Disaster Risk Management as a scientific challenge

Evidence for Policy School - Disaster Risk Management: Science and technology in support of decision making, in an environment of uncertainty

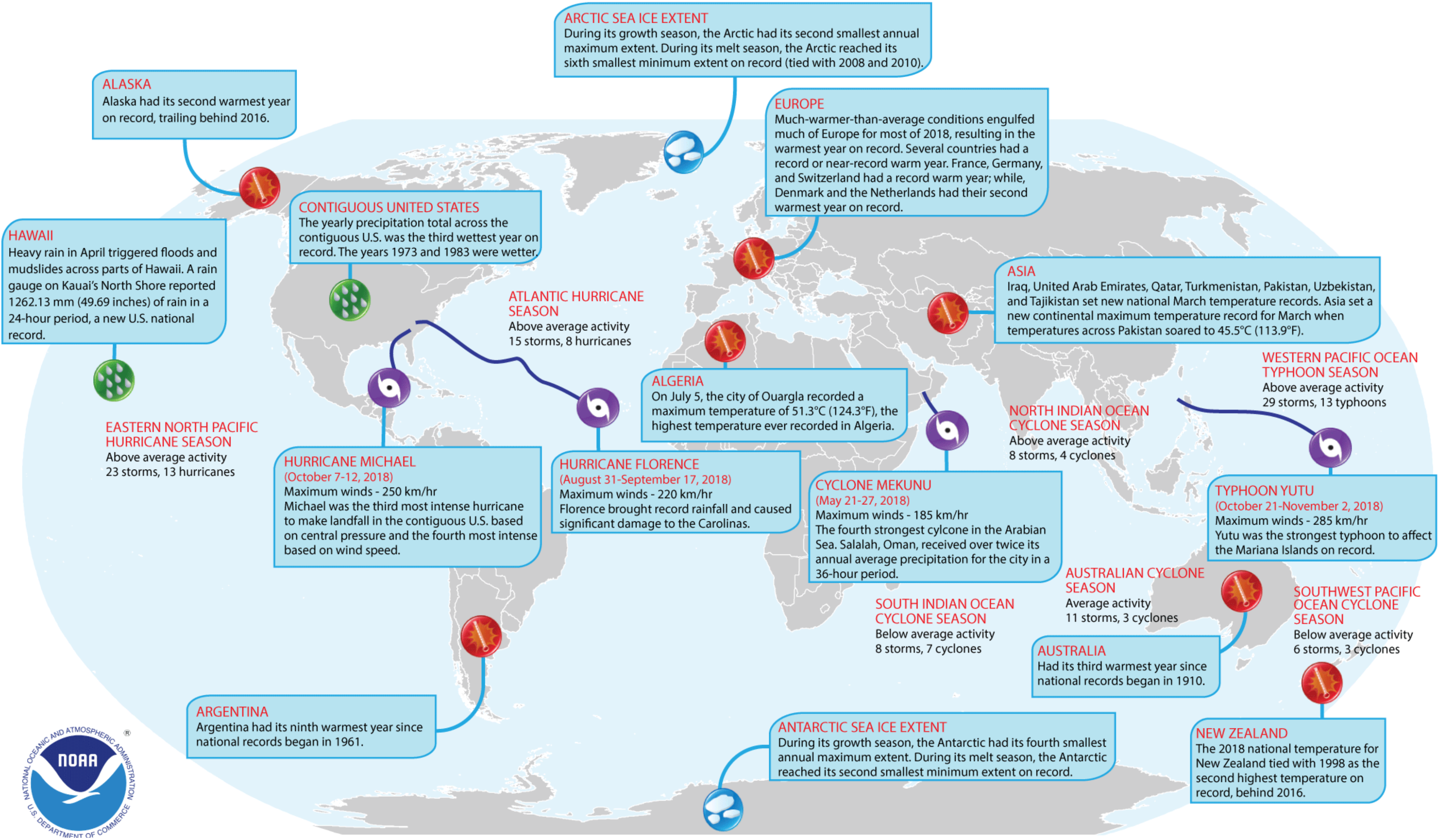
Florence, 13-15/01/2020

Jaroslav Mysiak,
Euro-Mediterranean Centre on Climate Change

Centro Euro-Mediterraneo sui Cambiamenti Climatici

Geography of hazards and risks

NOAA: Selected climate anomalies and events 2018



https://www.ncdc.noaa.gov/sotc/service/global/extremes/201613.gif

Geography of hazards and risks

PBL: The Geography of future water challenges

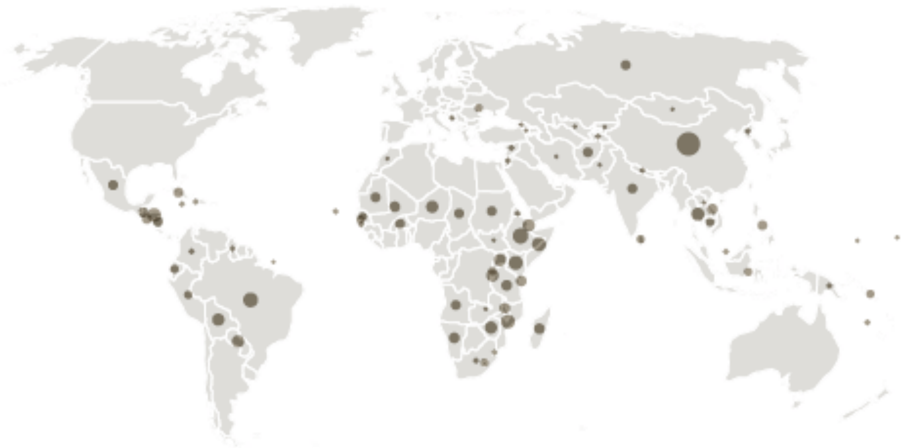
The impact of too little water

Drought occurrences 1996–2015
Droughts occur on all continents, but predominantly in the southern hemisphere.

Number of occurrences

10

Source: CRED



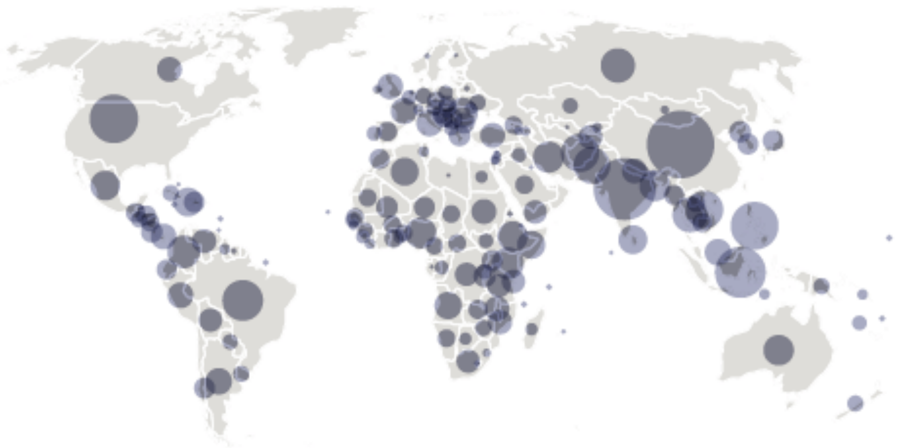
The impact of too much water

Flooding events 1996–2015
Flooding events lead to casualties, result in temporary dis-placement out of the area and high economic losses affecting both indus-tries and households.

Number of occurrences

100

Source: CRED

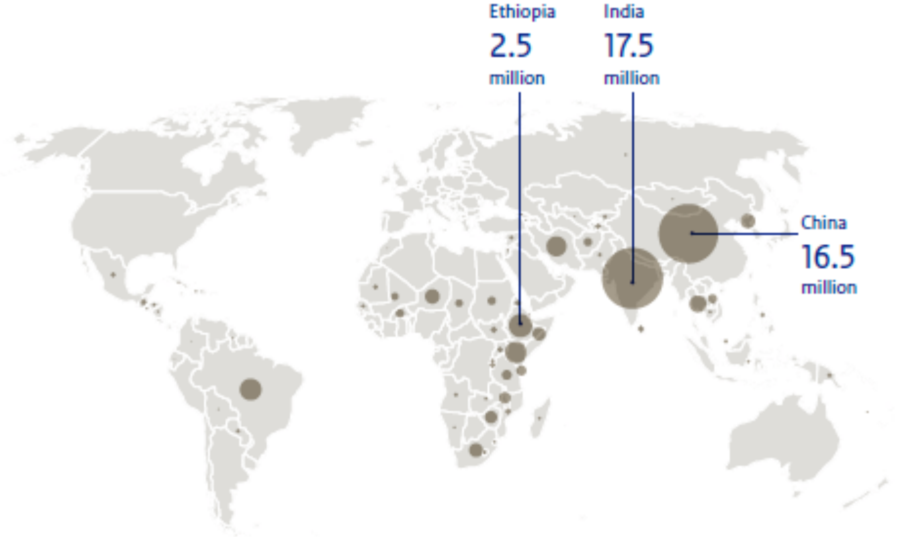


People annually affected by drought 1996–2015
Droughts lead to water scarcity for people, severe agri-cultural production loss, local food shortages, and wildfires.

Number of people affected, annually

10 million

Source: CRED

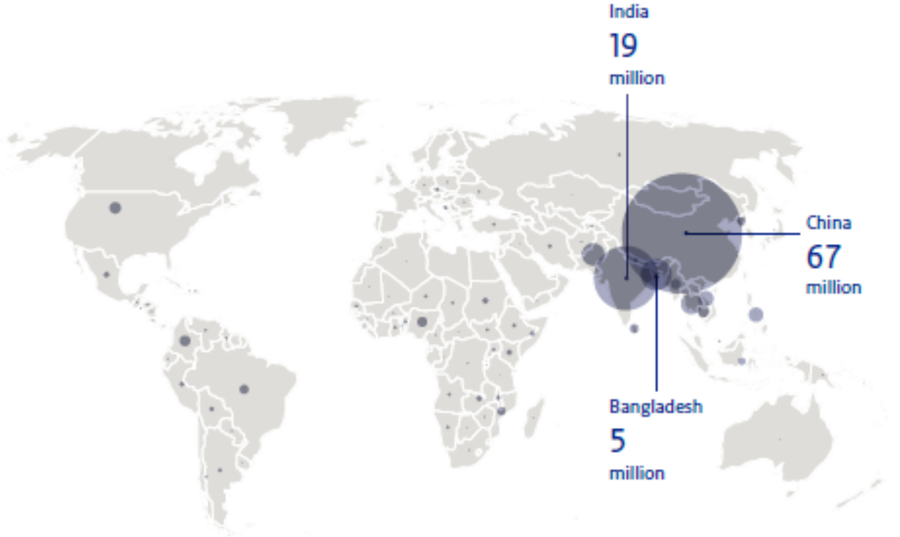


People annually affected by flooding 1996–2015
Flooding occurs all over the world, but the majority of the people affected live in Southeast Asia.

Number of people affected, annually

35 million

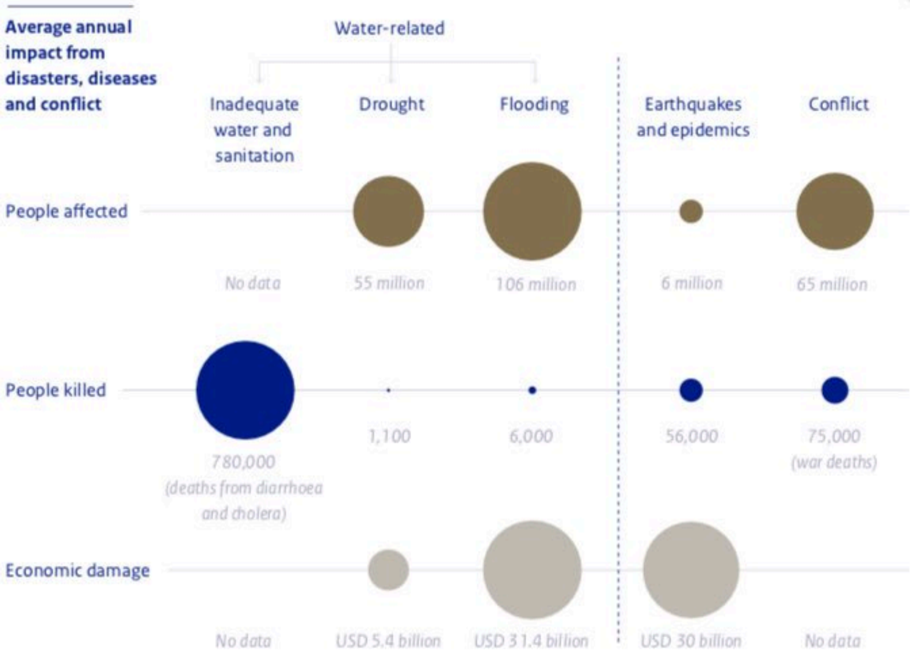
Source: CRED



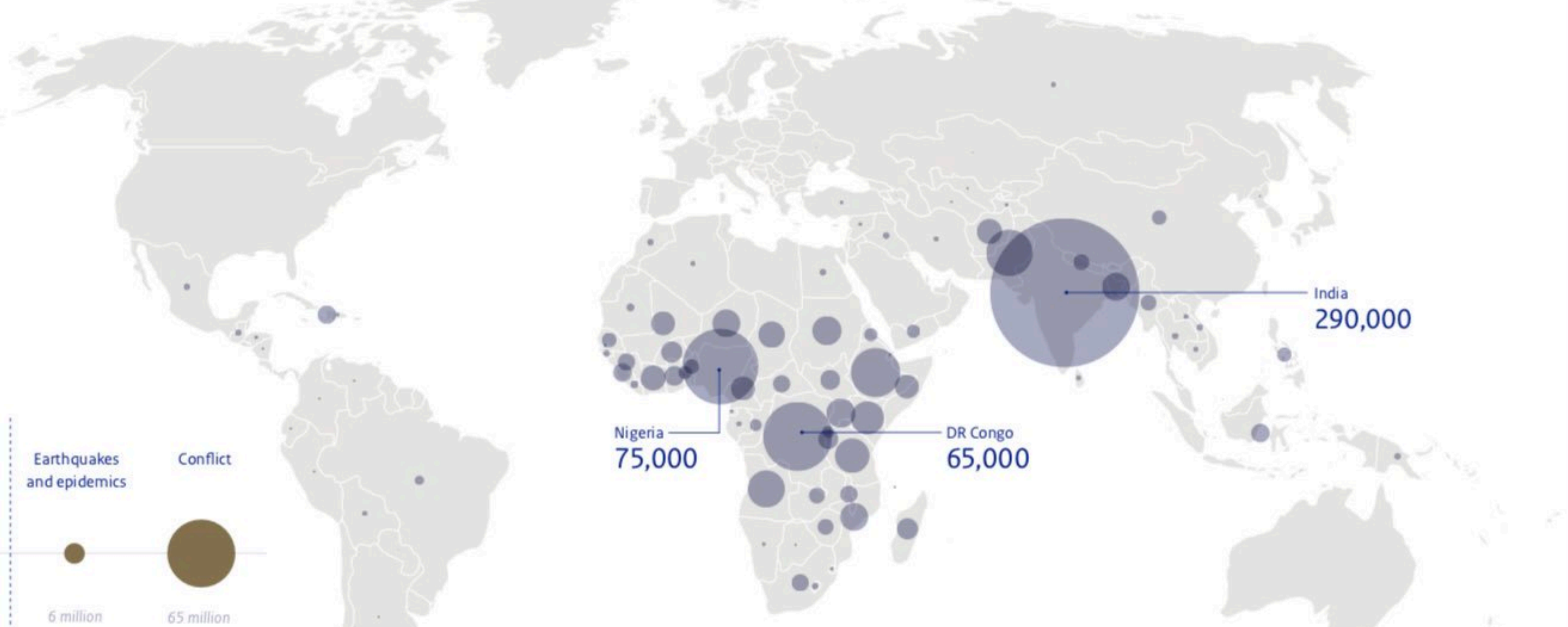
Geography of hazards and risks

Water pollution and water-related weather extremes (drought, extreme rainfall, flooding, storm surges) affect the lives of millions of people and cause billions of euros in economic damage, each year.

