaining less than a half the variability in the data. With other words, filling the gaps using fatalities as an explanatory variable is possible but subject to sizeable uncertainty.

### 3.2 Patterns

#### *3.2.1.Trends*

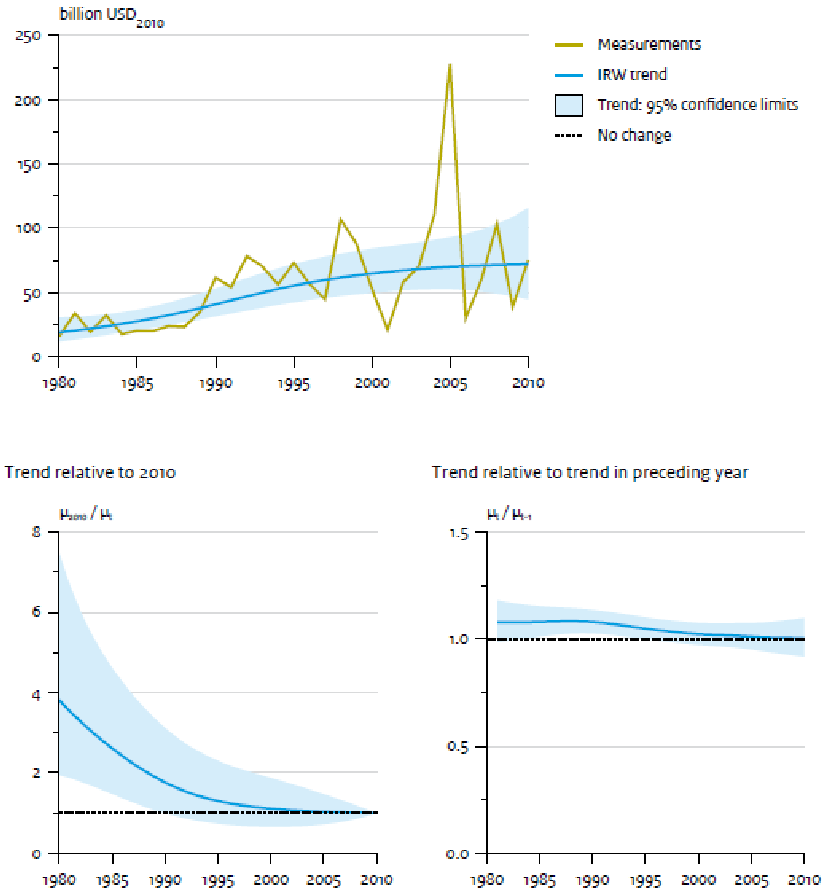
Today, the EEA indicator on economic losses does not include any trendline. However, it is an obvious and important question if impacts of disasters aggravate in Europe. To answer this question a statistical trend analysis has to be performed on the data over the whole time series. To do so, a great number of mathematical and statistical techniques are available.

One trend method - the Integrated Random Walk (IRW) model in combination with the Kalman filter - is appropriate here since it is fully statistical based, giving all uncertainty information on the trend estimated and on trend differences. The IRW model is part of the wider group of models denoted as *structural time series models*.

An example for global economic losses is given in the figure below. The upper panel shows global losses from weather-related disasters, thus excluding geophysical disasters. The trend, denoted as $\mu_t$, is shown along with 95% confidence limits. The lower left panel shows the pattern of  as the ratio [$\mu_{2010}$ / $\mu_t$ ] along with uncertainties and the lower right panel shows the ratio [ $\mu_t$ / $\mu_{t-1}$ ]. The implication of the results shown here is that the trend value in the final year 2010 is significant higher than all trend values before the year 1990.

A similar analysis can be performed a times series including more recent years. This is important since hazards may become more severe and/or more frequent, but due to changes in vulnerability impacts need not become more severe.

Figure 3.2A
**Global economic losses due to weather-related disasters**




Source: PBL

*IRW trend estimation for global economic losses due to weather-related disasters. The upper panel shows the data along with the IRW trend and 95% confidence limits. The trend ratio [$\mu_{2010}/\mu_t$] is given in the lower left panel and the trend ratio [$\mu_t/\mu_{t-1}$] in the lower right panel. Trend estimation was performed on logarithms of the original loss data.*

**Source: Visser et. al 2012, [https://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2012_Weather%20Disasters_555076001_0.pdf](https://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2012_Weather%20Disasters_555076001_0.pdf)**

### *3.2.2.Geographically*

So far, the data presented by EEA were for all EEA-33 countries together (and recently with a subset of EU-28 countries), e.g. in the economic losses over time or per country for all weather and climate-related hazards grouped. As added to the project description in the institutional agreement between Munich Re and EEA and as an unpublished experiment, to obtain more insight from the data. Based on the project description of the ETC/CCA several additional ways to obtain more insights from the data were tested. For some hazards, groups of countries, biogeographical regions or river basin districts can add to a better understanding of the hazards and their related losses. A proper geocoding of the damage makes it possible to analyse trends by hazards and geophysical features (rather than by political countries).

