EDO User Meeting

European Commission




Drought Risk Assessment:

Putting in practice strategic management

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Joint Research Centre

space 4 environment

Approaches to drought management

Towards strategic resilience

Nomadic

A natural event to be adapted to.

- The lifestyles of individual and communities inherently adapt to natures rhythms.
- Resilience through nomadic existence.
- Use of ecosystem services implicitly regulated.

Disaster

An unforeseeable natural disaster to be endured.

- Droughts seen as inevitable but unpredictable.
- Significant action is only taken after the emergence of the drought.
- Actions focus on immediate and local issues to secure drinking water and avoid famine.
- Commitment to prepare is based on community memory of recent droughts and is fundamentally unable to manage prolonged drought.
- Ecosystems exploited during a drought with little regard to future recovery.

Emergency

A hazard to be monitored, forecast and responded to.

- Monitoring and early warning systems provide some foresight of the developing drought.
- Drought alerts are issued and steps taken to limit drought losses.
- Recovery of key sectors, such as agriculture, seen as vital and aided through financial compensation.
- Reactive actions taken to protect priority species and ecosystem services.

Strategic

A proactive process of long-term risk based planning, response and recovery.

- A '**standards-based**' approach (current good practice)
  (i) Acceptable restriction frequency pre-defined based on historical events of reference; (ii) infrastructure developed to provide necessary reserve capacity; (iii) minimum flow requirements set to protect ecosystems.
- A '**risk-based**' approach (**the focus of this book**)
  (i) A broadly based portfolio of measures –applied at a range of scales -are used to deliver fair and sustainable outcomes; (ii) long-term, broadly based, benefits and costs traded to make best use of limited resources; (iii) impacts on economies and ecosystems understood and managed.

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Sayers et al., 2015

Changing the paradigm

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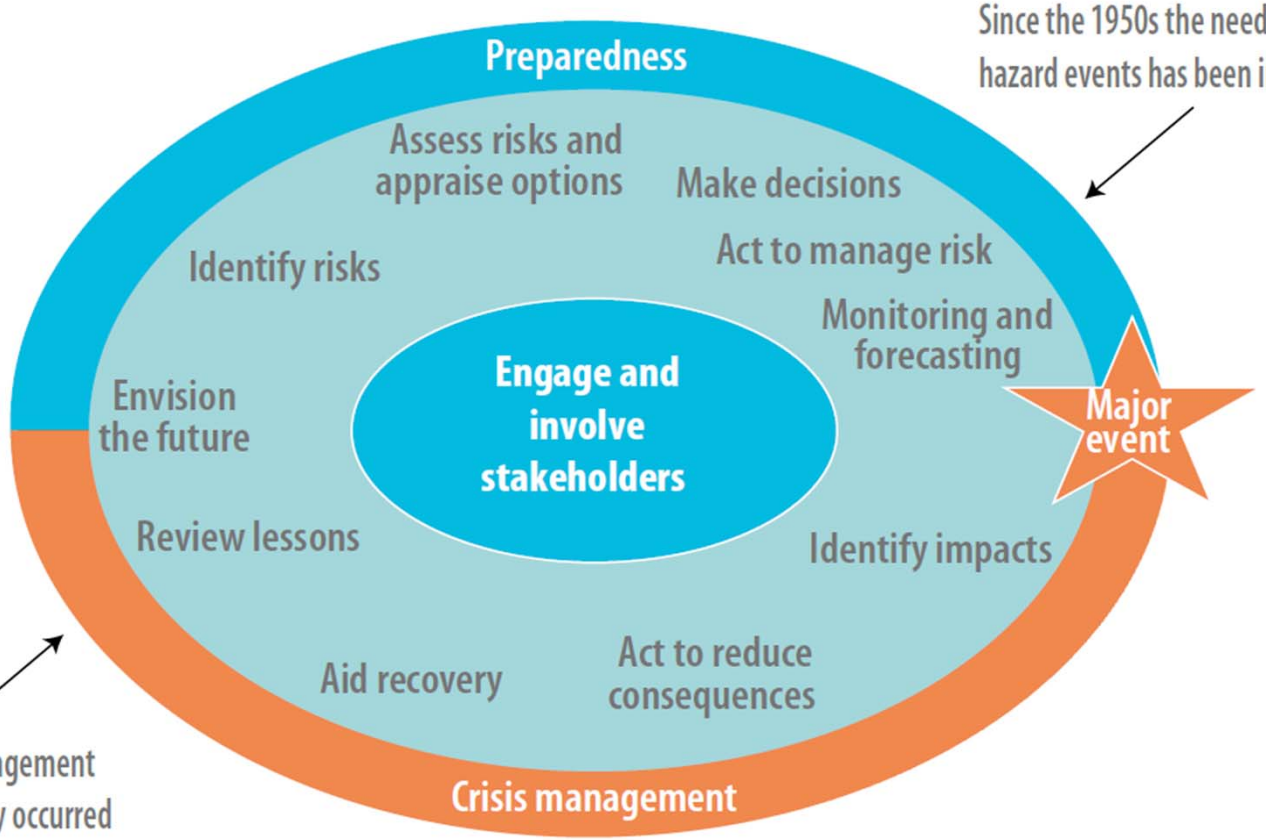

Since the 1950s the need to prepare for future natural hazard events has been increasingly recognized

Prior to the 1950s the focus of management was on responding to events as they occurred

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Crisis vs. Risk Management

Characteristics, costs and benefits

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Crisis Management	Risk Management
Expensive ◦ Costs + costs of inaction ◦ Repeats past mistakes	**Investment** ◦ Short-term—EWS, building networks, collaborations, institutional capacity ◦ Long-term—structural adjustments, policy shifts
Post-impact ◦ Drought relief/emergency assistance	**Pre-impact** ◦ Risk assessments, mitigation
Rewards poor resource management	Identifies and addresses the root causes of vulnerability
Treats the symptoms of vulnerability, i.e., impacts	Promotes improved stewardship of natural resources
Increases vulnerability, reliance on assistance from government & donors	Reduces vulnerability, builds self-reliance, reduces need for gov't. & donor interventions
	Assists climate change adaptation

Wilhite & Pulwarty, 2017

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Estimating drought risk

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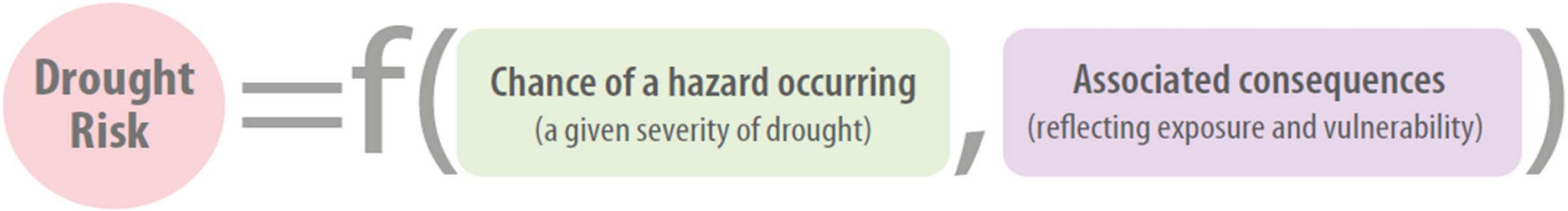
Drought risk is a combination of natural and human influences

As such, drought risk reflects two components: the chance that a drought hazard will occur and the magnitude of the associated consequences.



