MULTI-SECTORAL PARTNERSHIPS AND RISK INFORMATION

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Increasing trend in disaster losses

During the past decades, the frequency and impact of natural disasters has increased rapidly worldwide (Munich Re, 2014; 2015). A number of major disasters have occurred in Europe, prompting high economic damage and losses, casualties and social disruptions. Examples are the 2010 eruption of the Eyjafjallajökull volcano in Iceland; earthquakes in Italy in 2009 and 2012; droughts and forest fires in Portugal in 2012; and heavy rainfall that caused record floods in Central Europe in 2002 and 2013.

Natural disaster risks are of high concern for citizens and policy-makers in Europe. They are expected to further rise as a result of projected demographic development and land use change, with expansion of residential and production activities in hazard-prone areas. Climate change will further exacerbate risk from natural hazards, and it has been demonstrated with the increased frequency and severity of certain extreme climate and weather related events, such as droughts, heat waves and heavy precipitation (IPCC, 2012; IPCC, 2014).

Multi-sectoral partnerships to manage risk and resilience

Knowing the increasing trends in natural disasters and losses, it is imperative to take action on disaster risks to improve resilience of European societies to natural hazards. The main goal, therefore, of the ENHANCE project is to develop and analyse innovative ways to manage natural hazard risks. The key is to develop new multi-sectoral partnerships (MSPs) that aim at reducing or redistributing risk, and increase resilience of societies. **Multi-sectoral partnerships are defined as:**

"Voluntary but enforceable commitments between partners from different sectors (public authorities, private services/enterprise and civil society), which can be temporary or long-lasting. They are founded on sharing the same goal in order to gain mutual benefit, reduce risk and increase resilience".

New forms of MSPs are needed. For example, the recent responses to heat waves and floods in Europe demonstrate that the roles of public, private, and civil society actors (including individuals) in preparing for and responding to catastrophic impacts are often neither clear nor effective and sustainable.

MSPs and Risk Information – Why?

A better understanding of natural hazard risk and ensuing economic losses is important for preventing excessive socio-economic stress, and for coordinating responses to extreme events within the EU. This is particularly important in countries that suffered most and did not yet fully recover from the recent economic, financial, and sovereign debt crises.

INACCURATE RISK INFORMATION MEANS INSUFFICIENT PREVENTION AND RESPONSE

Figure 1 shows a map for New York City (NYC), for the actual flooding due to hurricane Sandy in 2012 (red color) and the official 1/100 flood zone (blue colors) provided by the Government before the hurricane occurred. **The figure shows that many of the actual flooded areas are outside the official flood zone. Inaccurate numbers of flood risk for an area may lead to the development of urban areas in unprotected areas, or to the development of levees that are designed too low for protecting people against extreme events.**

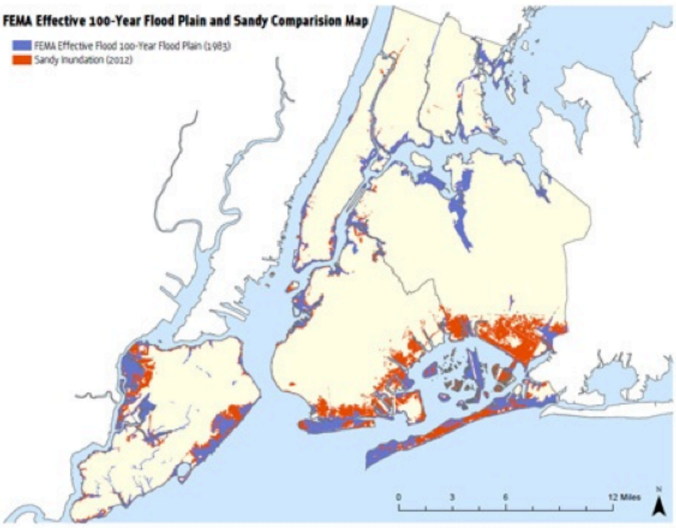

Figure 1. A map for NYC, for the actual flooding due to Hurricane Sandy in 2012 (red color) and the 1/100 flood zone map (blue colors) provided by the Government before the event (NYC, 2013).