Each year, water-related disasters, such as drought and flooding, affect approximately 160 million people, killing about 13,500 of them. Flooding affects most of these people (106 million, annually) and causes the largest economic damage (USD 31 billion, annually). Fortunately, due to improved early warning systems and increased disaster management capacity, the number of people killed by weather-related disasters has decreased, over the last decades.
Far more people are killed by other types of natural disasters, such as earthquakes and tsunamis, as well as by violent conflict.



The impact of water that is too dirty



The impact of inadequate water and sanitation

Annual deaths from diarrhoea (2012) and cholera (2008–2012)

100,000

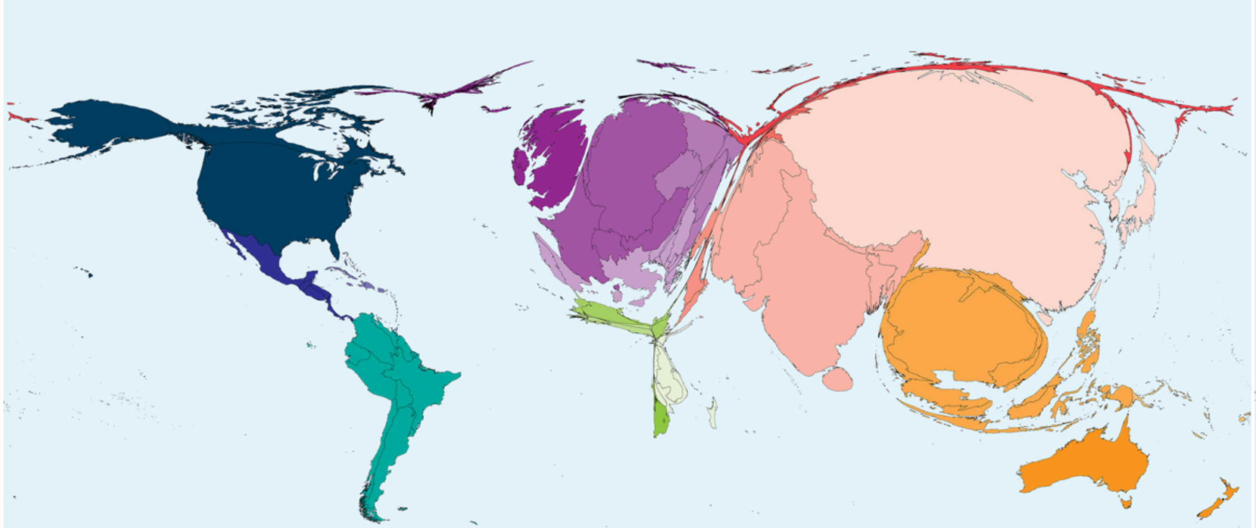
Source: Prüss-Ustün et al., 2014, Ali et al., 2015

Because of unsafe drinking water and lack of adequate sanitation, each year, millions of children under the age of 5 become ill, and almost 800,000 people perish from diarrhoea and cholera. Africa has the highest annual deaths, but numbers are also high in Southeast Asia.

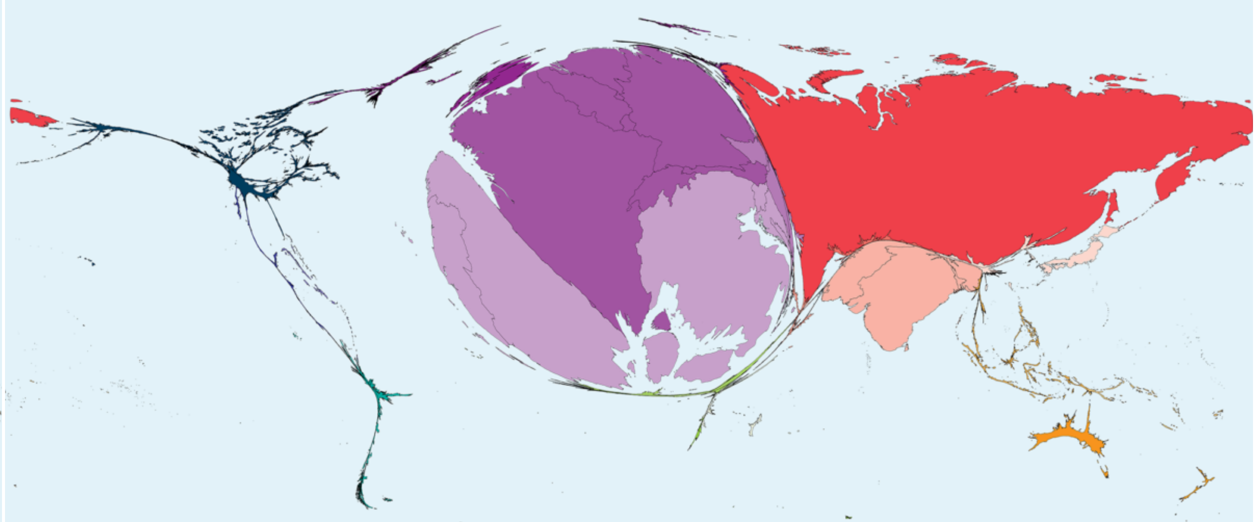
https://themasites.pbl.nl/future-water-challenges/

Geography of hazard and risk

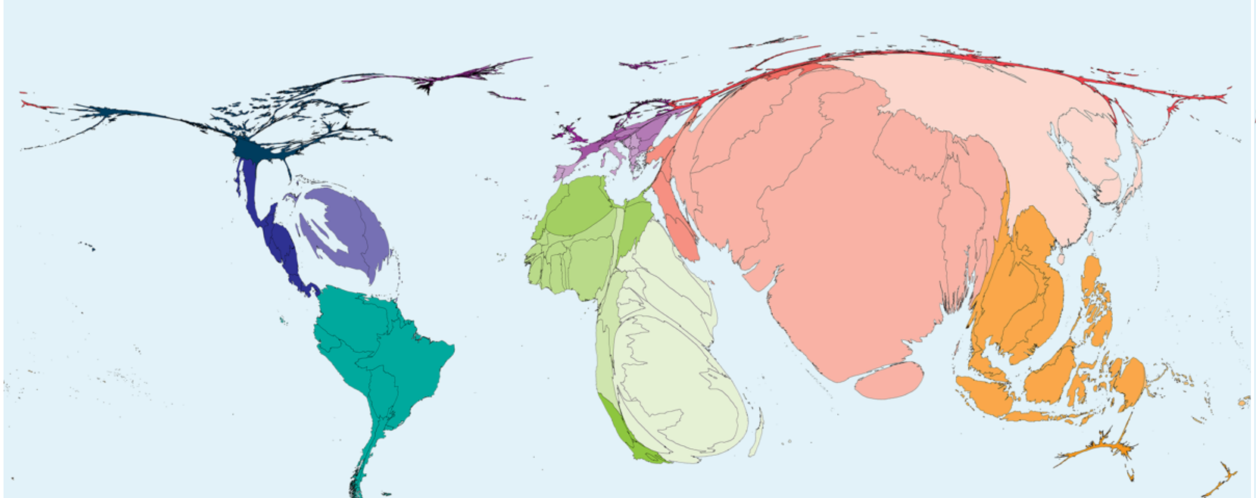
World mapper: The atlas of the real world