It is a qualitative or quantitative measure that reflects the interaction between meteorological drought hazard, the hydrological response of the basin and the vulnerability of the exposed people, ecosystems and economies.

Risk or Likelihood of Drought Impact

A composite approach

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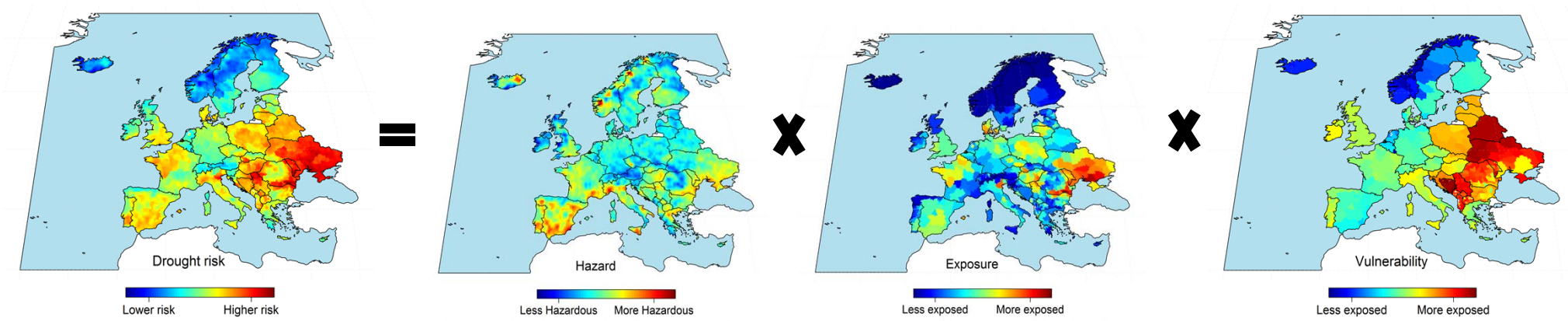
Risk = Hazard x Exposure x Vulnerability



Likelihood of drought impact

Probability of a drought event with a certain severity.

Amount of population, livelihoods, assets, resources, services potentially affected.

Susceptibility to suffer adverse effects

Relative statistic suitable for ranking regions: comprehensive picture of locations where the likelihood of drought impact is highest (lowest);

Not to be confounded with an absolute measure of economic loss or damage to human health or the environment: applicable to different social and economic contexts.

- Normalized statistics: 0 (min) – 1 (max);
- The legend breaks are statistical thresholds: percentiles of geographic distribution.

Carrao et al., 2016

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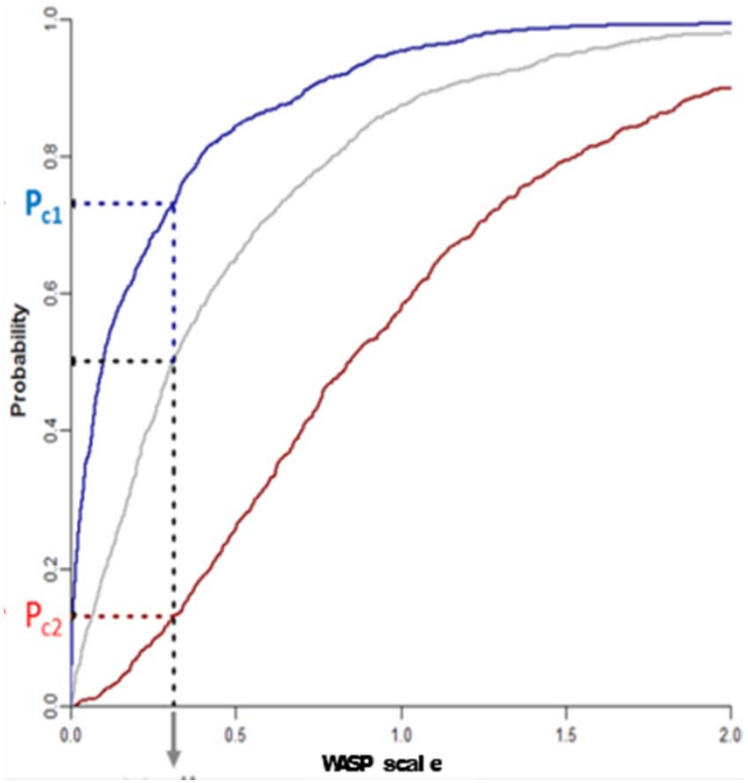
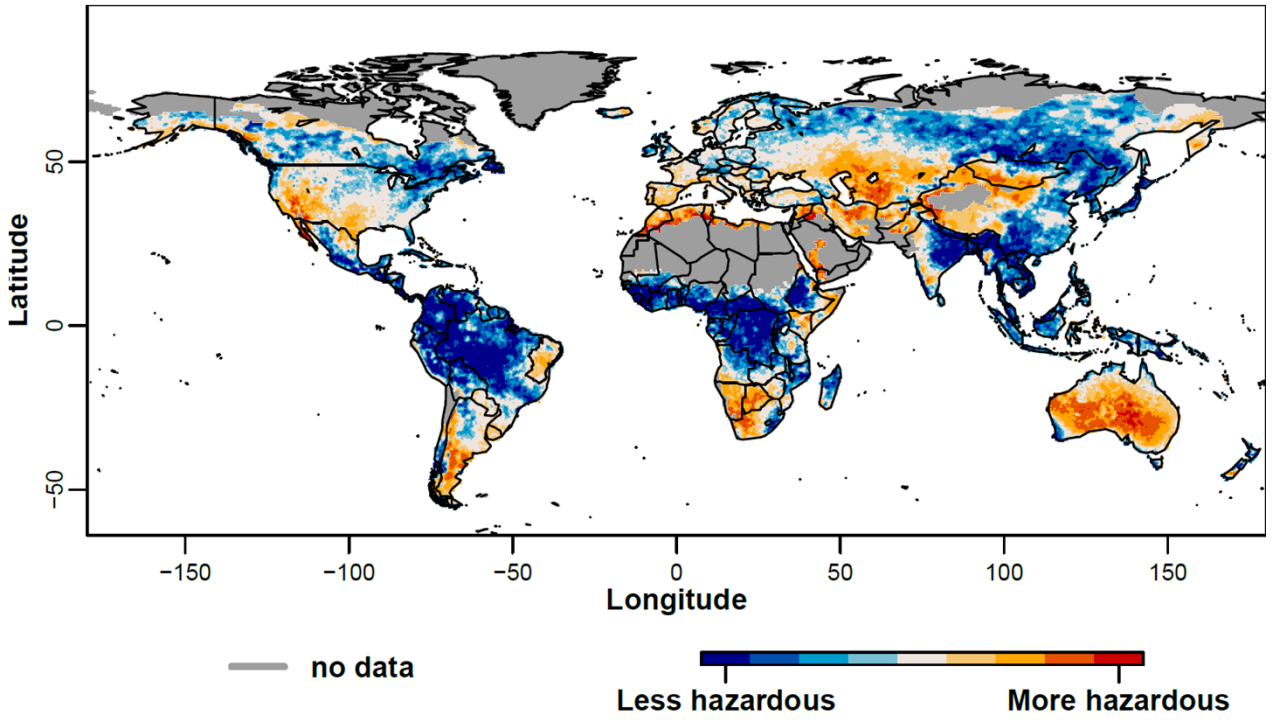
Drought Hazard