Therefore, various geocoding algorithm to localise the affected area were tested. The NatCatSERVICE data is provided with some location information in form of location name (town name, district/state, or portion of a country such as SW, N) and geographic coordinates (longitude/latitude) of the main affected area.

A first approach tested is based on extracting all location information and their subsequent semi-automatic geocoding. With a free Geocoding API, addresses are turned from text to latitude and longitude pairs. The geocoded records were checked and corrected manually, which requires substantial time. The disadvantage of this algorithm is that the damage can only be split among the affected areas linearly, there is no other way to divide the damage into actual share for each of the affected locations.

A second geocoding algorithm tested is based on the observed or modelled past climate data. In order to support the geo-localisation and classification of the intensity of catastrophic events in Europe at the NUTS2 level, daily precipitation data obtained from the E-OBS gridded version of the European Climate Assessment and Dataset (ECA&D) is used. The E-OBS dataset covers the area 25-75N and 40W-75E and a regular grid at 0.25°was used. Suing R packages rgeos, rgdal, and raster we extract the information about each event's onset and cessation. Then the areas affected by a chosen-threshold percentile intensity value of the damaging event (e.g. precipitation) were estimated. This step is repeated several times by increasing the threshold value, in order to avoid overestimation of the affected areas. The areas exposed to the highest intensity of the phenomena over the given period is than used to select the overlapping statistical (NUTS) regions and these are compiled to form the spatial footprint of the event. The advantage of this method is the possibility to distribute the recorded damage over the affected area according to the observed or modelled intensity of the phenomena.

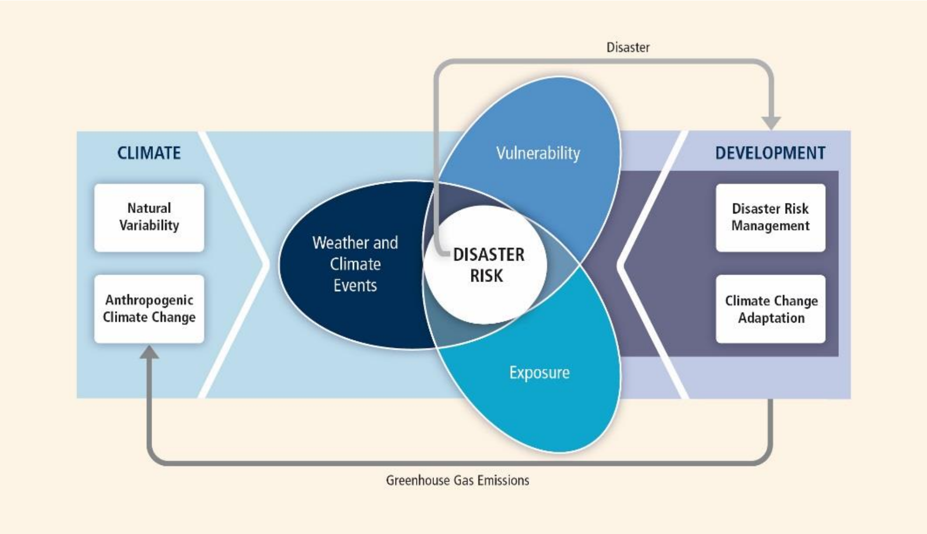
## 3.3 Different impact

### *3.3.1.Relation between hazards and impacts*

Impacts of weather-related disasters differ from the hazards itself. For that reason it could well be that, for example, the severity of storms along the coast of a country becomes more severe, but the impacts decrease since the dykes/levees have been heighted/strengthened over the past decades. Key here is the term vulnerability. From a communicational point of view it can be wise to add a graph explaining the terminology, like in the IPCC SREX 2012 report (and see figure on next page).

Furthermore, it is important to note that not much is known about historic development of vulnerability within EU countries. This is also true for future impacts of weather-related disasters. Due to this knowledge gap modeling proposals are complex (see also 3.4). If fitted to recorded data, the added value of modelling impacts of natural/weather-related disasters should be discussed.