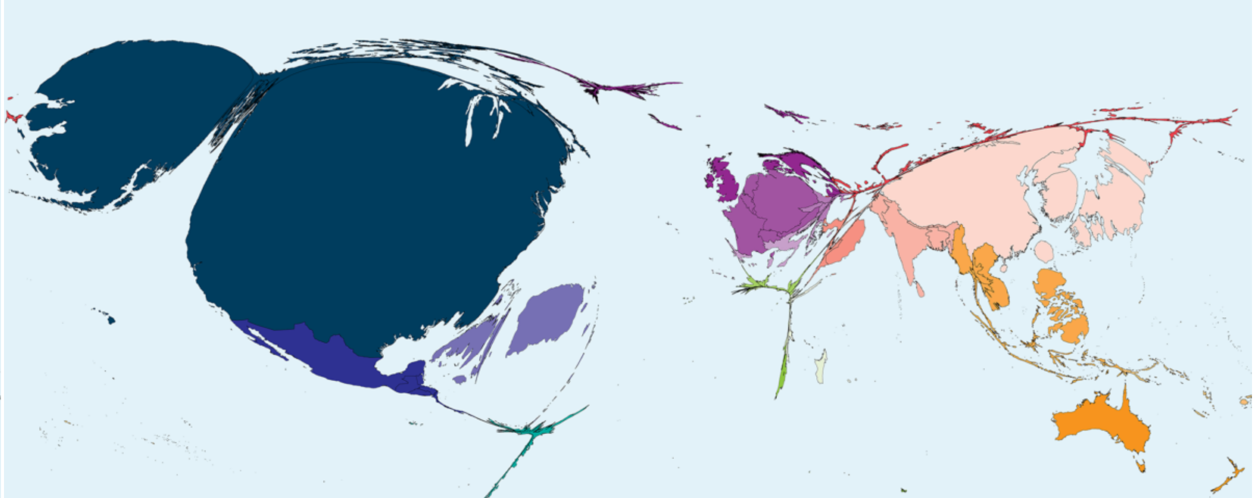
Economic damage by floods 2001-2017



Mortality by heat waves 2001-2017



Mortality by floods 2001-2017

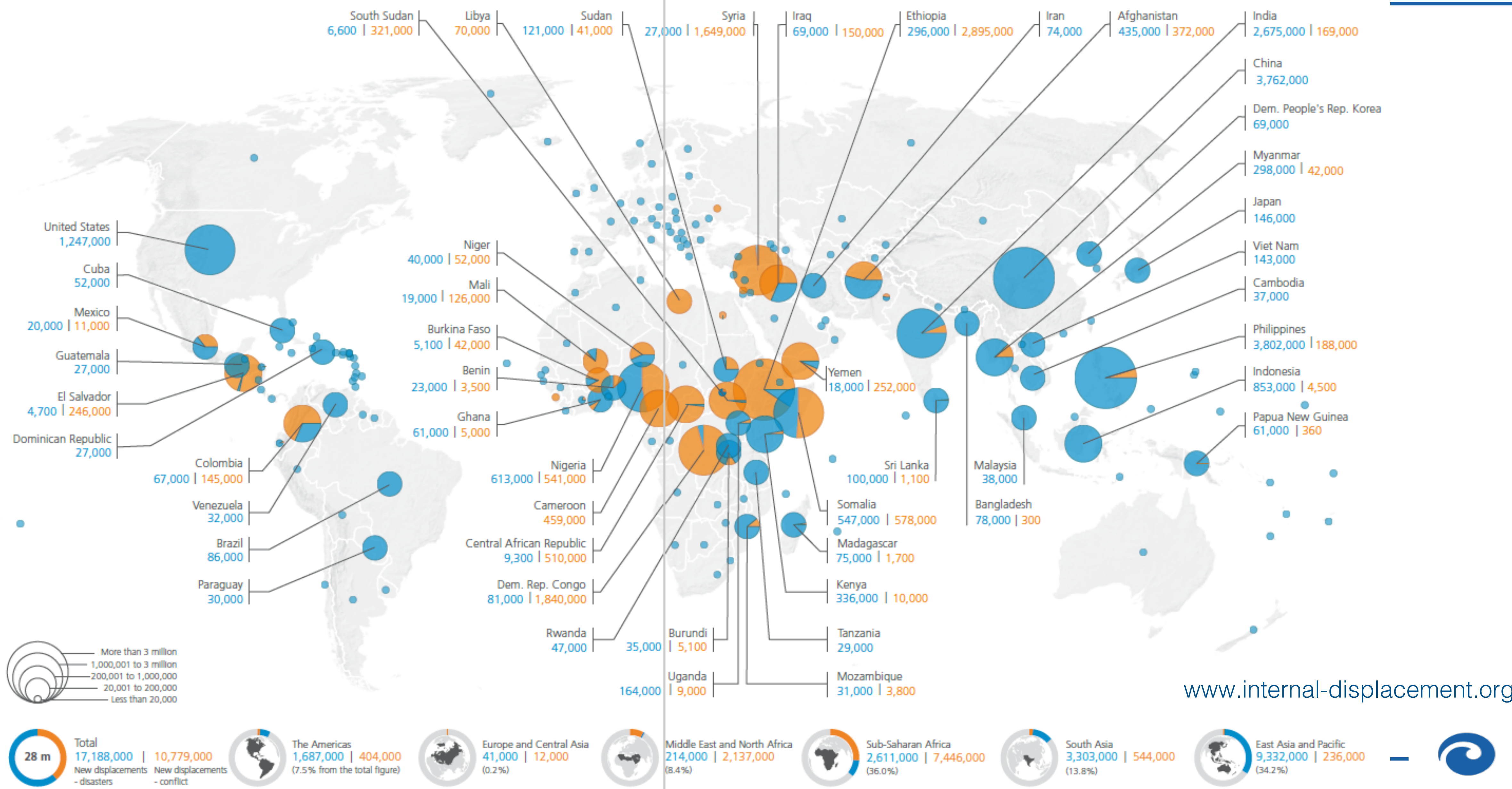


Mortality by storms 2001-2017

https://worldmapper.org

Internal displacement

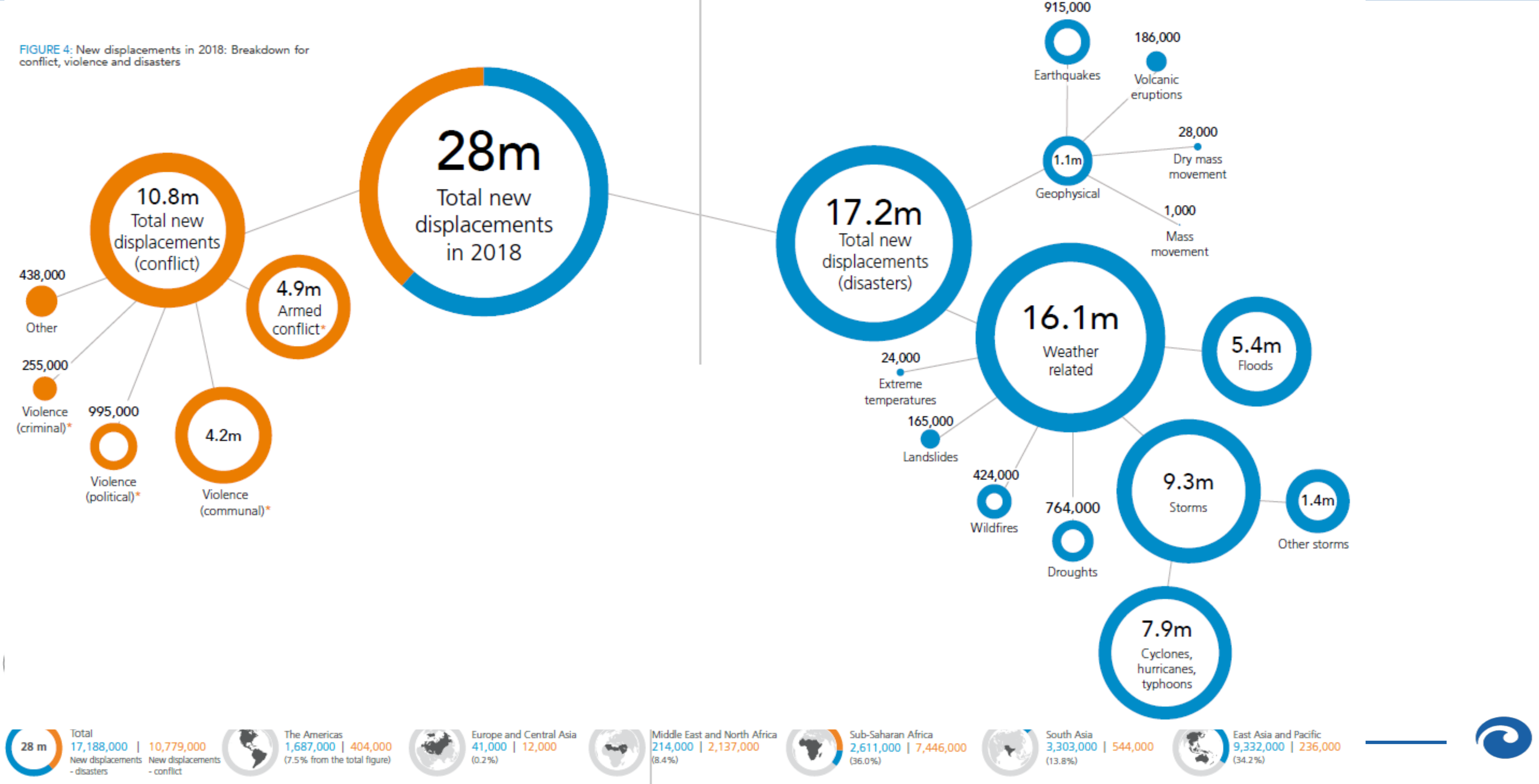
Internal Displacement Monitoring Centre: GRID2019



So

Internal displacement

FIGURE 4: New displacements in 2018: Breakdown for conflict, violence and disasters



Geography of disaster science

Elsevier: Science of Disaster Science

Death toll versus publications

countries with the highest death tolls from natural disasters tend to have low volumes of disaster science scholarly output

27,273

the number of recent scholarly output in disaster science

9,571

the number of recent disaster science publications on geophysical disasters

China

the most prolific country in disaster science scholarly output overall and disaster prevention scholarly output

Japan

the most specialized prolific country in disaster science, overall and in research on each disaster management cycle stage

Economic loss versus publications

countries with the highest economic losses from natural disasters tend to have the largest disaster science scholarly output

0.22%

the share of recent global scholarly output belonging to disaster science

>5,000

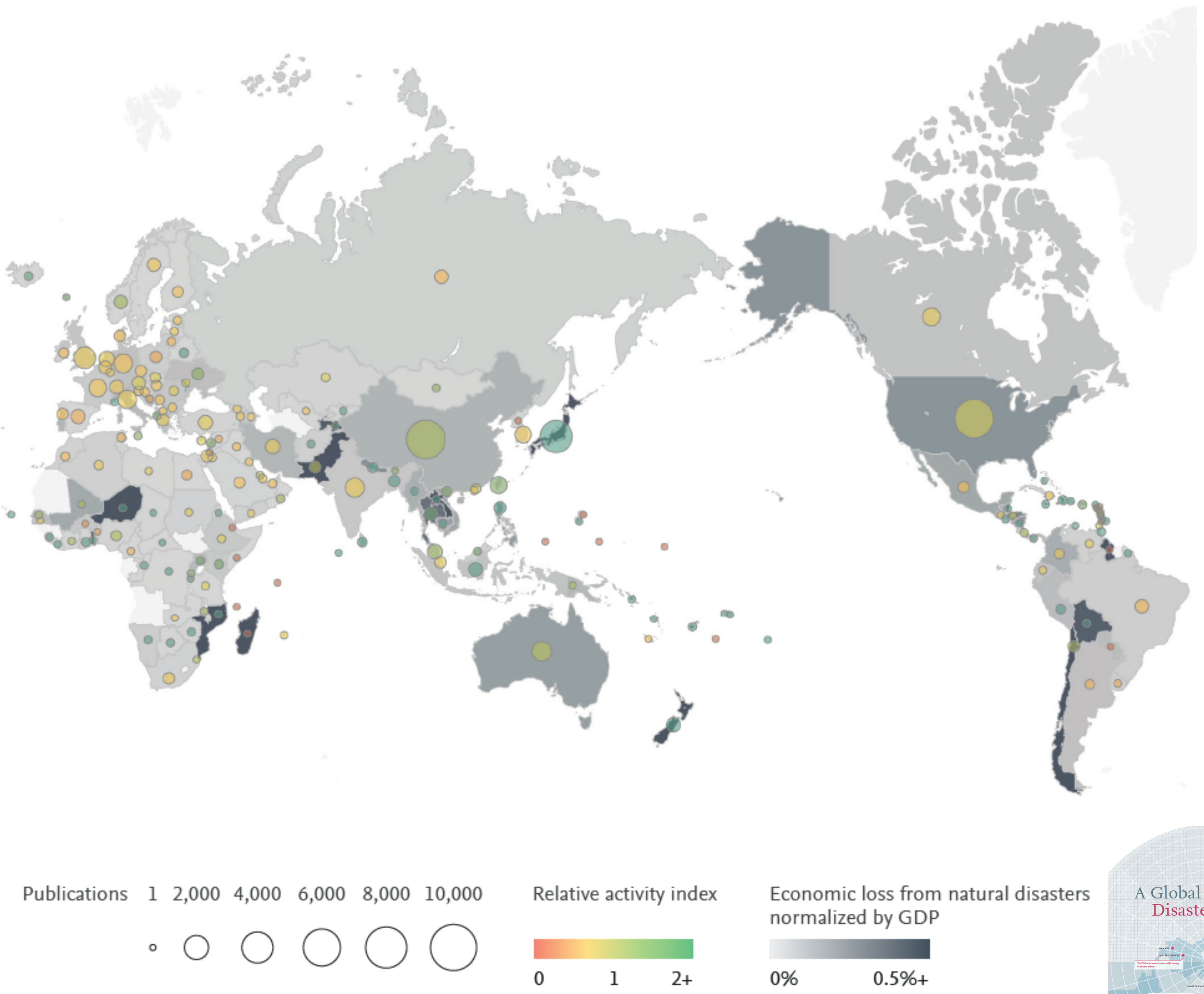
the number of recent disaster science publications on each of the following disaster types: geophysical, meteorological, chemical & radiological, and hydrological

USA

the most prolific country in disaster preparedness, response, and recovery scholarly output

Philippines, Indonesia, Bangladesh, Japan, New Zealand, Thailand, Taiwan

territories with 125+ recent papers in disaster science that are 50%+ more specialized in disaster science than the global average



IPCC Special Report 1.5 Degree SR1.5

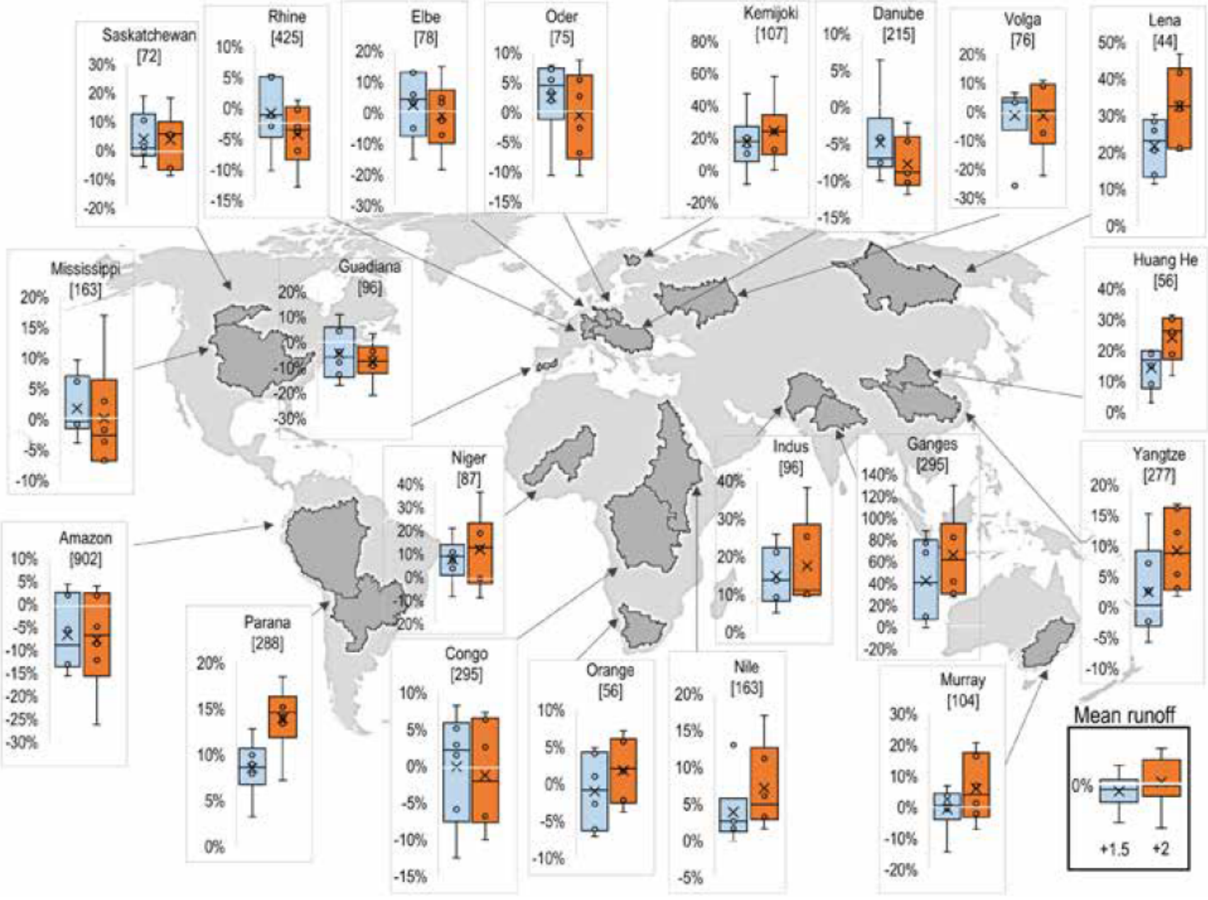


Figure 3.15 | Runoff changes in twenty-one of the world's major river basins at 1.5°C (blue) and 2°C (orange) of global warming, simulated by the Joint UK Land Environment Simulator (JULES) ecosystem–hydrology model under the ensemble of six climate projections. Boxes show the 25th and 75th percentile changes, whiskers show the range, circles show the four projections that do not define the ends of the range, and crosses show the ensemble means. Numbers in square brackets show the ensemble-mean flow in the baseline (millimetres of rain equivalent) (Source: Betts et al., 2018).