Probability distribution of meteorological drought severity (WASP) between 1980-2010

- overall median
- area above median
- area below median

Relative approach

Carrao et al., 2016

Proxy indicators of Drought Exposure

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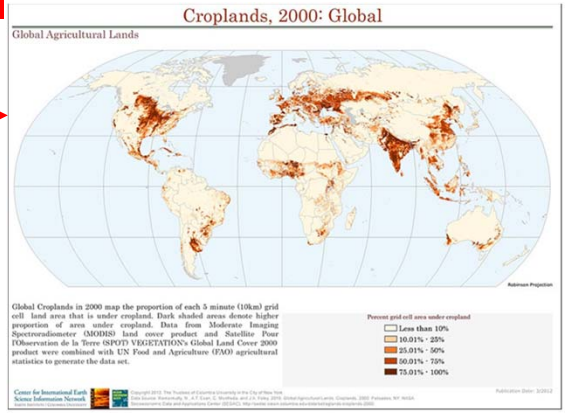
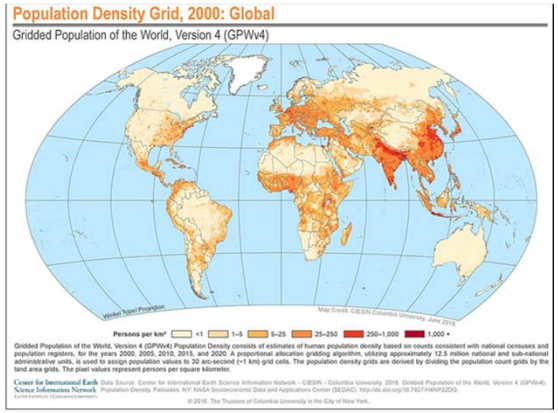
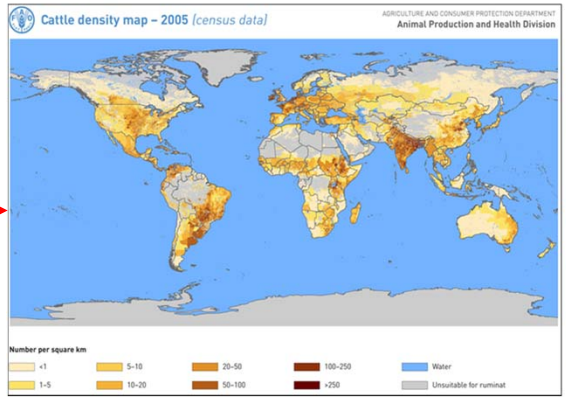
NOT a comprehensive assessment of all dimensions of drought exposure!

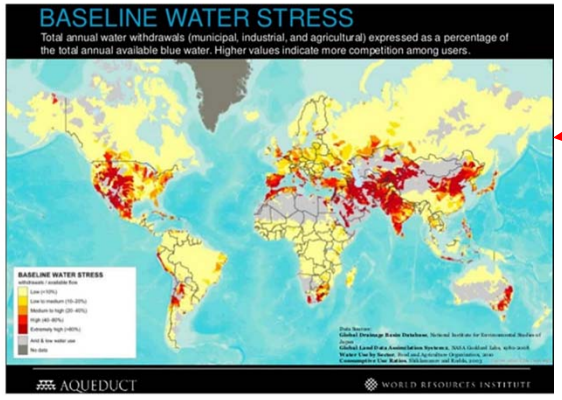
Socioeconomic drought:
The concept of *socioeconomic* impact recognizes the relationship between the lack of goods and services, and the amount of human demands.





Agricultural drought:
Data on crop and livestock production.





Hydrological drought:
Data on offtake water rates in relation to the normal operations of several systems (i.e. domestic, industrial, irrigated agricultural).

Slow onset hazard: comprehends entities that can be adversely impacted at different stages of the same hydro-meteorological anomaly.

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Composite Measure of Drought Exposure

- Single unit-free and non-parametric statistic (DEA) that summarizes the multiple input proxy indicators at a particular geographic region: from 0 to 1;

- The values are relative to the most exposed geographic region(s) at a given moment in time: suitable for ranking and comparison;

- Can be updated in time: the striking contrasts are appropriate for stimulating debate about government policy priorities, mitigation and adaptation plans;

- Multi-scale approach: the output maps are a focused measure, zooming on the selected regions of interest.

Composite Measure of Drought Exposure

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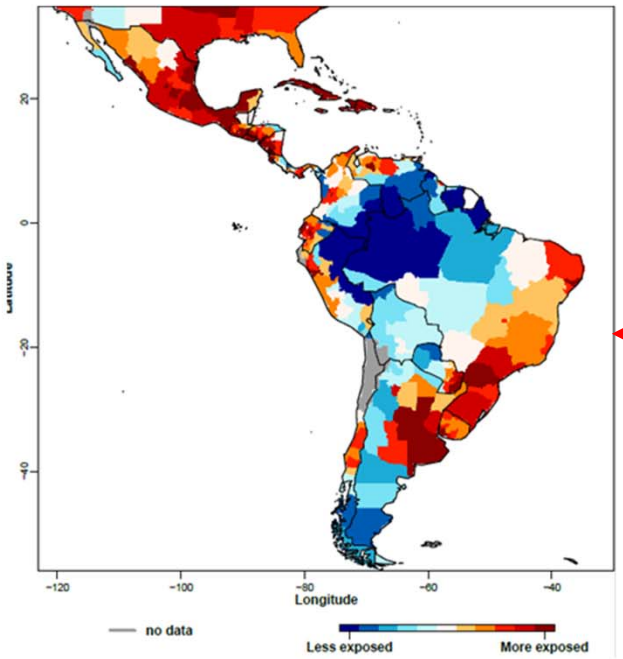
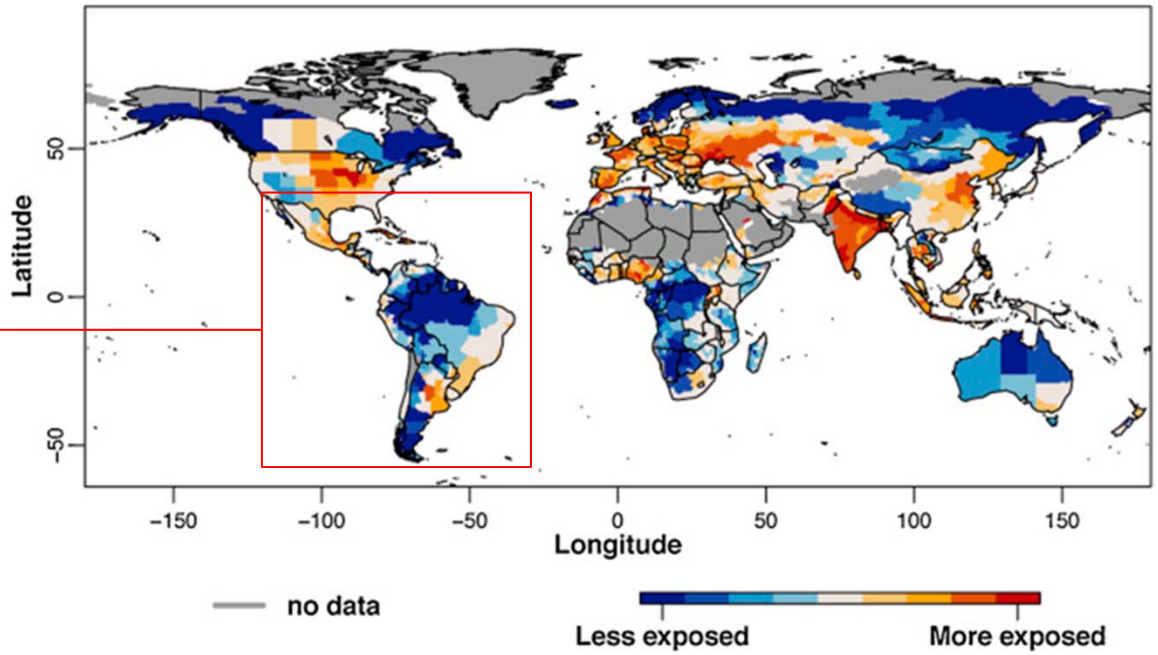