Following the UNISDR risk framework, **there are three important sources of information for estimating risk:**

1. *Exposed assets:* What assets are at risk, such as people, buildings and infrastructure?
2. *Hazard:* What is the potential magnitude and frequency of hazards that threaten those assets?
3. *Vulnerability:* what is the level of protection and preparedness to reduce risk of the exposed assets? Using the risk information types, risk can be calculated from (exceedance-) loss probability curves. These curves show the relation between potential losses for each probable hazard event.

Comprehensive and accurate risk information is key to effective risk management and planning across MSPs in the US, the EU and elsewhere. The ENHANCE project has tackled this challenge in a number of case studies.

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#switch2sendai

Sendai Framework calls for quality-assured data sets on natural hazards

The importance of the quality-assured, systematically collected and thorough datasets on impacts of natural hazards, and the loss data systems (LDS) have been highlighted by the Sendai Framework for Disaster Risk Reduction 2015-2030 and the OECD.

Currently, empirical data on losses from natural hazards in Europe are fragmented and inconsistent. Because open and accessible records on disaster impacts and losses are prejudiced by data gaps, European policy makers have little choice but to resort to proprietary data collection.

The Sendai Framework calls on the national and regional governments to better appreciate the (knowledge of) risk. Empirical and evidence-based risk analysis and assessment are a vital part of the disaster risk reduction (DRR) efforts. The open-ended intergovernmental expert working group (OIEWG) was instituted to develop a set of indicators for measuring global progress. Sendai Framework is not alone in this quest. The OECD invited the member countries to better prepare for catastrophic and critical risks.

ENHANCE CASE-STUDY RESULTS ON RISK INFORMATON

The following ENHANCE case studies demonstrate the importance of comprehensive and accurate risk information for disaster risk management.

Enhancing the resilience of railway infrastructure in Austria

The railway transportation system of the Austrian Alps plays an important role in the European transit of passengers and freights. In total, 11.7 million tons of goods were transported across the Austrian Alps in 2013, which is 28 % of the total volume recorded for the inner Alpine Arc.

If traffic networks are (temporarily) disrupted, alternative options for transportation are rarely available. The mountainous environment limits the space usable for permanent settlements and infrastructure, e.g. amounting to only 15 to 20 % of the whole Alpine Convention territory. Hence, railway lines often follow floodplains or are located along steep unsteady slopes, which considerably exposes them to flooding and in particular to alpine hazards, e.g. debris flows, rockfalls, avalanches or landslides.

The case study aimed at developing an **empirical modelling approach for estimating direct structural flood damage to railway infrastructure.** The expected structural damage was estimated via a combination of event data, i.e. photo-documented damage on the Northern Railway in Lower Austria caused by the March river flood in 2006, and simulated flood characteristics, i.e. water levels, flow velocities, and combinations thereof. A model was applied for three flood scenarios with return periods of 1/30, 1/100 and 1/300 years along the March river (see Fig. 2 and Tab. 1).

- **a** In damage class 1 (synthetic **1/30-year event**), the track's substructure is (partly) impounded, but there is no or only little notable damage.
- **b** In damage class 2 (synthetic **100-year event**), the track section is fully inundated and significant structural damage has occurred (or must be expected)
- **c** damage class 3 (a synthetic **300-year event**), additional damage to substructure, superstructure, catenary and/or signals occurred so that a full restoration of the cross-section is required.

The damage classes are estimated for each 100 m-segment.

Flood scenario [probability]	Repair costs estimated by the RAIL model
1/30	EUR 17 698 600
1/100	EUR 21 511 600
1/300	EUR 93 168 900

Table 1. Estimated repair costs for different hydraulic scenarios and their probabilities along the March river.

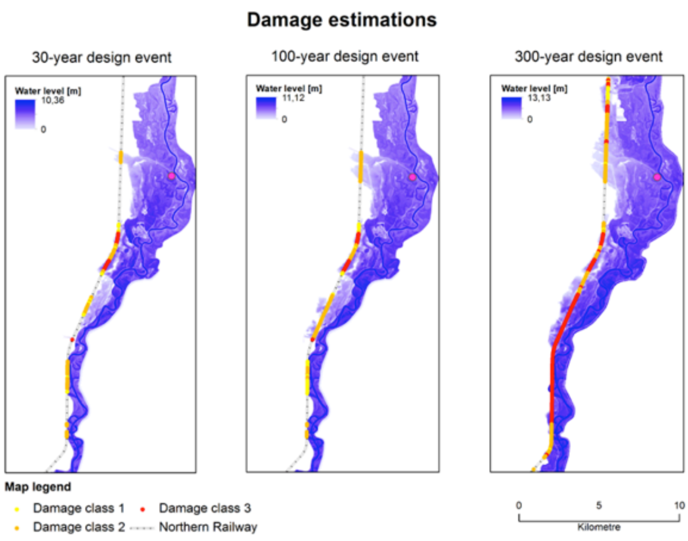

Figure 2. Estimation of potential structural damage at the Northern Railway for three flood scenarios.