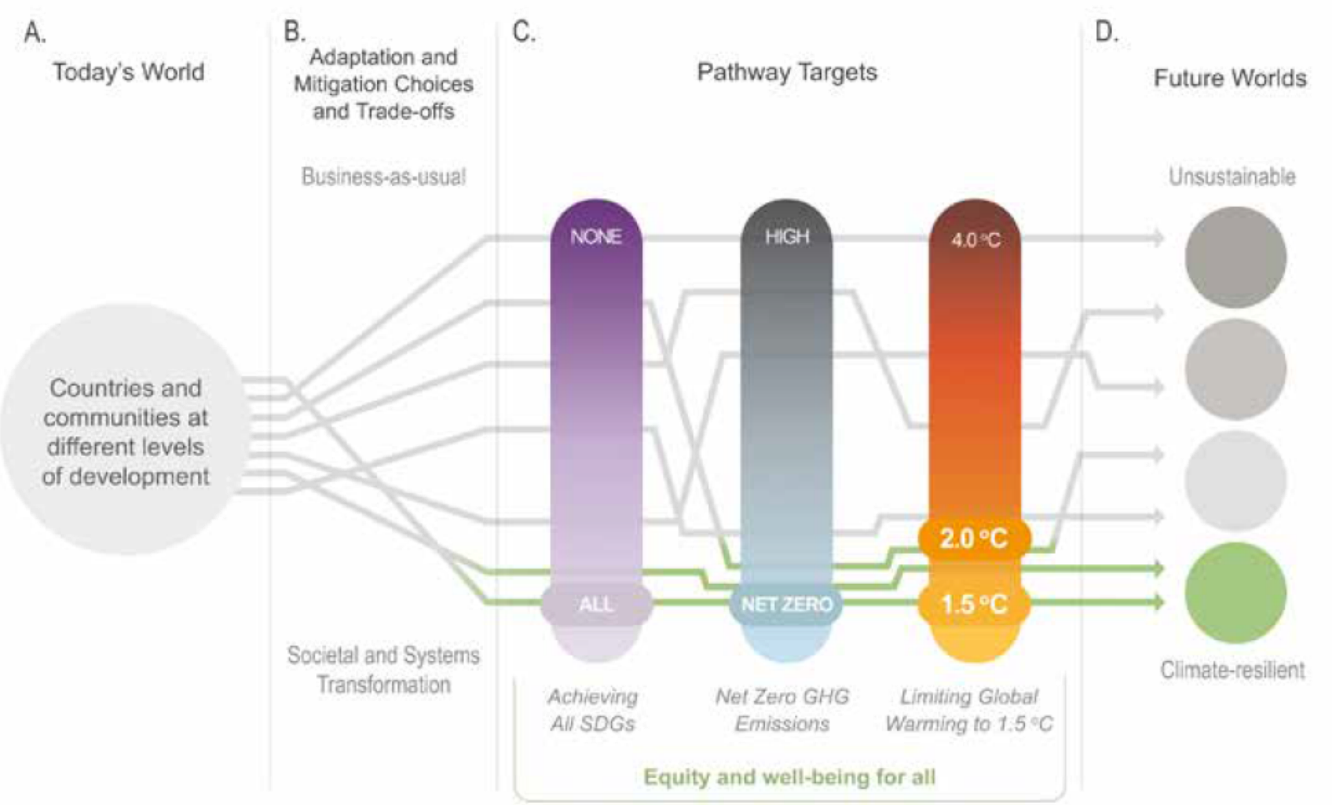


Figure 5.1 | Climate-resilient development pathways (CRDPs) (green arrows) between a current world in which countries and communities exist at different levels of development (A) and future worlds that range from climate-resilient (bottom) to unsustainable (top) (D). CRDPs involve societal transformation rather than business-as-usual approaches, and all pathways involve adaptation and mitigation choices and trade-offs (B). Pathways that achieve the Sustainable Development Goals by 2030 and beyond, strive for net zero emissions around mid-21st century, and stay within the global 1.5°C warming target by the end of the 21st century, while ensuring equity and well-being for all, are best positioned to achieve climate-resilient futures (C). Overshooting on the path to 1.5°C will make achieving CRDPs and other sustainable trajectories more difficult; yet, the limited literature does not allow meaningful estimates.

Advancements of climate risk analysis

High performance computing has enabled new generation of climate models that are better capable of simulating climate extremes. Robust estimates are possible also for longer period return values.

Multi-model ensembles with high spatial resolution capable of exploring model uncertainty and better inform public policy choices.

Detection and attribution more reliable when based consistent evidence from observations and numerical models capable of replicating the event.

Near-term (multi-year to decadal) **predictions** reliability.

Improved **modelling capability**, including multi-hazard assessment, empirical corroboration of damage models, impact propagation through networks, stress testing of critical infrastructure components. Improved availability of hazard data (e.g. flood hazard and risk prone areas)

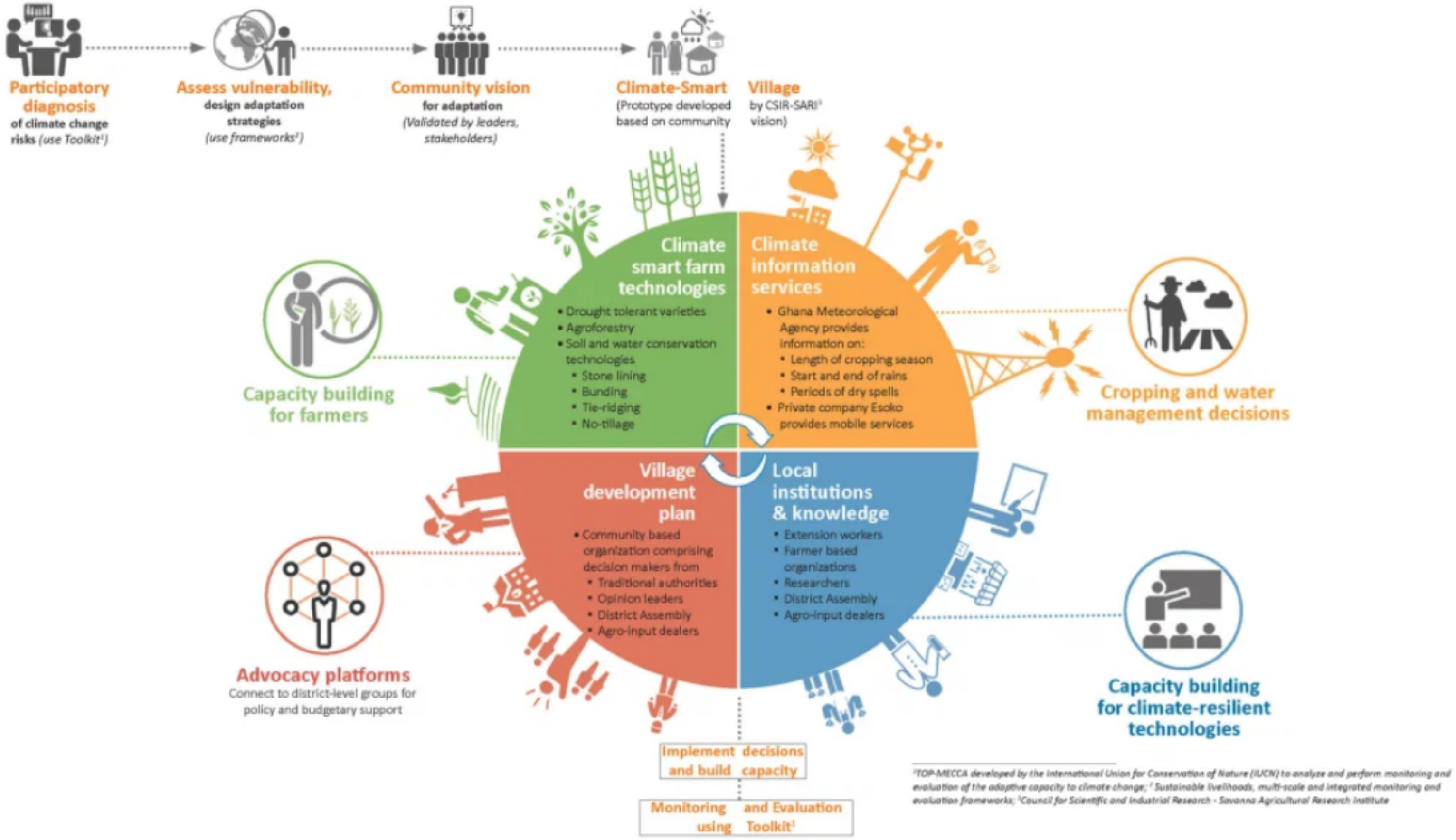
High resolution exposure data including population, gross added value, gross domestic/regional product, buildings, infrastructure, industrial facilities

Better record of existing risk mitigation measures

Working in partnerships

Climate services

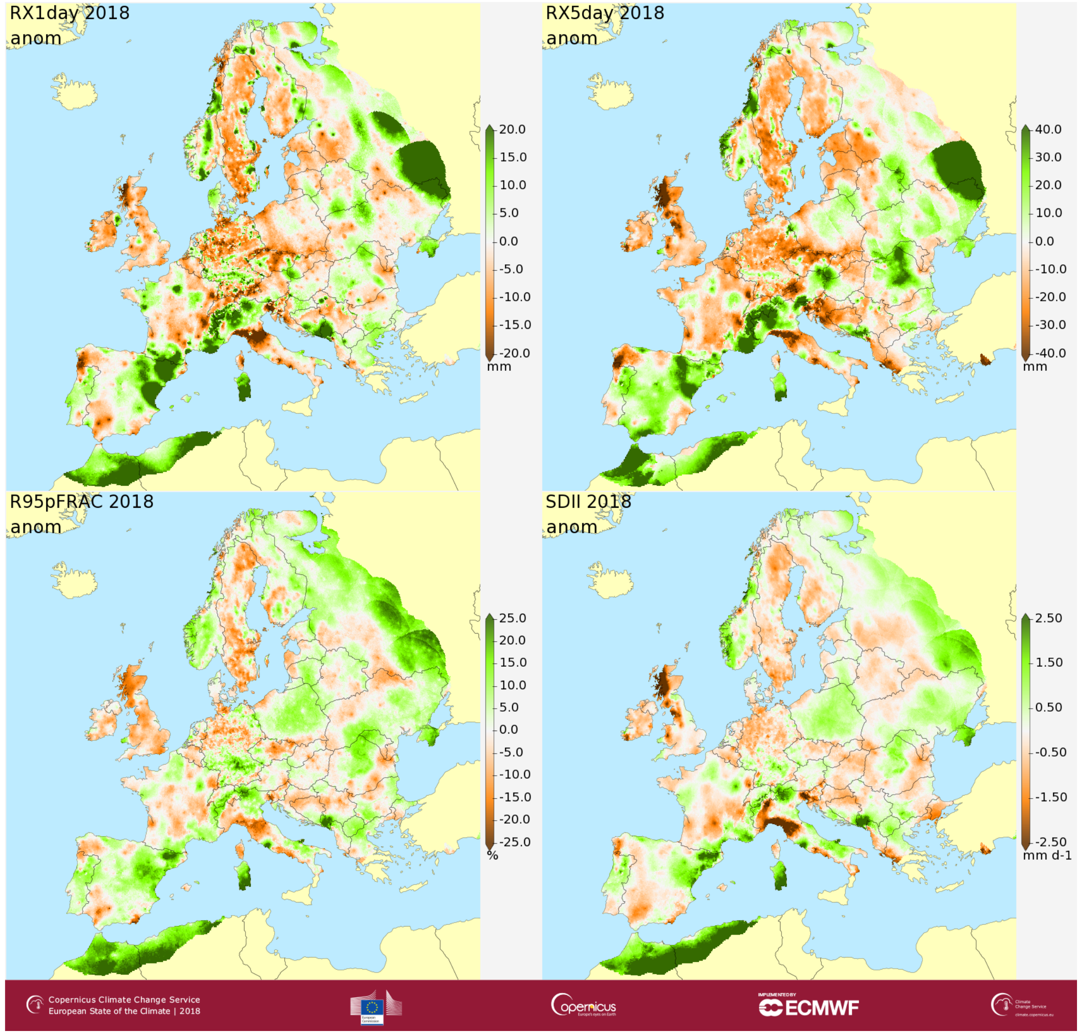
- Climate innovation and piloted climate services produce action-oriented knowledge that rally transformational change
- spurred by multilateral frameworks such as UN Sustainable Development Agenda, Sendai Framework for Disaster Risk Reduction, and UNFCCC Paris Agreement on Climate Change.
- knowledge-intensive business services - advanced technological and professional knowledge; both users and purveyors play a vital role in co-designing and co-producing the service solutions

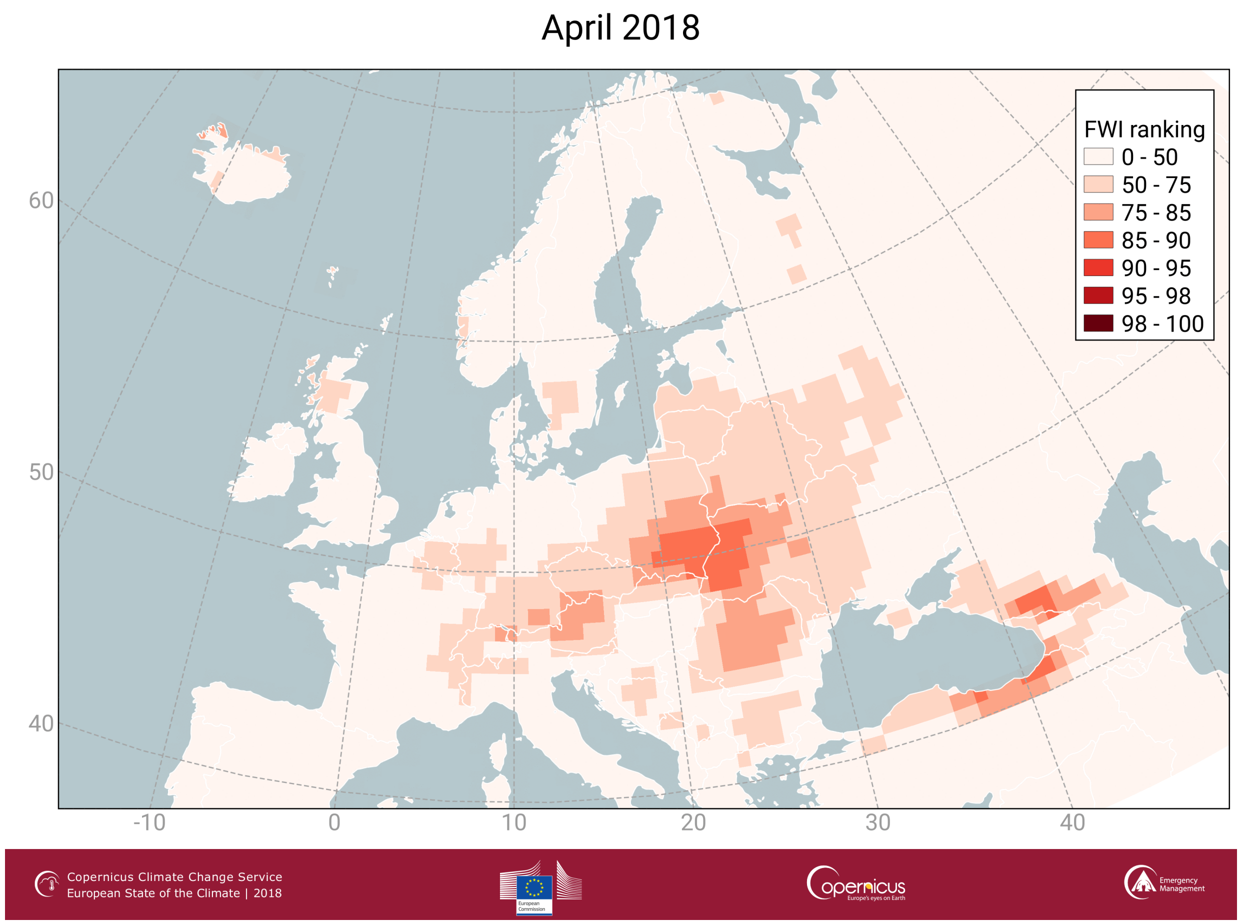


Source: https://yujiearthman.wordpress.com/2018/01/14/the-future-way-of-community-system/

Copernicus climate change services

C3S: State of the climate 2018





Fire Weather Index (FWI) for April to August 2018. Darker reds indicate very high to extreme fire danger compared with the period 1981-2010. Data source: Copernicus EMS fire danger data, Credit: Copernicus Emergency Management Service (Copernicus EMS)/ECMWF.