South-Central America



Global

Carrao et al., 2016

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Scale dependency

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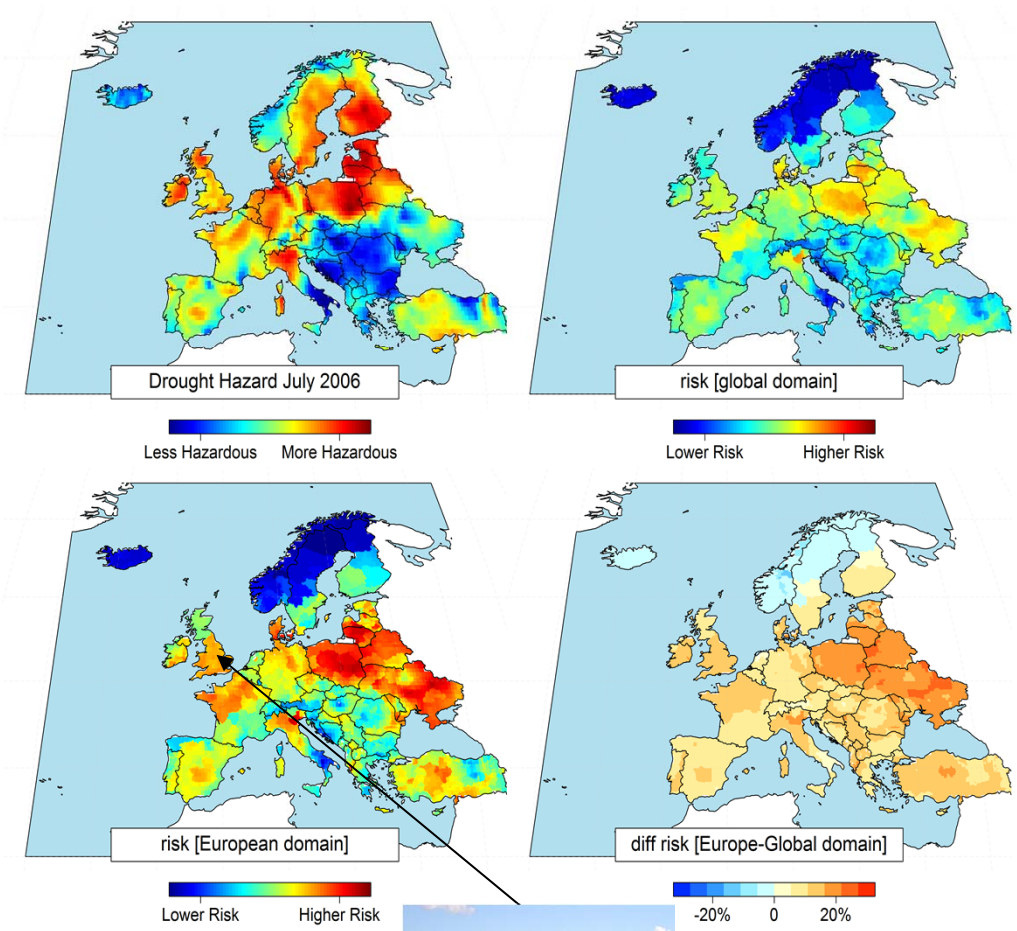
Drought Risk computed with the contextual approach for different spatial domains

Example for **July 2006** (Drought in NW Europe):

- Normalized SPEI-12 for JULY 2006 (top left)
- Vulnerability and exposure normalized at global level (top right)
- Vulnerability and exposure normalized at European level (bottom left)
- Difference between both (Europe-Global) (bottom right)



Low water levels at Derwent Water, Cumbria UK, July 2006

(Source Wikipedia)

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Proxy Indicators of Vulnerability Factors

$$dv_i = \frac{Soc_i + Econ_i + Infr_i}{3}$$

Social Factor:
Level of well-being of individuals and communities

Economic Factor:
Economic status of individuals, communities and nations

Infrastructural Factor:
Infrastructures needed to support the production of goods and sustainability of livelihoods

- Rural population (% of total population); World Bank
- Refugee population (% of total population); World Bank

- Improved water source (% of rural population); World Bank
- Life expectancy at birth (years); World Bank
- Population ages 15-64 (% of total population); World Bank
- Literacy rate (% of people ages 15 and above); World Bank
- Government Effectiveness; WGI
- Disaster Prevention & Preparedness (US$/Year/capita); OECD

Proxy Indicators at Country Level

- Agriculture (% of GDP); World Bank
- Poverty headcount ratio at $1.25 a day (PPP) (% of total population); World Bank

- GDP per capita (current US$); World Bank
- Energy Consumption per Capita (Million Btu per Person); U.S. EIA

Proxy Indicators at Subnational Level

- Agricultural irrigated land (% of total agricultural land); FAO
- % of retained renewable water; Aqueduct
- Road density (km of road per 100 sq. km of land area); gROADSv1

Carrao et al., 2016

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Proxy Indicators of Vulnerability Factors