Drought management: Global and Jucar basin (Spain) cases

In the ENHANCE project, drought has been studied through two case studies: A **global analysis** and a **regional case study in the Jucar basin in south-eastern Spain.**

- For the **global study**, two hazard indicators were used: the Water Crowding Index (WCI) and the Water Scarcity Index (WSI). The WCI quantifies water scarcity as the yearly water availability per capita at a country or basin level. The WSI uses a ratio between withdrawals and water availability as an indicator for water scarcity conditions. Using time-series of precipitation, evapotranspiration, runoff, and soil moisture, drought index values are composed. Apart from the **hazard side, exposure** and **vulnerability** terms determine for a large part the impact of drought and water scarcity conditions.

At global scales, **exposure** to drought or water scarcity conditions is often expressed by means of socio-economic indicators such as population or agricultural land area affected. Whilst **vulnerability** is often taken into account in indirect terms only at the global scale, local information on the adaptive capacity of a region to drought or water scarcity conditions enables the inclusion of this term in case study analyses.

- The **Jucar basin (Spain)** uses a combination of indicators for the assessment of current and future drought risk, and for operational use. Information on river flow and reservoir storage levels are combined with knowledge on sectoral water needs and costs of potential water shortages to assess the probability of hazardous drought conditions and their associated (economic) impacts.

- Vulnerability to drought and water scarcity conditions in the Jucar basin is mainly determined by the portfolio of different water uses being dependent on the same source of water and by the operational management of drought conditions.
- At this operational level, drought risks are governed by monitoring multiple drought indicators (reservoir volumes, aquifer storage, streamflow, rainfall) and the timely declaration of emergency states if necessary.