Economic assessment of climate-related risks

Serves multiple purposes

- Effectiveness and efficiency of reducing and financing disaster risk, and adapting to changing climate.
- Risk-sensitive development, social protection systems, economic cohesion and solidarity.
- Fosters climate (and also meteorological and hydrological) services, by exploiting the value embedded in the Copernicus Earth observation program.
- Micro- and macro-prudential regulation, economic policy coordination and internal security.

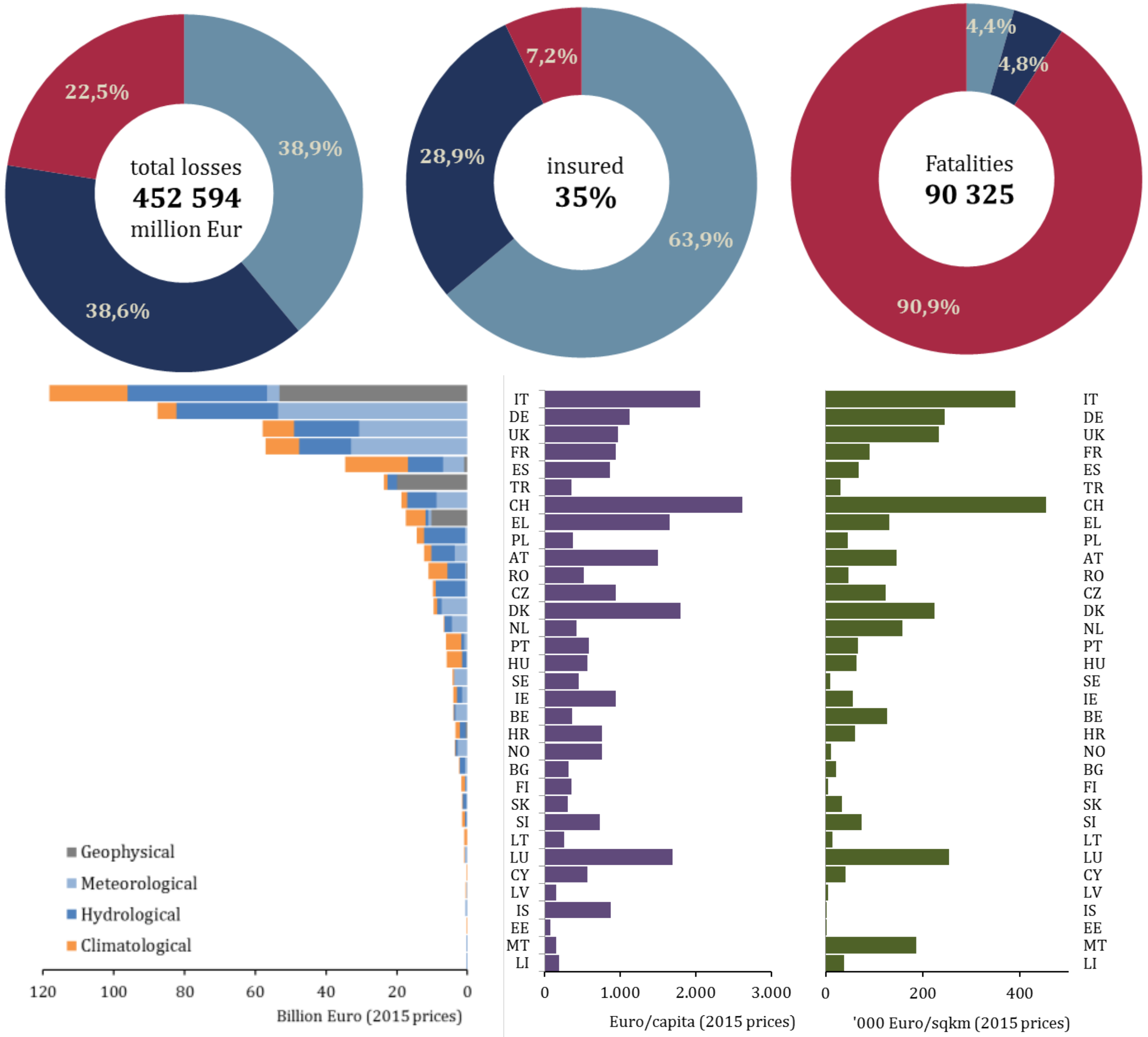
Challenges

- Economic damage and losses caused by natural hazards in Europe are driven by small number of highly damaging events (70% of damage caused by 3% of events).
- Hazard interdependencies and correlated loss probabilities critical for designing robust insurance schemes.
- Expected sequence or chain of events, amplifiers, interdependencies and spill overs, speed of recovery and distribution of impacts important for understanding fiscal impacts
- Natural hazard risk relevant for governments' debt sustainability

Economic impacts of extreme climate

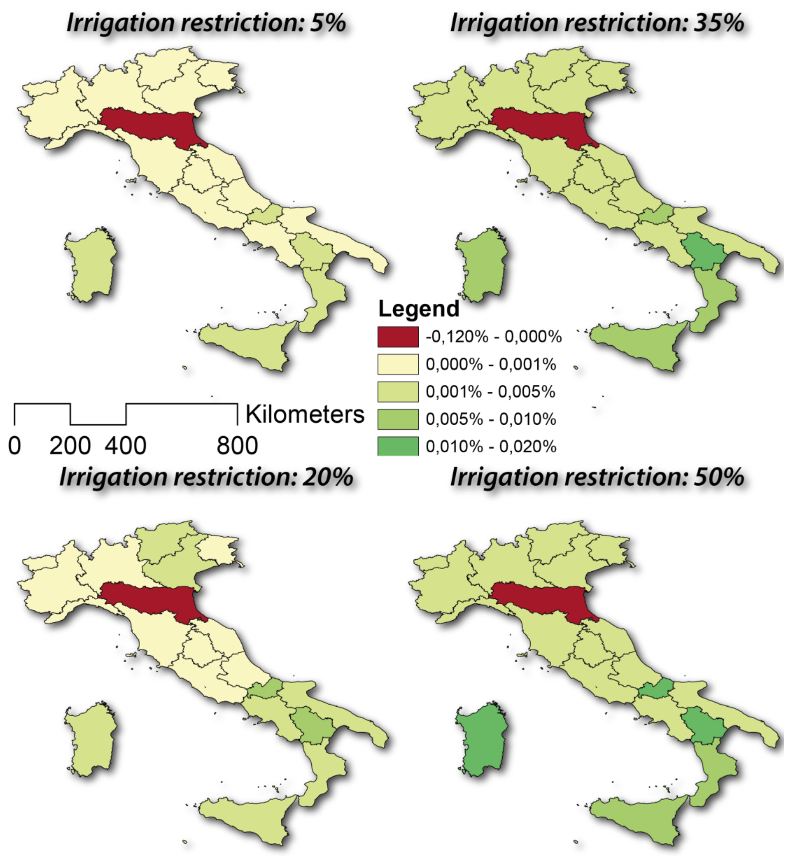
EEA: CLIM039

- Total registered economic damage caused by extreme weather and climate related events over 1980-2017 ~ 453 billion EUR (2017 Euro value)
- In Italy, the damage amount to 65 billion Euro of which only 3 billion insured. Italy is the major beneficiary of the EU Solidarity Fund.



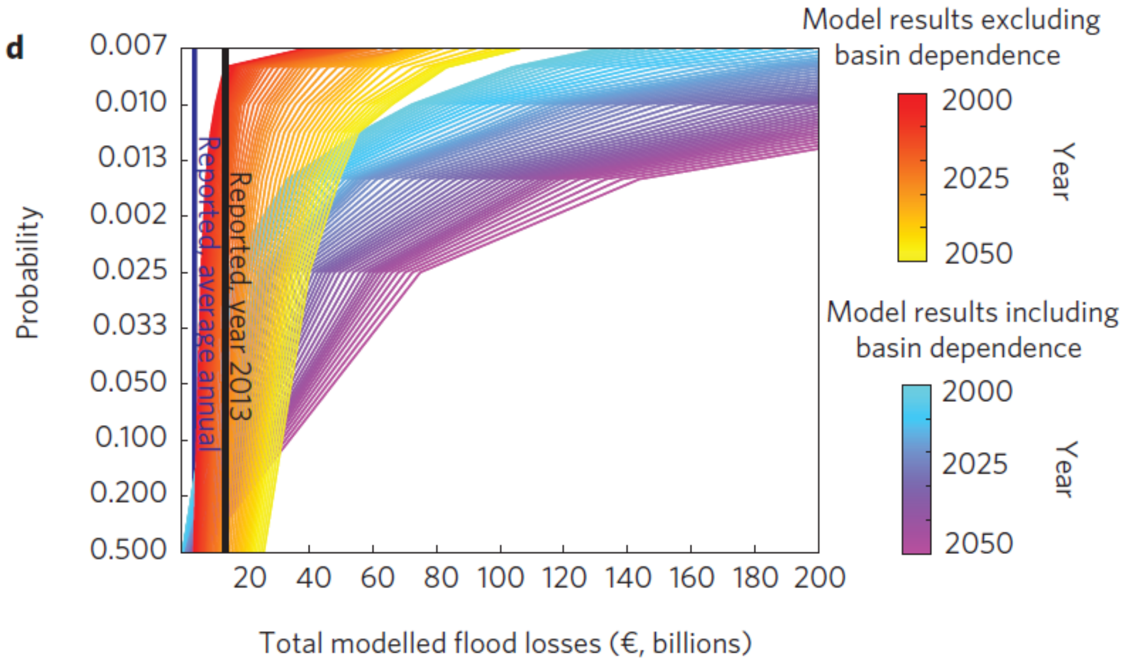
Advancements of climate risk analysis

Did you know that climate-related risk elsewhere in your country makes your region susceptible to harm?



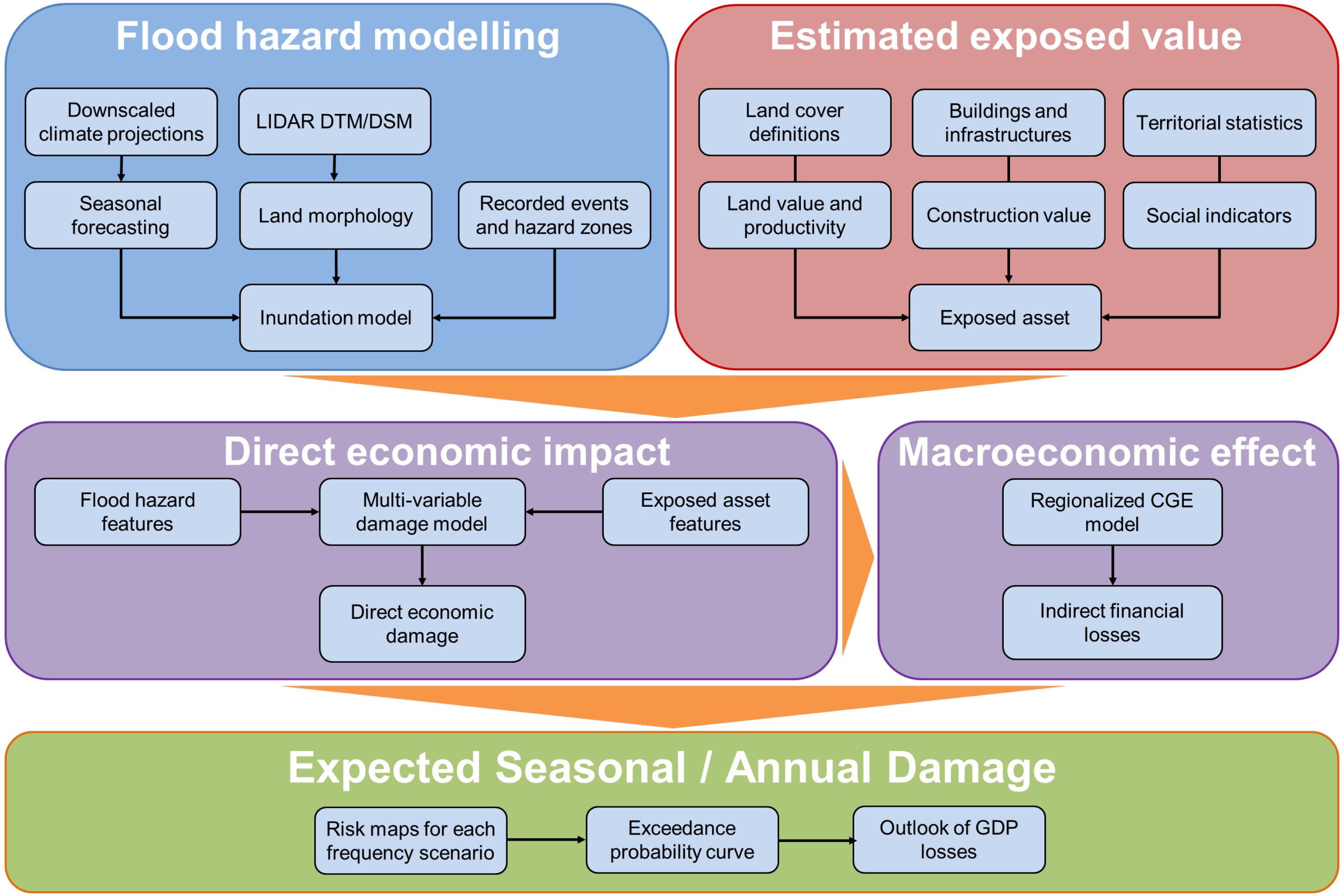
Gross added value losses (in % over the baseline) for selected irrigation restrictions in Italian regions
Perez Blanco et al., 2017

Did you know that we systematically undervalue natural hazard risk?