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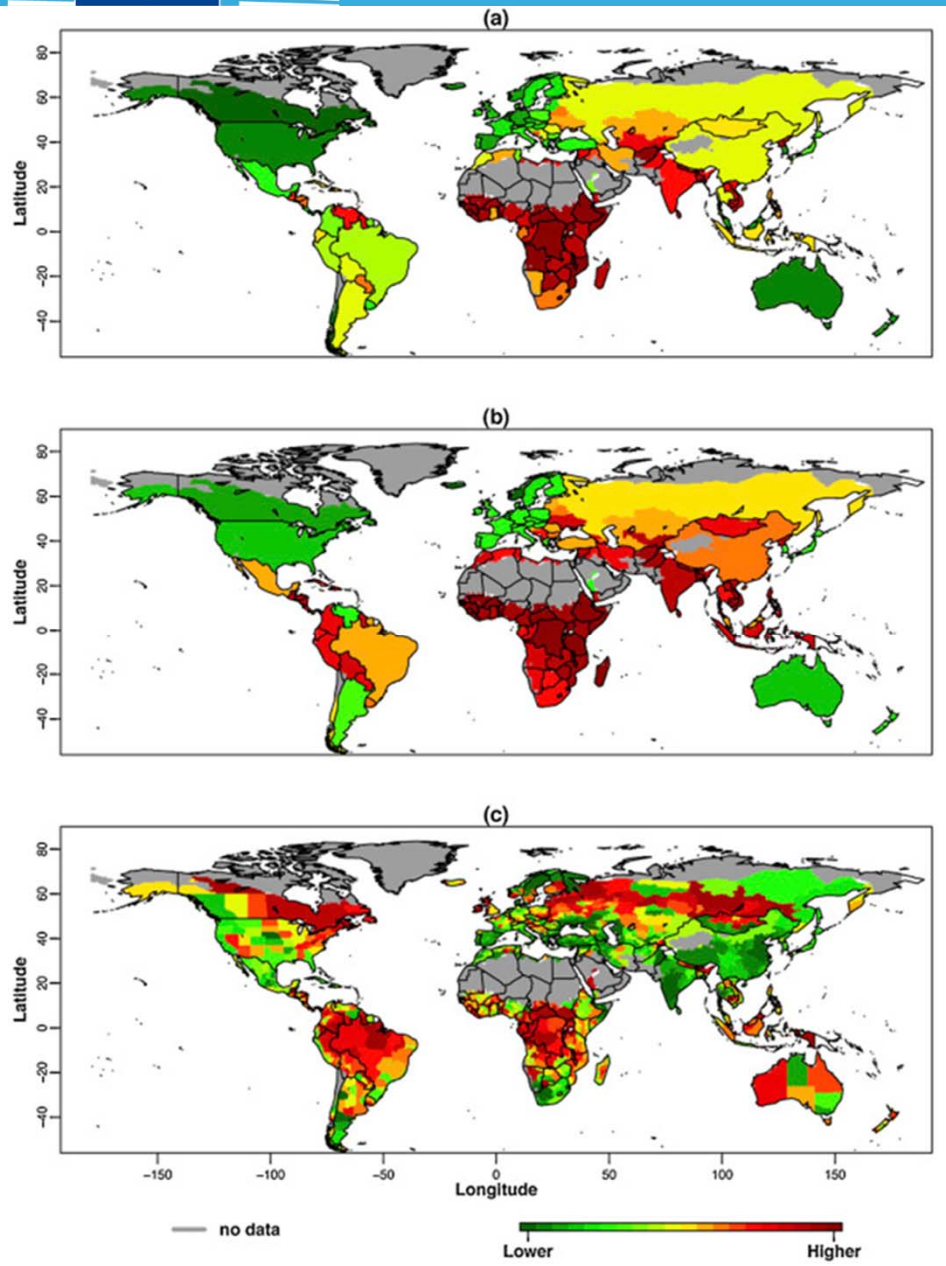


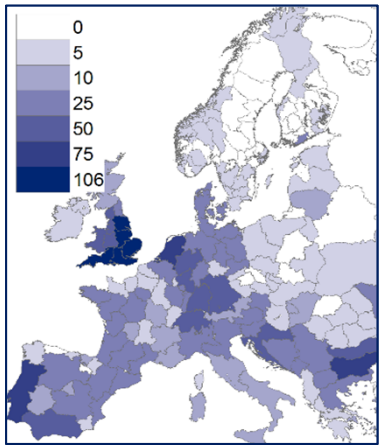
Carrao et al., 2016

Linking number of impacts to drought indices

An impact approach

European Commission

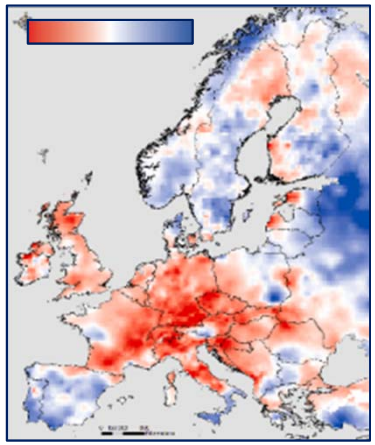
No. of impacts/sector (e.g. agriculture)



EDII Database

NUTS-combo region	Year	Impact	SPEI-12
DE1	1975	0	-1.3
DE1	1976	1	-2.1
DE1	1977	0	-0.4
…	…	…	…
DE1	2000	0	-0.8
DE2	2001	0	0.3
DE3	2002	0	0.8
DE4	2003	1	-2.8
DE5	2004	1	-1.1
…	…	…	…

Drought Indicator (e.g. SPEI)



$$LIO = \log\left(\frac{LIO_N}{1-LIO_N}\right) = \alpha_M + \beta_M \cdot P_N$$

= intercept by macro region
= slope by macro region
= predictor by NUTS-combo region