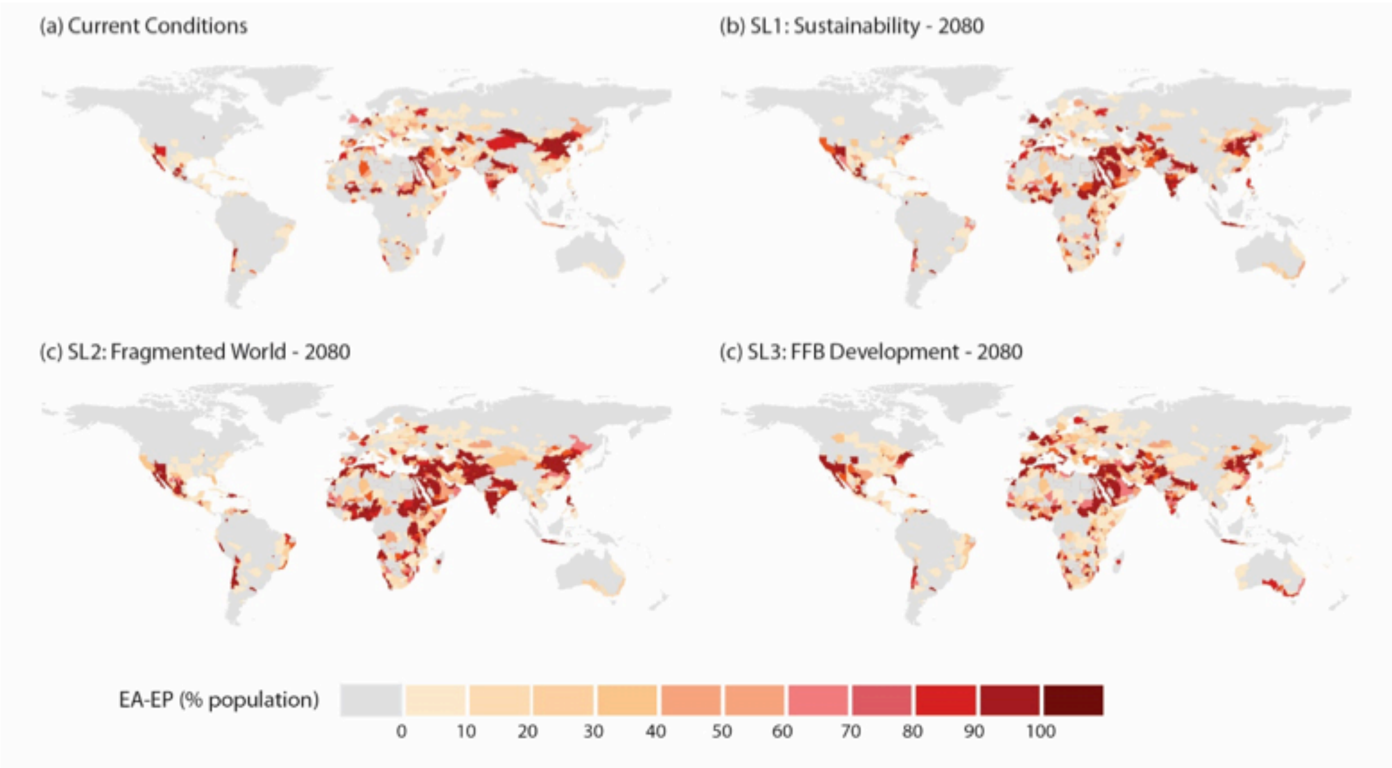

Figure 3. Global Water scarcity risk (EA-EP) per water province under historic and 2080s conditions. Risk levels were estimated using different climate models and expressed as percentage of the total population. Risk levels are showed for (a) the historic conditions, and in 2080 for (b) storyline Sustainability, (c) Fragmented World, and (d) Fossil-Fuel Based (FFB) Development. The grey areas represent areas with zero or non-significant risk.

Portugal wildfires

A key hazard in Portugal is wildfire with many major episodes over the recent past. In 2003, Portugal had the worst ever recorded fire season, with about 450 thousand hectares burned. The central part of the Portuguese mainland was the most affected, including the district of Santarém, where the case studies of the ENHANCE project, the municipalities of Chamusca and Mação, are situated.