Jongman et al., Nature Climate Change, 2014

Climate service for damage & losses



CLARA

Climate forecasts enabled knowledge services

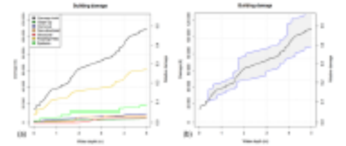
CLARA sets to develop fourteen climate services building upon the Copernicus seasonal forecasts, and demonstrate their marketability and value.

Italy is notoriously prone to flood hazard risk, as a result of its peninsular and mountainous conformation. Since 1980s, the average annual damage exceeded 1 billion Euro.

Modena, 2014

Damage and losses

Damage » economic value of impaired physical assets, assessed using an empirically validated **multivariate damage model** (INSYDE).



INSYDE: an open-source flood damage model based on explicit cost analysis (Dottori et al. 2016)

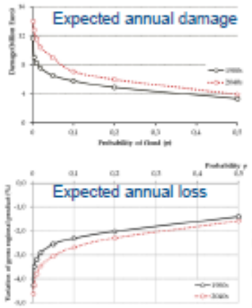
Loss » second-order impacts caused by business interruption and disruption of lifelines (e.g. transport, water and energy supply). Indirect losses are estimated using regionalized **computational general equilibrium** (CGE) model.

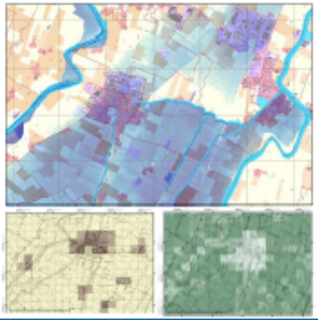
FLOOD MAGE

Flood damage and loss service

This service estimates financial and economic impacts of floods driven by environmental changes and post-disaster recovery pathways. The modular design uses high resolution assets mapping, climate risk and flood hazard modelling, statistical analysis, catastrophe loss modelling, and recursive dynamic general equilibrium modelling.

The services builds upon the knowledge gained from reconstruction of past flood events and their impacts. The scale of analysis varies from asset to city-wide, inter-regional, national and pan-European levels, and is complemented by coping/adaptive capacity analysis.

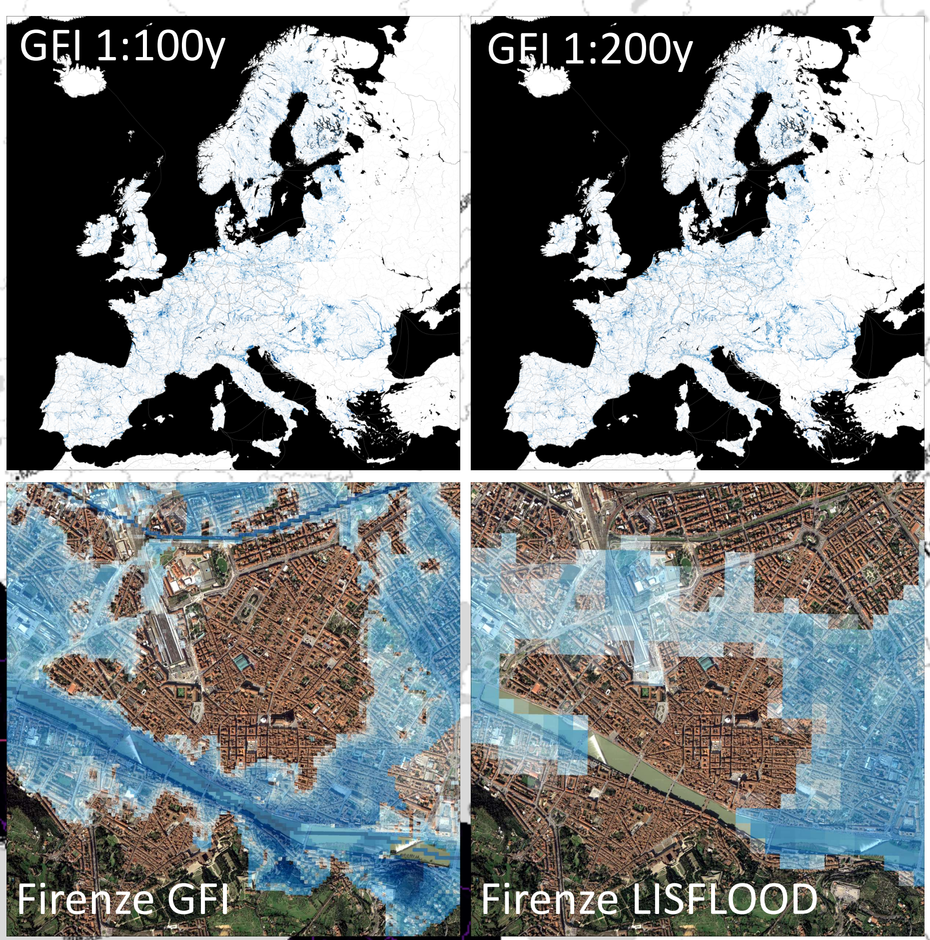




www.clara-project.eu
Amadio M, Euro-Mediterranean Centre on Climate Change
mattia.amadio@cmcc.it

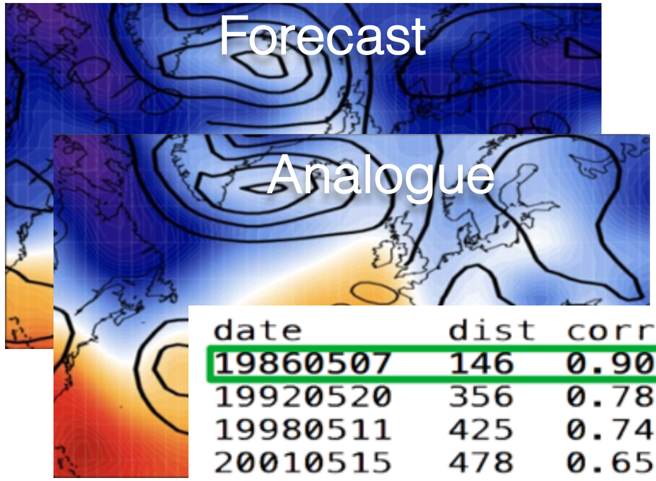
The CLARA project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No 730482.

EFAS 15days forecast



Geography of hazard and risk

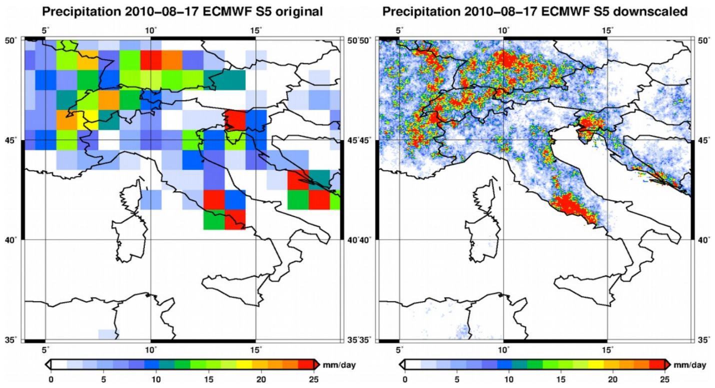
Analysis of **climate analogues** iden-tifies days in the past that had similar climate indices compared to the period of forecast. It provides daily weather boundary conditions according to which the probability of extreme events can be estimated on a 5-10 km grid.



date	dist	corr
19860507	146	0.90
19920520	356	0.78
19980511	425	0.74
20010515	478	0.65
20130510	553	0.61
20090523	740	0.59

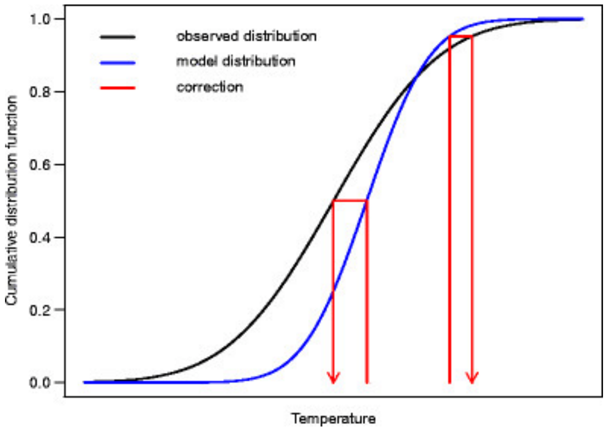
RainFARM is a stochastic preci-pitation downscaling method at fine resolution (1 km) from large-scale spatio-temporal precipitation grids.

It distributes precipitation over complex orography using weights based on existing fine-scale precipitation climatology.



This function performs a **quantile mapping** based on a nonlinear approach. The function computes two dynamical properties (distance and persistence) of the underlying attractor (SLP/SST).

Those proxies are then used to classify the data in terciles. Once the data is classified, a quantile mapping approach is applied.

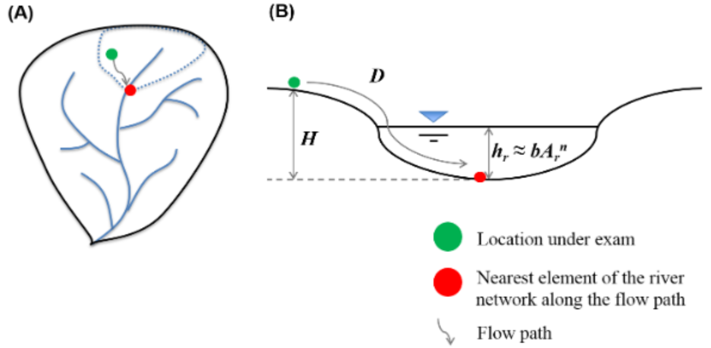


Inundation models

Fluvial

Geomorphic flood index performs a linear binary classification of flood-prone and flood-free areas by combining the GFI with flood hazard information derived by existing inundation maps.

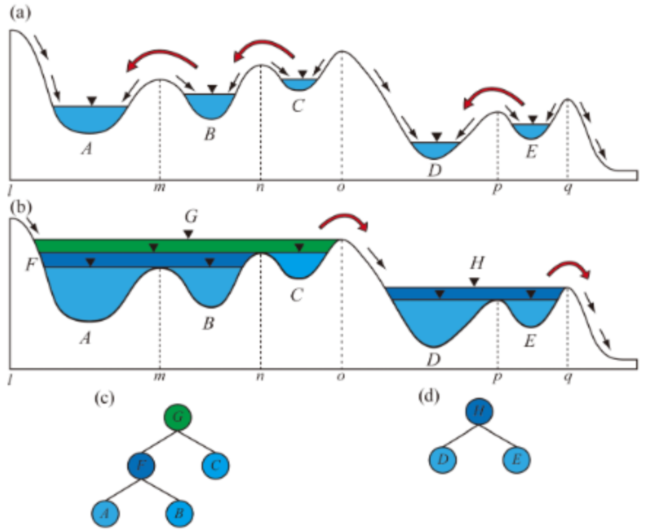
Hydrodynamic models LISFLOOD-FP and ANUGA are able to simulate the overflow of water from rivers and canals to the floodplain, generating a hazard map (water depth).



Pluvial

Fill&Spill aims to identify pluvial-flooded areas on the basis of surface depressions in the DEM and their relative structure.

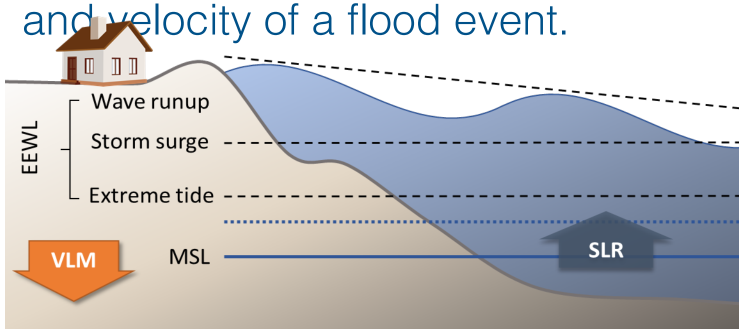
The volume of rainfall is accumulated in depressions (blue-spots) and, as they are filled, water starts to flow in depressions located at lower altitudes.