LIO: Likelihood of Impact Occurrence

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Blauhut et al., 2015

Map the regional distribution of risk for specific sectors

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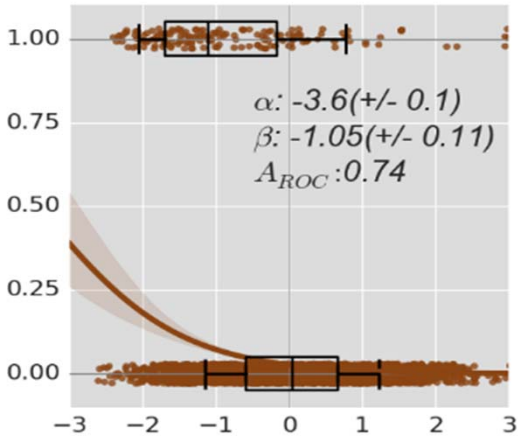
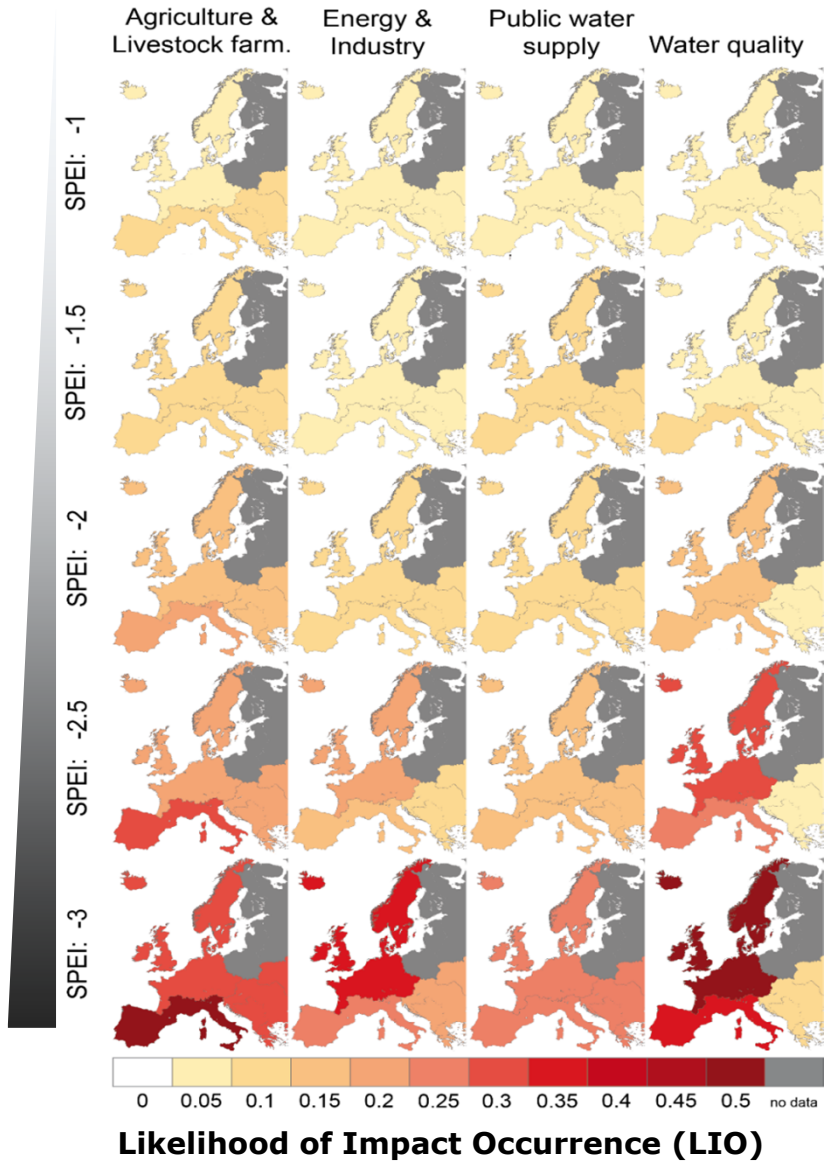
The same drought hazard index per sector and region: SPEI12

LIO Curve



Per macro-region & sector



How probable is the occurrence of an impact in a given sector as a function of the selected drought indicator

Blauhut et al., 2015

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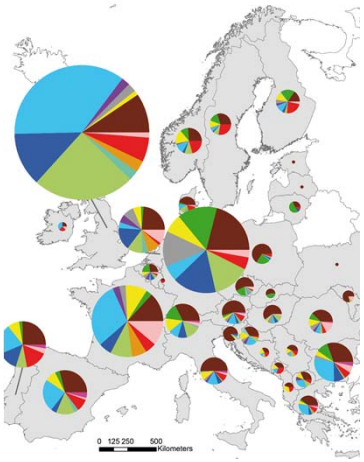
Hybrid approach

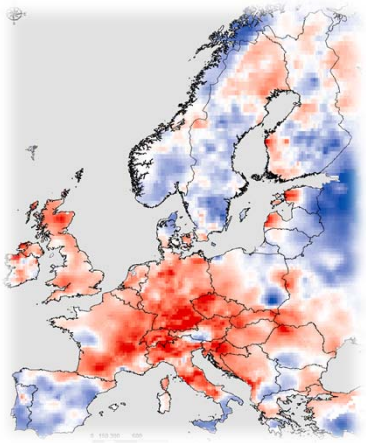
Impacts x **Hazard** x **Vulnerability Factors** = **Risk**

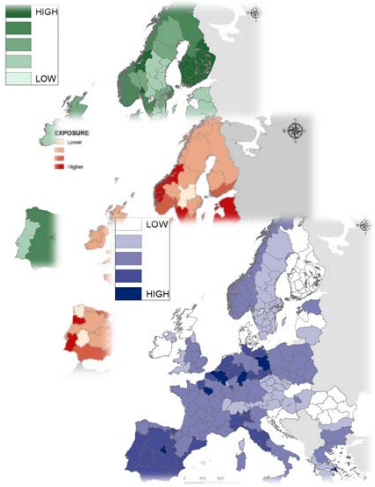
15 impact Categories (annual impacts)

5 indices (different timescales, months)