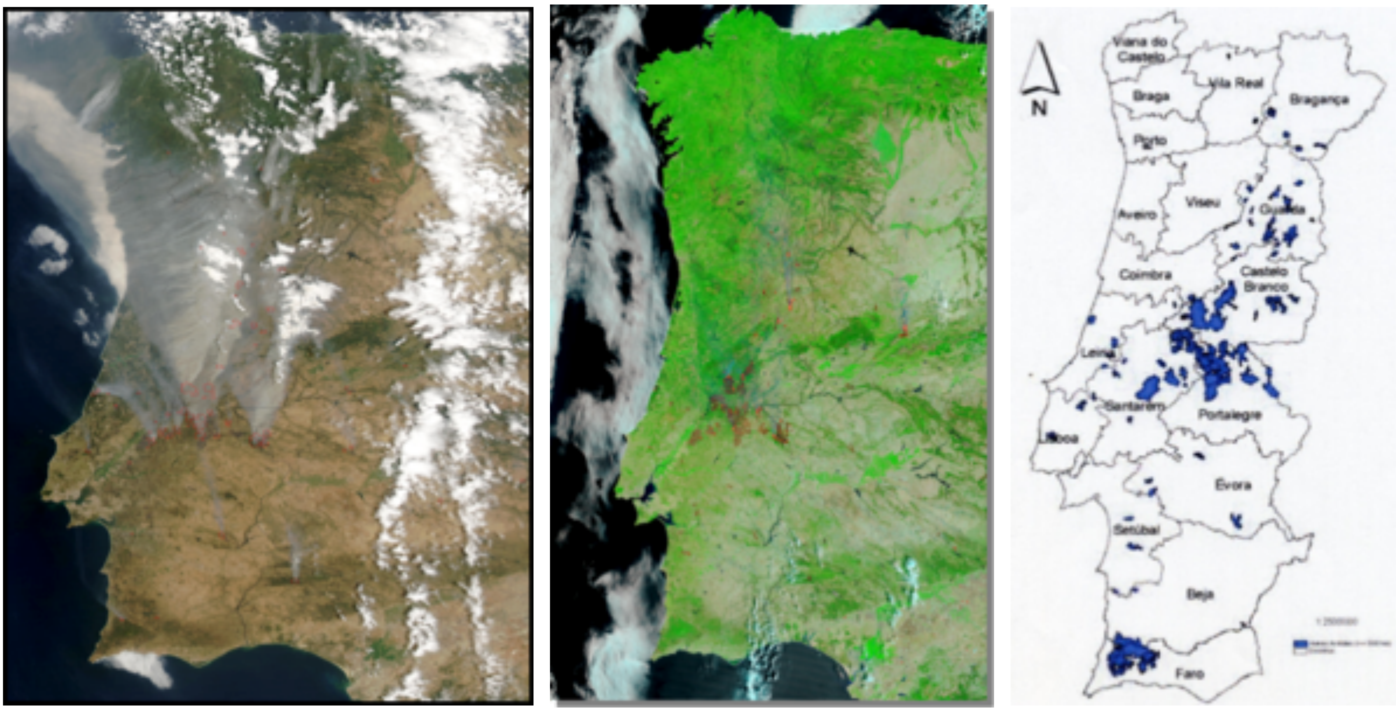

Figure 4. Satellite images of summer 2003, showing smoke during wildfires (left), the distinctive scars of wildfires in the landscape (center) and the final shapes of fires showing the district of Santarém in Central Portugal (right).

Using the unit values for losses included in the National Forest Strategy of 2006, an **exceedance probability-loss curve** was established indicating, for the two most extreme years (2003 and 2005), values of estimated losses for the district of Santarém higher than €100 million.

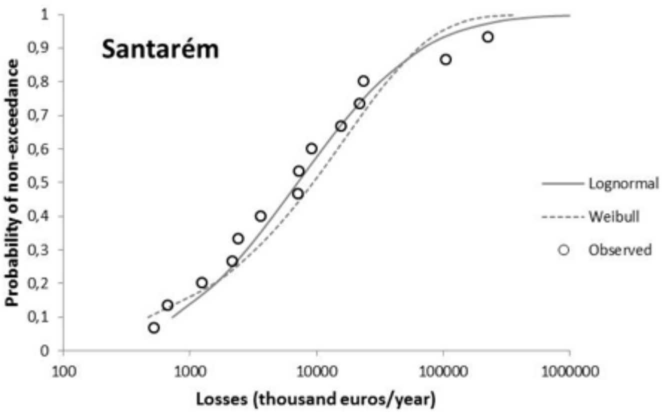

Figure 5. Exceedance probability-loss curve for wildfires in the district of Santarém.

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Port of Rotterdam: flood risk

The port of Rotterdam is the second largest port in the world. The harbor is situated in the south-western river delta of the Netherlands and is prone to natural hazards (wind storms, flooding). Industries, energy plants, port facilities, railways, tunnels, and container terminals are potentially at risk. In addition, a large section of Rotterdam's working population is employed in the port area, and many businesses are highly dependent upon port activities. Severe economic damage can occur from long-term closures of the port and its industry.

The case study shows that insurance and subsidy incentives can stimulate households to implement loss-reducing measures, thereby reducing overall flood risk of the port area.

In a so-called **'agent-based model'**, households respond to insurance premiums, premium discounts, and subsidies, which are based on the changing risk environment. The agent-based model is driven by a **flood risk**, which calculates the risk from flooding based on the exposed assets (Figure 6), the flood hazard in terms of the inundation depth for flooding event under different return periods, and vulnerability information represented by stage damage curves (Figure 7).