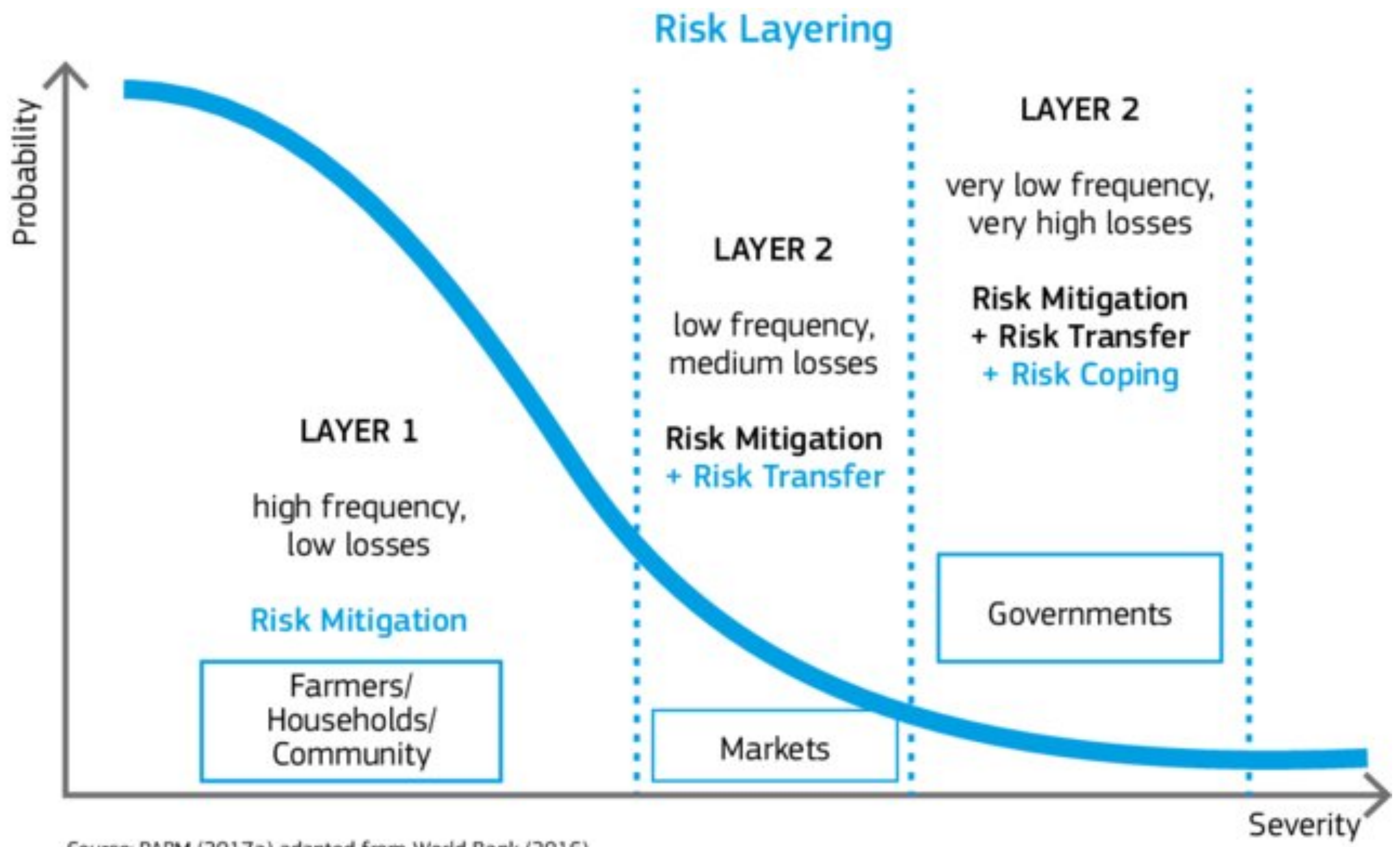
Coastal

Region-growing flood model aims to map the extent of a flood event through the spreading of water level using gravity and the DEM as main inputs.

ANUGA is a 2D hydrodynamic model based on a finite-volume method for solving the shallow water wave equations. ANUGA is capable of simulating the extent, depth, duration, and velocity of a flood event.



Risk financing



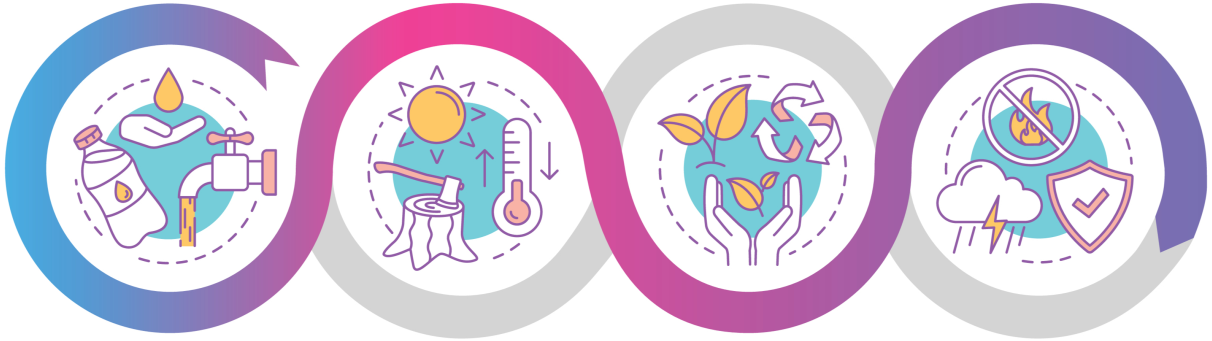
Source: PARM (2017a) adapted from World Bank (2016)

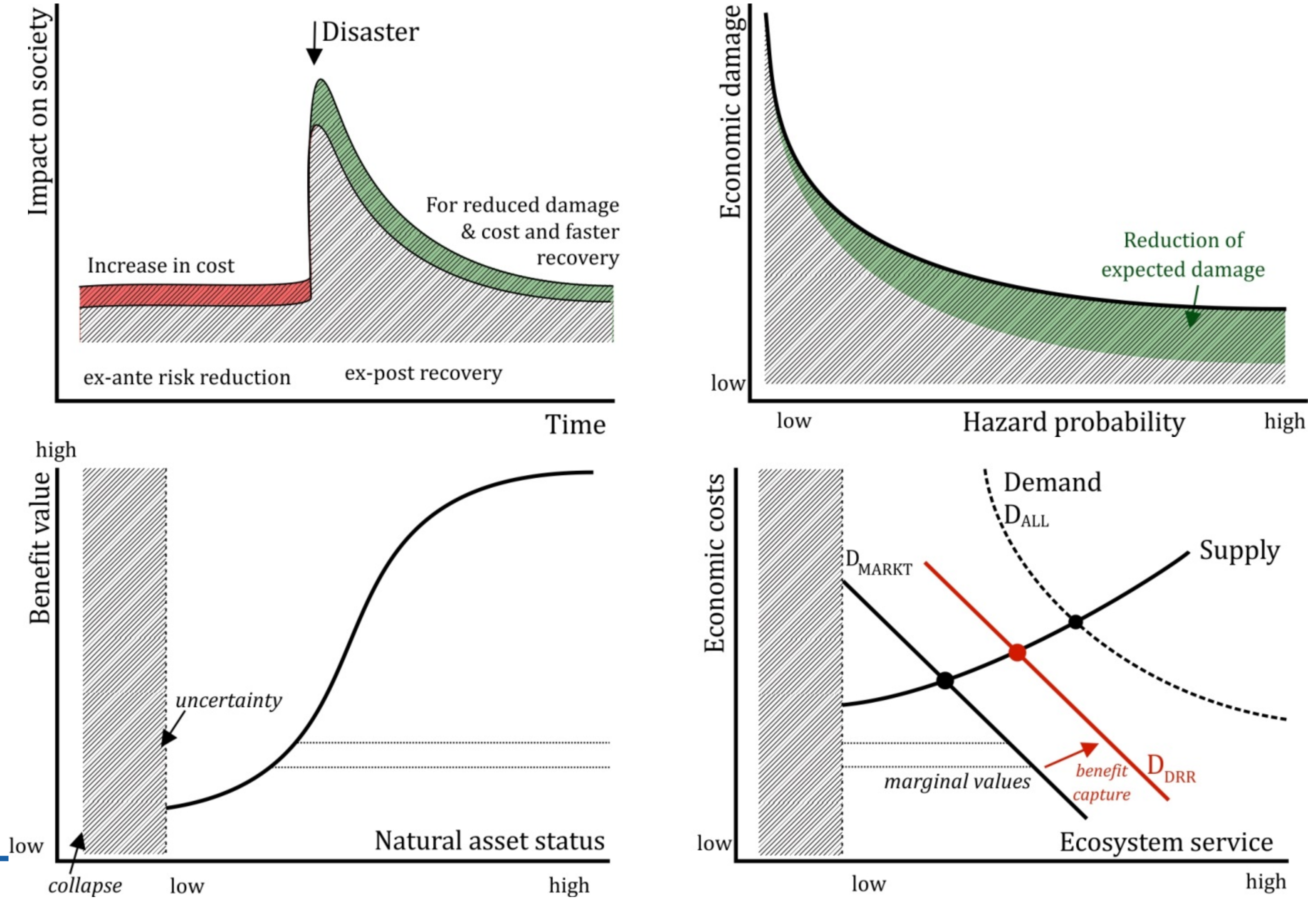
Ecosystem services

Ecosystems can provide means to mitigate natural hazard risks and boost societal resilience, locally or regionally. Compared to engineered or built solutions, ecosystem-based approaches may be cost-effective, and have certain co-benefits.

Ecosystem services **have an economic value** in the context of natural disaster risk reduction and climate adaptation, **even if no price actually is paid** for their provision and/or maintenance.

The failure to account for their true social value leads to market distortion and, ultimately, insufficient level of protection with lasting, in some cases irreversible, damage.

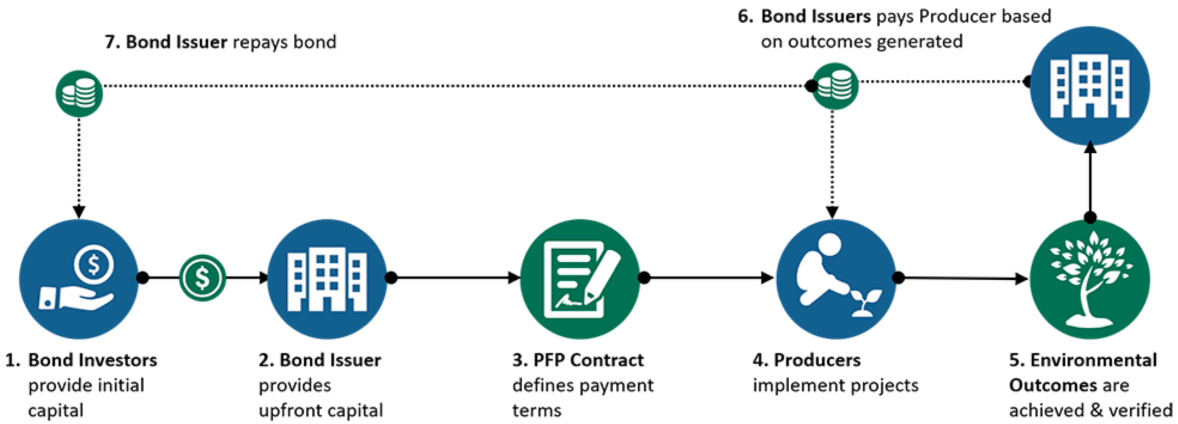




Risk financing by means of nature-based solutions

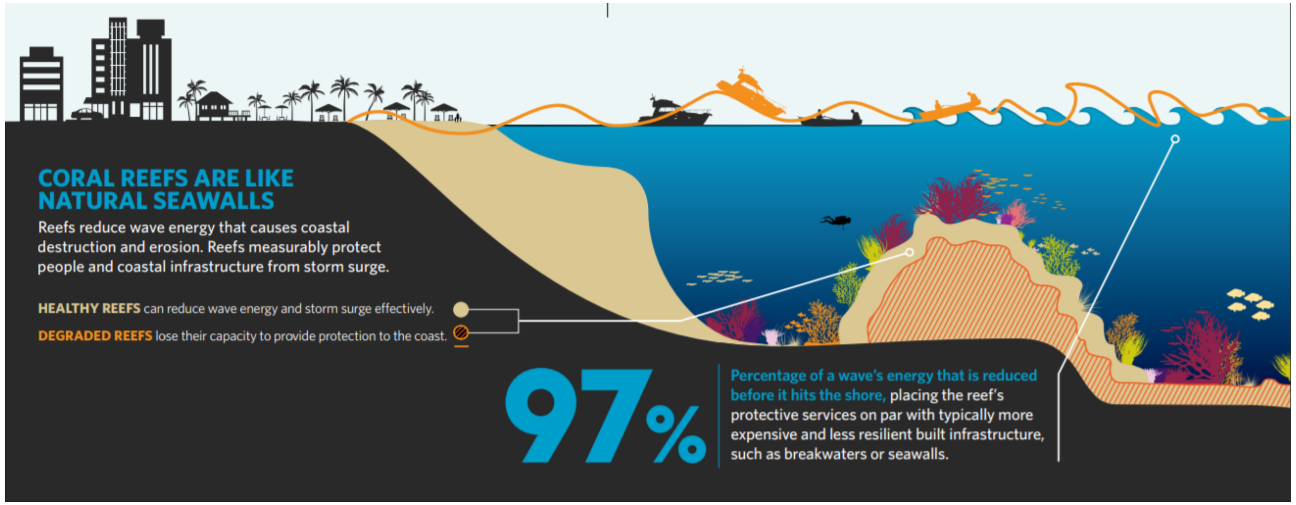
Green bonds

- *debt* instrument focusing on environmentally-friendly or sustainable initiatives - green infrastructure, water management, biodiversity,
- e.g. water utility may issue green bonds to finance green infrastructure to reduce pluvial flood hazards; repaid by stormwater fee,