81 vulnerability factors *(De Stefano et al. 2015)*



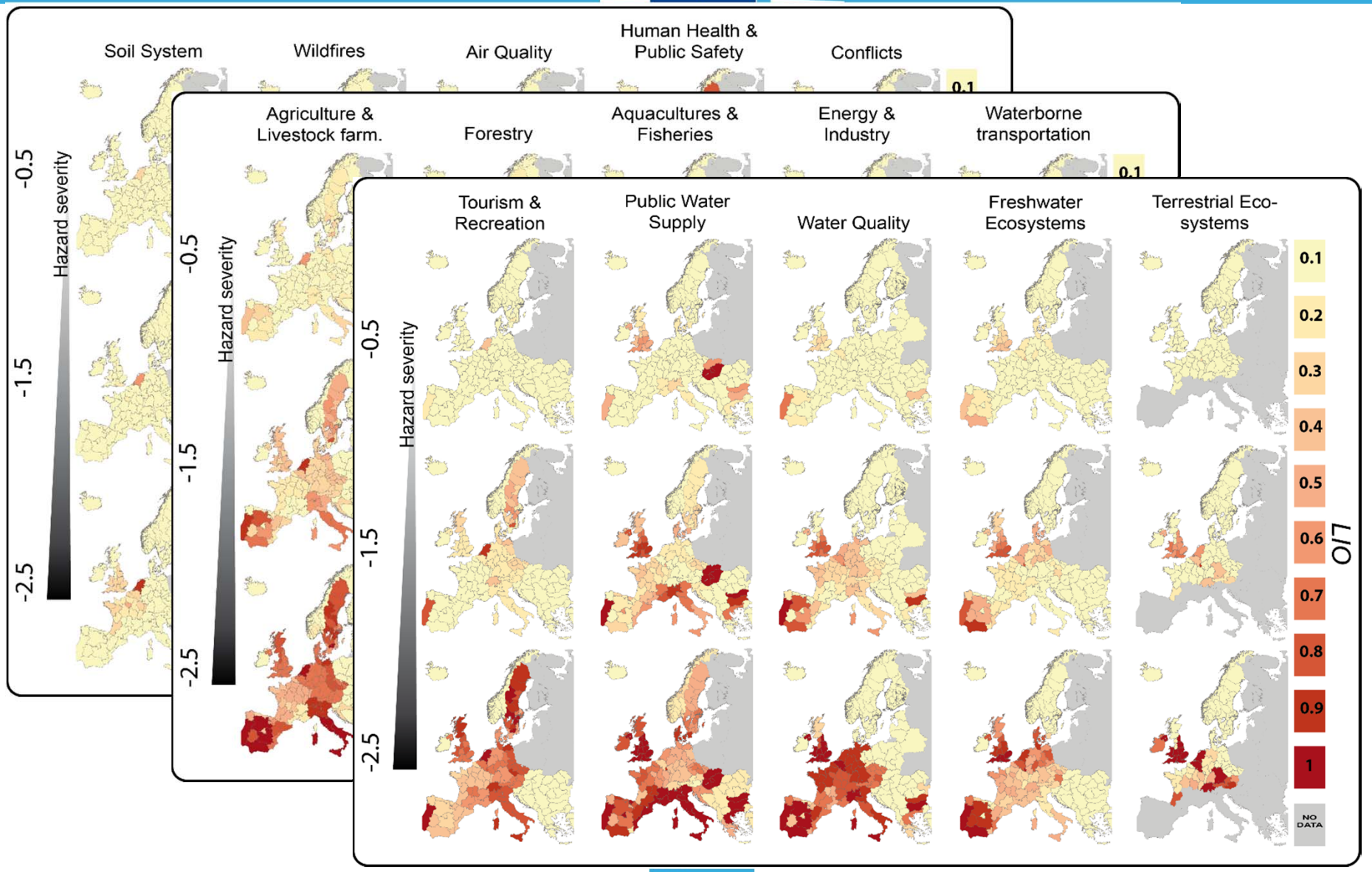




- Region and sector specific identification of relevant drought hazard indices
- Region and sector specific identification of relevant vulnerability factors
- Combination of best performing hazard indices and vulnerability factors

Blauhut et al. 2016

Map the regional distribution of risk for specific sectors



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Blauhut et al. 2016

Linking quantitative damages to drought indices

An impact approach

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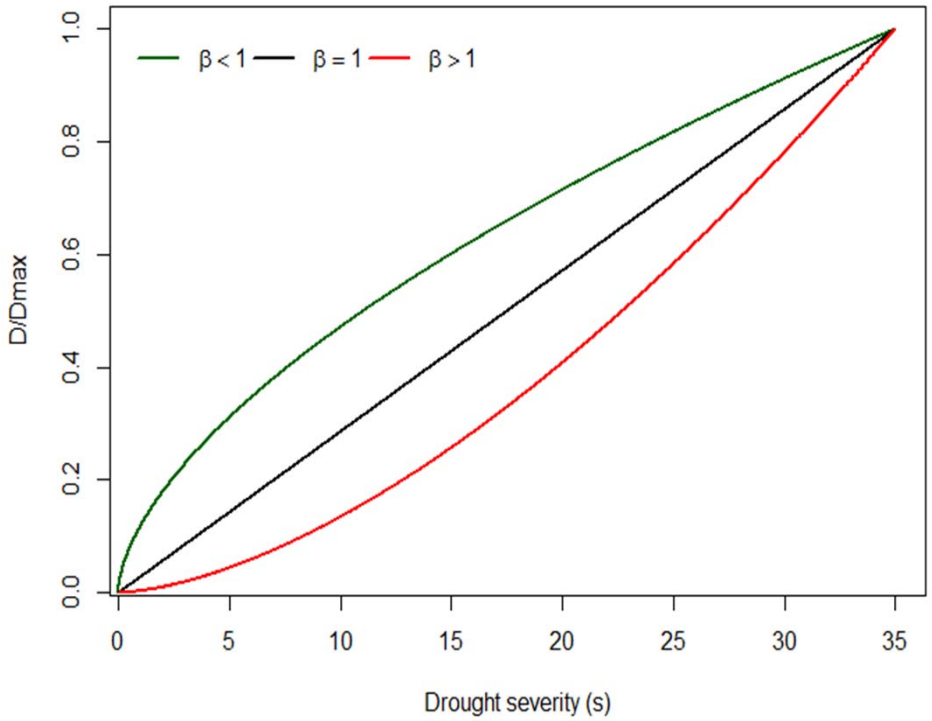
Drought Damage $\approx \alpha\, s^{\beta}$ *(s: drought severity)*



BETA = 1 linear relation

BETA < 1 limited growth relation

BETA > 1 exponential relation

BETA = 0 no relation

BETA << 0 positive effects of droughts?!