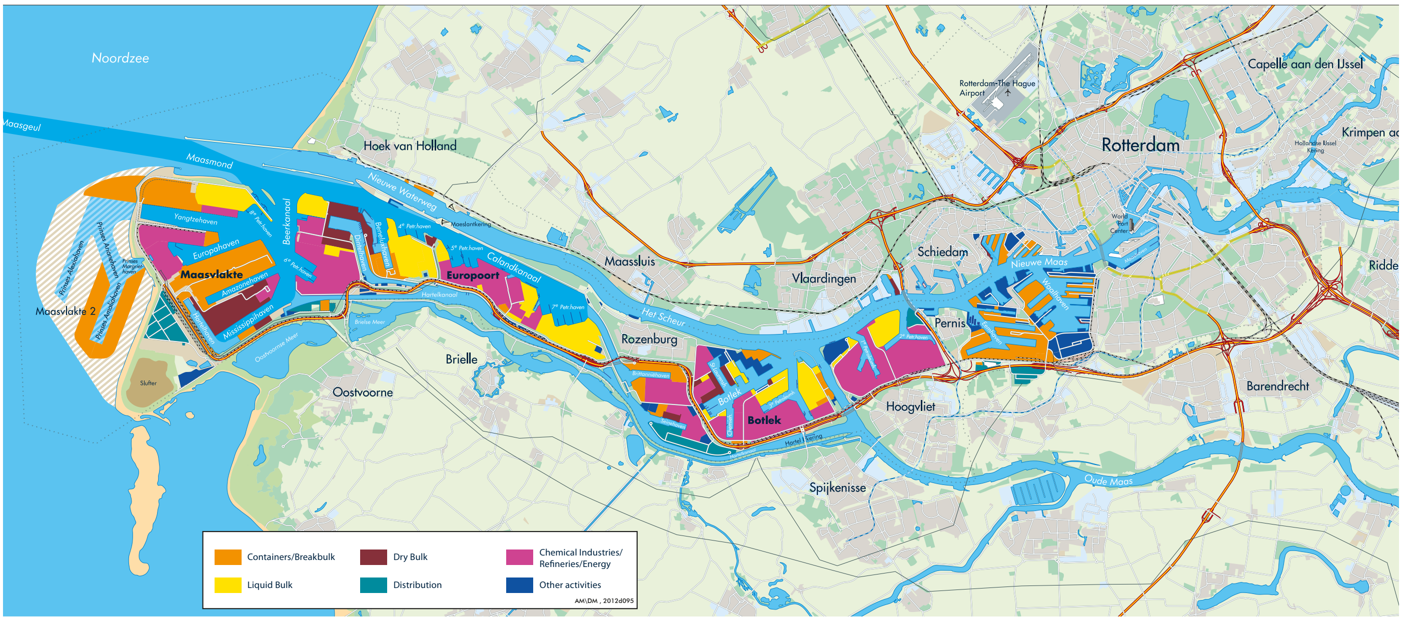

Figure 6. Exposed assets: Land use map Port of Rotterdam (Image Courtesy to Port of Rotterdam Authority, 2012).

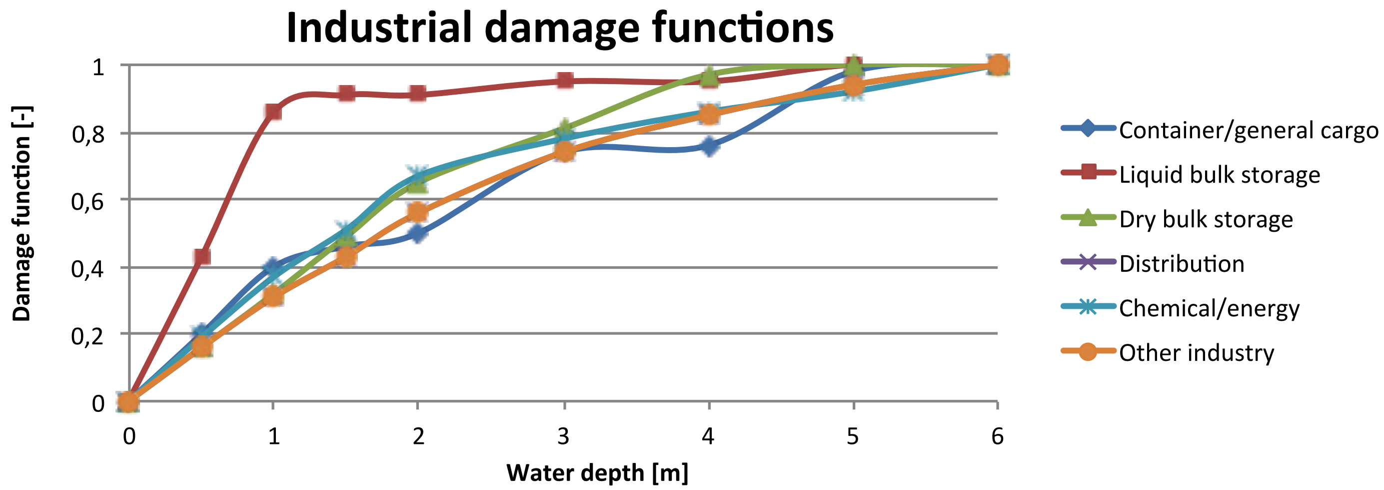

Figure 7. Exposed assets: Land use map Port of Rotterdam (Image Courtesy to Port of Rotterdam Authority, 2012).