As added to the project description in the institutional agreement between Munich Re and EEA and as an unpublished experiment, to obtain more insight from the data. Based on the project description of the ETC/CCA a last exercise was testing the inverse normalisation of damage taking into account the evolution of a hazard. For fluvial floods, being the only hazard where the analysis was performed, the damage is explained by the extent of urban areas inundated for the maximum annual discharge registered or modelled. In this way it is possible to estimate to what extent the hazard intensity can explain the variation of the damage, and thus to what extent the varying exposure is responsible for the observed damage.




**Source: IPCC SREX 2012 report, https://www.ipcc.ch/site/assets/uploads/2018/03/SPM_Fig1.jpg**

### *3.3.2.Humanitarian (and other) impacts*

The present work of EEA highly relies on economic losses and only limited on humanitarian impacts (fatalities), while categories as 'people affected' are neglected so far.

The calculated economic losses can have different patterns over time compared to fatalities and other humanitarian impacts.

In the EU floods Directive, economic, social, ecologic and cultural heritage impacts are asked for. However, quantitative information on ecological and cultural heritage impacts are not collected in a standardized way over a long time and for different hazards.

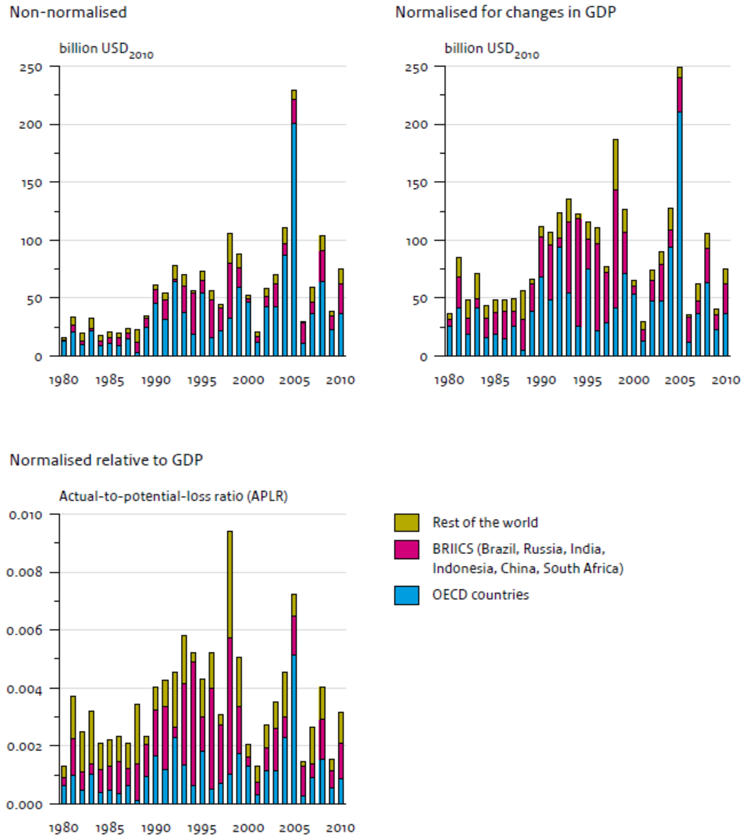
### *3.3.3.Normalisation of loss data for GDP*

Today, the EEA work on economic losses includes data normalised for changes in GDP per country over time. In addition, it is common practice in the field of disaster analysis to normalize economic losses to the wealth of countries(normalised relative to the GDP), and humanitarian impacts for growth in population over time. In this way the impact of a disaster is seen relative to the wealth or population size, and thus relative to the **carrying capacity** of a country.

An example of two normalization procedures for global losses of weather-related disasters is given in Visser et al. (2012a) and the figure below.

The upper left panel shows the non-normalized data for the sample period 1980-2010. The upper right panel shows a corrected graph for wealth. Here, each disaster in year t and region x is corrected by multiplication of the factor [wealth of region x in the final year / wealth of region x in year t]. The term 'wealth' is approximated by GDP. The lower panel is corrected for both spatial and temporal differences as follow [economic loss in region x and year t / GDP in region x and year t].

Figure 6.2
**Global economic losses due to weather-related disasters, per region**




Source: PBL

*Weather-related economic losses without normalisation (original loss data, upper left panel), with GDP correction per region (upper right panel) and with APLR (Actual-to-Potential-Loss Ratio) indexation following Neumayer and Barthel (2011). The upper two panels are expressed in billion USD (2010), the lower panel is a dimensionless loss ratio.*

**Source: Visser et. al 2012,**
**https://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2012_Weather%20Disasters_555076001_0.pdf**

*3.3.4.other disaster impacts*

To understand the magnitude of weather and climate-related impacts, it can help to show other disaster impacts to compare with. So far the EEA work only includes geophysical hazards as non-climate related hazard category.