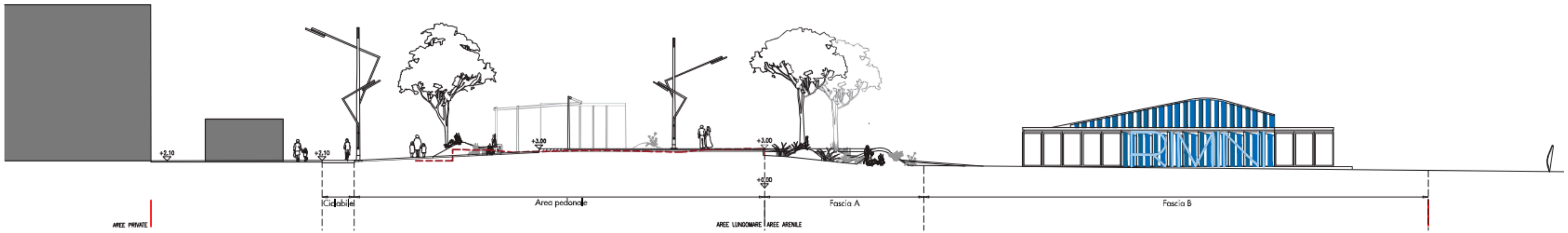


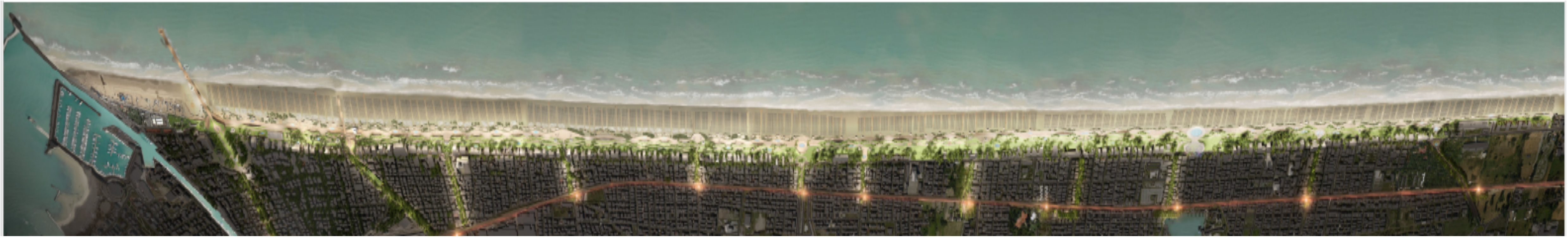
Management trust and coral reef Insurance

- Coastal zone management **trust** established with support of **The Nature Conservancy** (TNC) to bring new private capital to coral reef and beach protection and restoration in Cancún and Puerto Morelos, Mexico,
- Parametric insurance scheme for the reef established with Swiss Re paid by the Trust

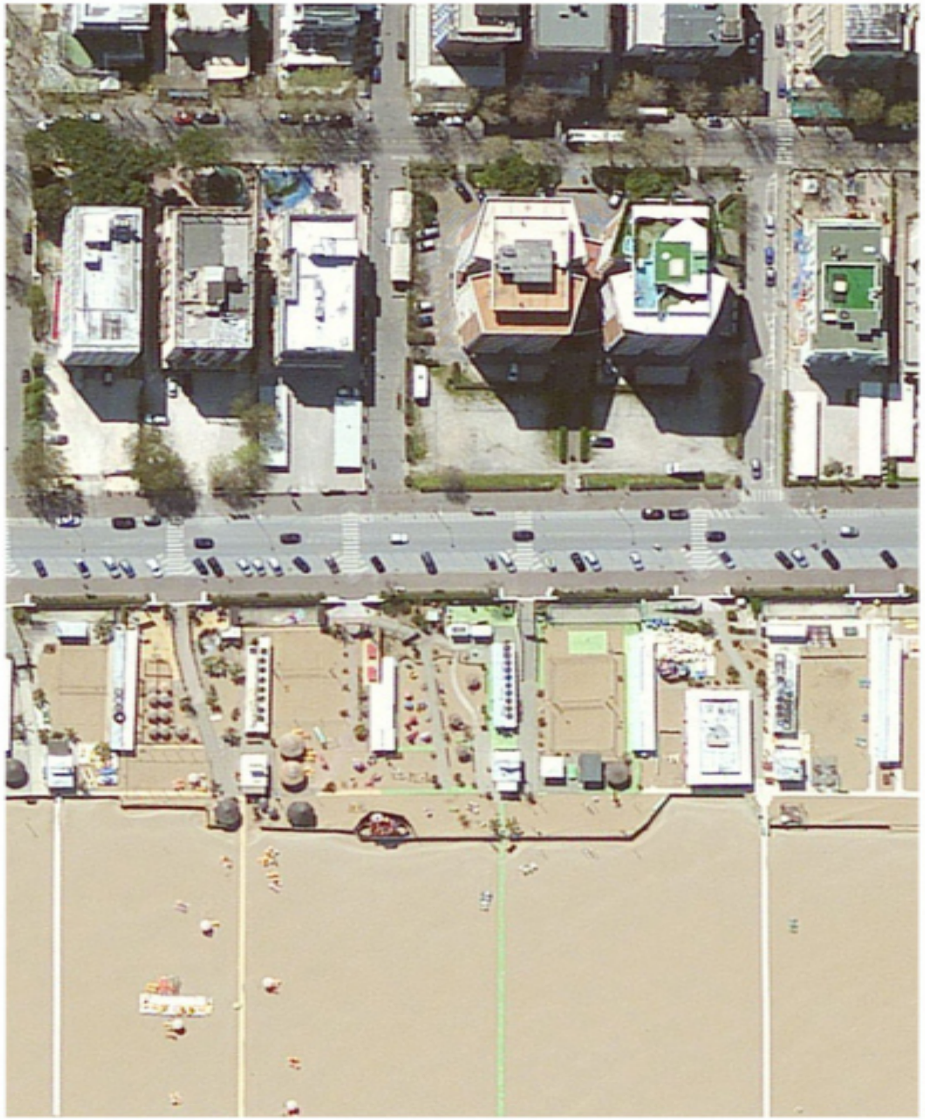


Sea park Rimini

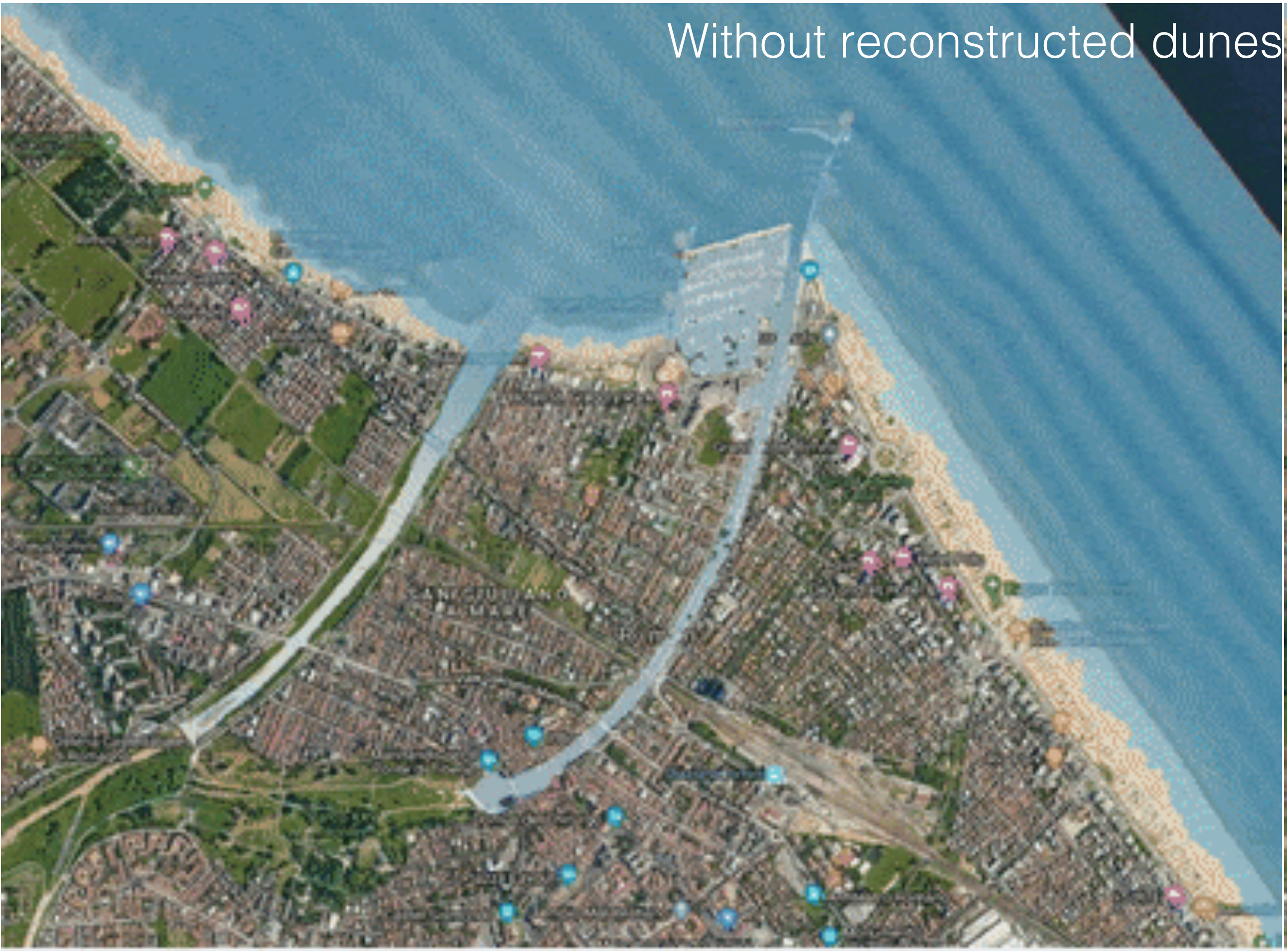


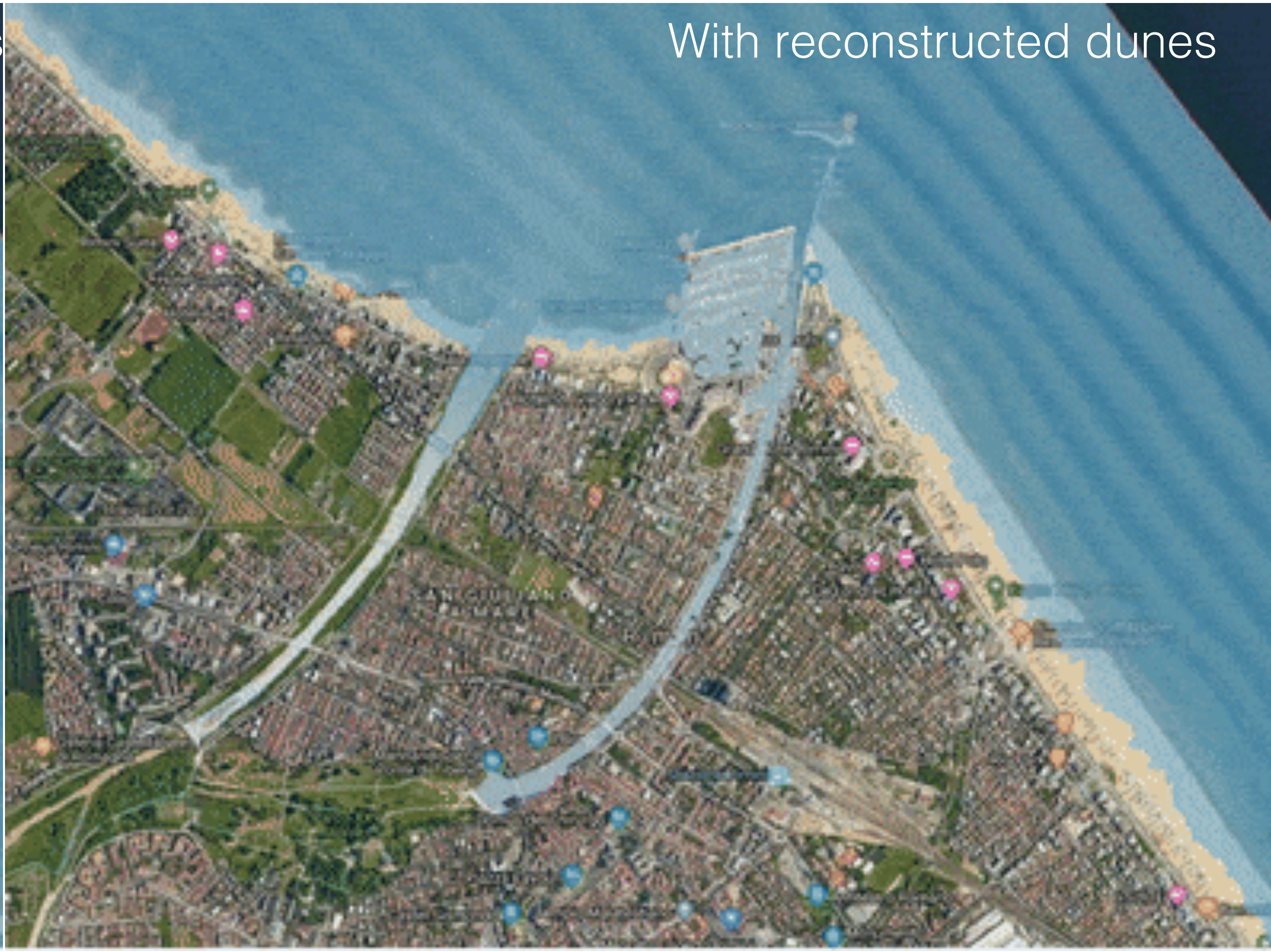


Sea park Rimini cont.



Sea park Rimini cont.





Scenario LisCoast JRC RP 100 2050 RCP 45 – 2,84m

Policy coherence

Long-term national programmes and innovative risk financing instruments.

Web-based knowledge portals and multi-stakeholder coordination platforms.

Monitoring, reporting and evaluation activities (MRE).

Improved risk assessment methods.

A well-functioning system of public and private, user-driven climate services can help catalyse economic and societal action, and transformation that reduces risks and improves societal resilience.

Nature-based solutions (NBSs) are examples of means to boost societal resilience.

By Frits Ahlefeldt

Horizon Europe’s mission-oriented research

Knowing, valuing and managing risks and vulnerabilities, their distributional, spill-over and cascading effects on social and economic fabric, planetary health as well as provision of essential services **is an intrinsic part of resilience**.

Community **resilience is a common good and public service of general interest** which should be underpinned with substantive targets addressing social justice and solidarity, economic cohesion and environmental integrity.

A **new social contract** should be formulated on the basis of individual and collective resilience to the impacts of climate change, effective engagement and shared responsibilities of all community members.

At the time of digital revolution and open data **it is not acceptable that not all communities and regions dispose with adequate and up-to-date climate risk information and knowledge**, or lack capacity and capabilities to design territorial and development policies and plans based on that knowledge.

Horizon Europe Mission Board

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Working method, engagement and communication strategy and use of evidence

24 January 2020

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Thank you for your attention!

jaroslav.mysiak@cmcc.it

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