EXTREME EVENTS AND STATISTICS

Extreme value theory is needed to model statistical properties of extreme events that lie outside the range of observed data. The usual statistical techniques focus on average events, and have a great bias in estimating extremes. One reason for this is that standard estimation techniques only serve well where there is a large density of observed data. Furthermore, most data is (naturally) concentrated toward the center of the distribution (the average) and so, by definition, extreme data is scarce and therefore estimation is challenging. Figure 8 shows an example of fitting extreme value statistics (A so called 'Gumbel plot') through measured data of river discharges for the river Rhine in The Netherlands (the black dots). Since only ~100-150 years of measurements are available, the rarest event is the maximum discharge in that period: ~12500 m3/s, with a probability of ~1/100. However, for policy reasons, we would like to estimate an extreme discharge that has a probability of 1/1000. Therefore, we need to extrapolate the measured data using Extreme Value Statistics, which gives us a discharge of ~16000 m3/s.

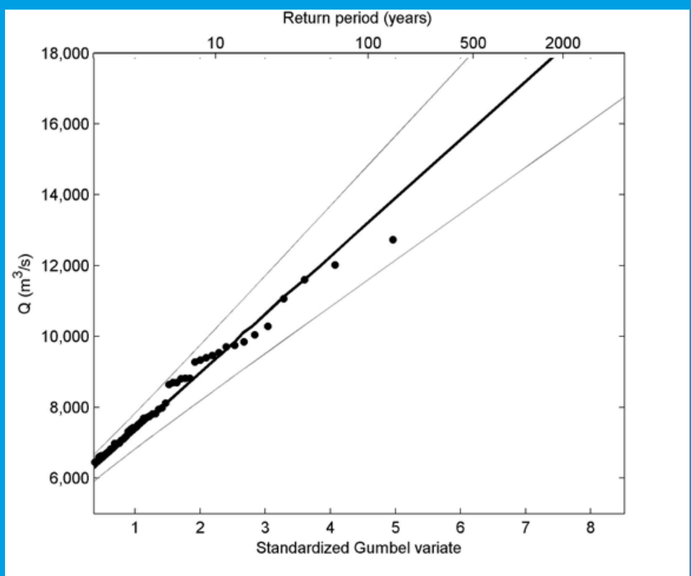

Figure 8. Fitting extreme value statistics (A so called 'Gumbel plot') through measured data of river discharges for the river Rhine in The Netherlands (the black dots).

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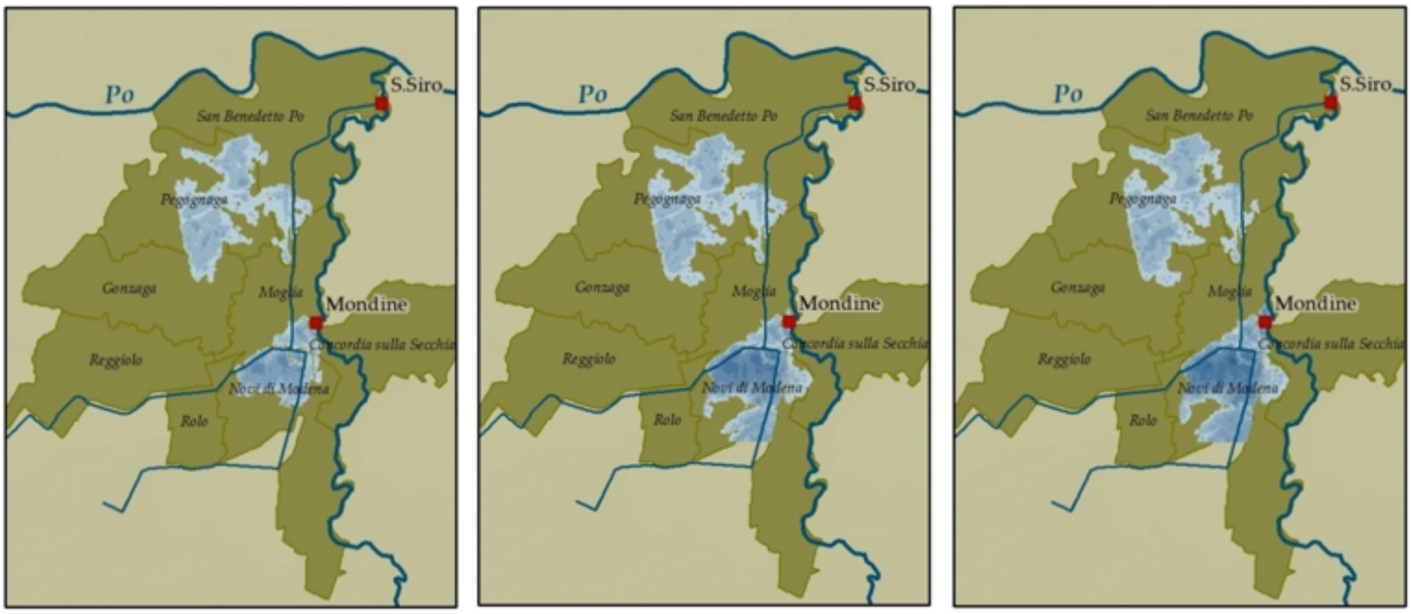
Controlled floods to reduce risk, Italy