As an example, other categories that can be used (given the data availability) to frame the importance of climate-related hazards are epidemics or industrial and transport accidents.

## 3.4 Modelled data

*3.4.1.Economic modelling of damage and losses caused by natural hazards*

**Natural hazards cause financial and economic losses**. The financial impacts consist of value of capital lost, recovery and opportunity costs. These impacts may set off supply and demand shocks that affect regional economies in and beyond the disaster affected areas. The direct damage to tangible productive assets is equivalent to indirect economic losses caused by disruption of production webs, ideally measured by flows. In the aftermath of a disaster, the demand for liquid capital may increase its price, level of fiscal consolidation and perceived trustworthiness playing a role. Efforts to restore the productive and non-productive capital losses generates new demand and changes consumption patterns that may lead to changes of prices and trade levels, and to changes in fiscal revenues. However, these wider economic impacts of extreme weather and climate-related events have been less exploited than direct damage estimates and are not covered in datasets like NatCatSERVICE or EM-DAT.

**Understanding risk dynamics.** A sound understanding of risk does not only imply accounting for the past damage and losses. Natural hazards are outcomes of multiple stochastic processes. On the temporal dimension, the probability distributions span over years, decades and centuries. In some cases, the probabilities of once-in-millennia or even rarer events are still relevant for today's decision making. These stochastic processes are often not stationary but respond to environmental changes, including climate change. Hazard manifestations of similar intensity and magnitude may also result in different damages and losses, depending on circumstantial factors. The vulnerability and susceptibility to harm are also time-dependant, changing and evolving as our societies transform in demography, wealth, cohesion and use of technology.

**Modelling indirect economic damages;** Different models exist that simulate indirect economic losses from natural disasters. Such models estimate the impacts of extreme weather and climate events on the economic flows - for example on the production of economic sectors and the regional or national gross domestic product (GDP) ([7]). Standard input-output (IO) models are relatively simple, static, and linear models imitating the interrelationships between economic branches within a national or regional accounting system. Computable general equilibrium (CGE) models are nonlinear models of circular flows of goods and services between agents, where representative households and firms choose their demand and supply following constrained optimization problems, taking prices as given. Prices are determined by market equilibrium conditions, allowing substitution effects and more realistic behavioural content and working of both factor and product markets compared to IO models. Finally, econometric models, based on time-series data, have the advantage of being statistically rigorous and have forecasting capabilities. As such, they are often unsuitable for a detailed analysis of the specific losses of a disaster. Hybrid models make it possible to exploit the advantages of the above models.

*3.4.2.Modelled hazard and risk data*

Statistical disaster damage and losses approaches that rely on empirical record may not adequately consider rare phenomena that lie outside the range of any available observation. Probabilistic catastrophe models estimate the loss potential by combining properties or assets at risk with modelled hazards and damage/vulnerability models (see e.g. De Groeve et al. (2014), Wahlström (2015), Ward et al. (2015)) for river floods, coastal flooding, wind storms, droughts and landslides. **Hazard and risk modelling help to *reassess* economic impacts of larger disasters for which the empirical records are incomplete or missing.**

([7]) Although these models have advanced over time, their effective applicability to real-world cases has been constrained by a number of factors, including their intrinsic level of uncertainty (arising from the number of assumptions) and the difficulty to model the complex dynamics of a system in the aftermath of a disaster.

### 3.5 Global context

As for the comparison with non-weather and climate-related hazards, loss data for Europe (being EEA-33, EU-28 or another group of countries) in a global context can show its relative importance even when a detailed calculation as for EEA-33 countries is not possible.

Also for some of state of the environment indicators at EEA, like Global and European temperature or Global and European sea level, the data for Europe are shown compared to the global ones.

## 4. The expert workshop

During the expert workshop, the views and demands from policymakers will be presented and then the work of EEA and the ETC/CCA on economic losses from weather and climate related events will be explained and discussed. The different options to improve the analysis and further develop the work will be discussed in the light of what is possible with the data available, which options for improvements are scientifically sound and what policy questions can be addressed. The list in chapter 3 is not exhaustive and additional ideas are welcome as well.

There are so far no decisions taken by EEA on further developments. Based on the workshop input, the different options will be prioritised. It is also possible that some of them are seen as highly relevant, but not to be repeated on a yearly basis, while for others it makes sense to repeat the exercise yearly. Furthermore not all potential improvements would be for EEA to implement and the workshop will also reflect on which organisations can be most suitable for which type of improvements.

After the workshop EEA supported by the ETC/CCA will develop a plan on how the EEA assessment on economic losses can be improved and expanded based on recent scientific insights and data availability. This plan, in the format of a short workshop report, will be disseminated to the participants of the workshop for feedback.