The flood risk analysis for Northern Italy, in the Po river basin, was compelled as a result of the severe earthquake that hit the Emilia Romagna region in 2012. The earthquake disrupted the flood protection system. Flood risk increased consistently in urban, industrial, and agricultural areas. To prevent larger impacts, a multi- sectoral partnership was installed between the Civil Protection Agency, the Land Reclamation and Irrigation Boards, and the Regions of Lombardy and Emilia Romagna in 2012.

The risk assessment for this MSP delineated the areas exposed to higher flood risk under different precipitation and disruption scenarios. In addition, **it estimated economic losses caused by uncontrolled floods in terms of capital stock damage and foregone production losses.** The simulated volume of drained water and timing of its outflow were further analysed using a 2D hydrodynamic model and a high-resolution digital elevation model to produce flooding maps for each scenario (See Figure 9). The analyses showed simulated damage between €20 and €100 million.



RP1 RP10 RP50

Figure 9. Flood scenario under most severe disruption scenario for return period (RP) 1/1, 1/10 and 1/50 years.

The risk scenarios developed within the ENHANCE project demonstrate that **risk information is critical for effective disaster risk management across sectors.** The availability of accurate and comprehensive information is necessary for informed decision-making in order to prevent excessive socio-economic stress from extreme events and to better coordinate disaster responses within the EU.

THIS POLICY BRIEF IS BASED ON RESEARCH OF THE ENHANCE PROJECT

Jongman B, Hochrainer-Stigler S, Feyen L, Aerts JCJH, Mechler R, Wouter Botzen WJ, Bouwer LM, Pflug GC, Rojas R, Ward PJ (2014), Increasing stress on disaster-risk finance due to large floods. Nature CC, 4(4):264-268.

JRC (2015) Guidance for Recording and Sharing Disaster Damage and Loss Data: Towards the development of operational indicators to translate the Sendai Framework into action, Joint Research Centre, Institute for the Protection and Security of the Citizen and the EU expert working group on disaster damage and loss data, Ispra., 2015.

Kellermann, P., A. Schöbel, G. Kundela, A.H. Thieken (2015): Estimating flood damage to railway infrastructure – the case study of the March River flood in 2006 at the Austrian Northern Railway. – Accepted at Nat. Hazards Earth Syst. Sci.; discussion paper in Nat. Hazards Earth Syst. Sci. Discuss. 3: 2629-2663, doi: 10.5194/nhessd-3-2629-2015.

Koks, E.E., Bockarjova, M., Moel, H. de & Aerts, J.C.J.H. (2014). Integrated Direct and Indirect Flood Risk Modeling: Development and Sensitivity Analysis. Risk Analysis. 10.1111/risa.12300.

Monteagudo, D.H., Andreu Alvarez, J., Solera, A., S., Arquiola, J. P., Benavent, A. M. (2013) Risk profile of the Jucar River Basin case study. In: Mysiak (ed.) Risk profile case study using the conceptual framework. ENHANCE deliverable 7.1, 2013.

Veldkamp, T.I.E., Wada, Y., Aerts, J.C.J.H., Ward, P.J. (2016). Towards a global water scarcity risk assessment framework: incorporation of probability distributions and hydro-climatic variability. Environ. Res. Lett. 11 024006. http://dx.doi.org/10.1088/1748-9326/11/2/024006.