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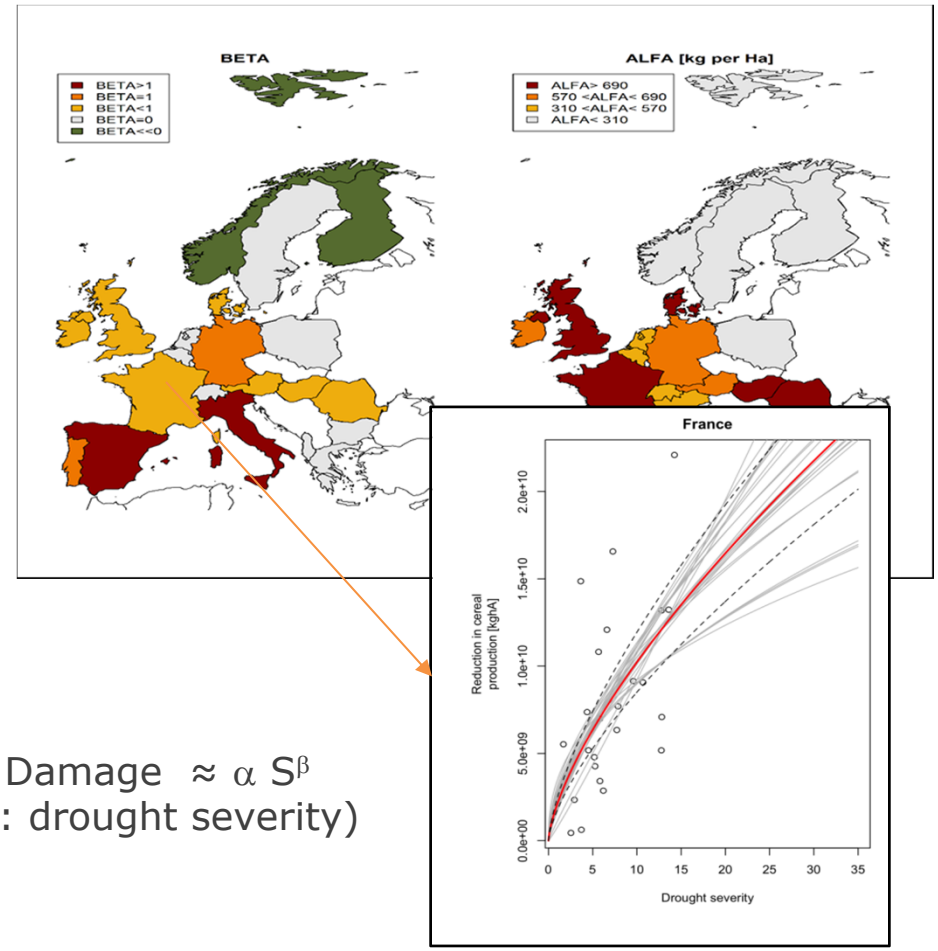
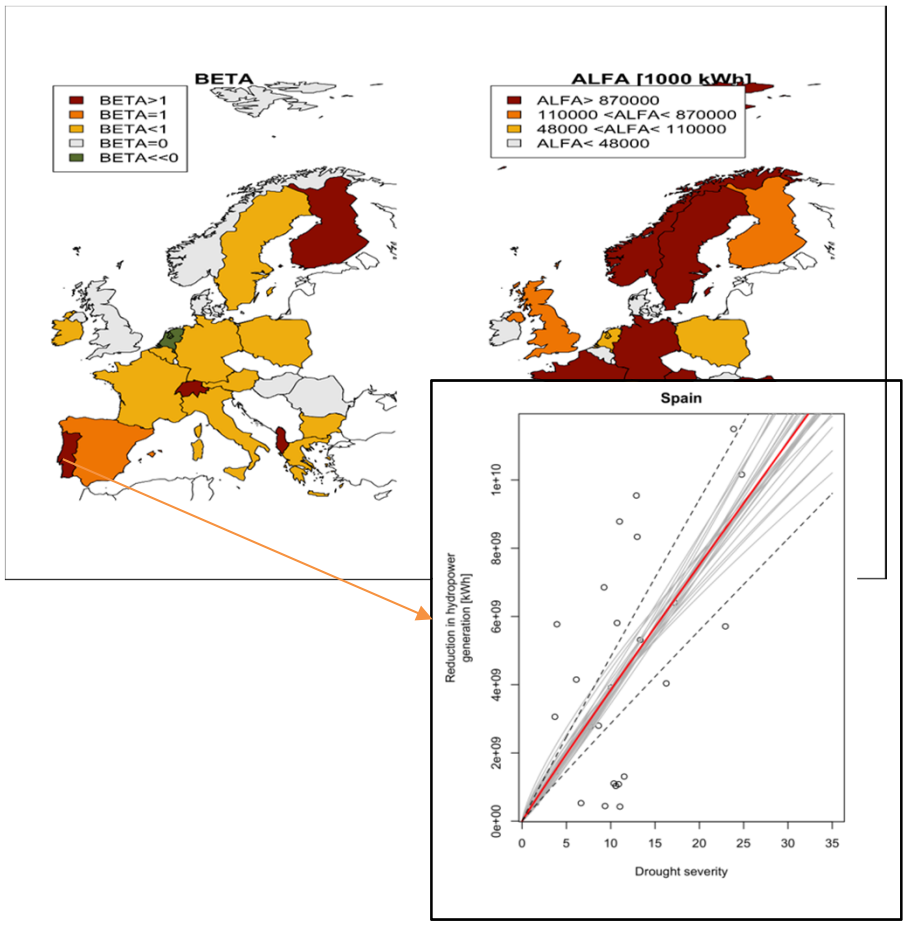
Naumann et al., 2015

Drought severity vs reduction in crop production

Drought severity vs reduction hydropower generation





Damage $\approx \alpha S^{\beta}$
(S: drought severity)

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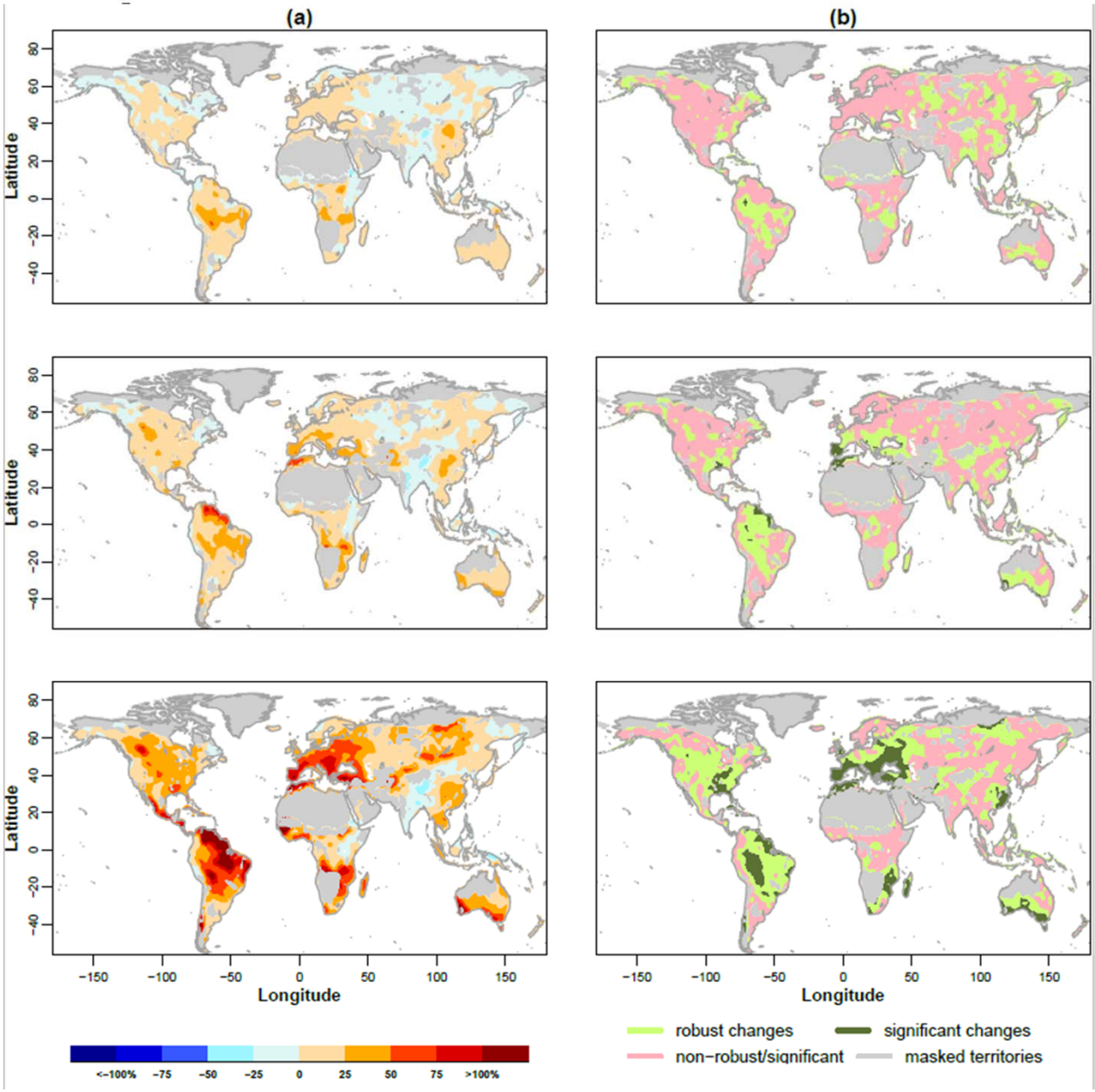
Naumann et al., 2015

Projecting drought risk...

(a) Percentage change in Drought Hazard between the reference period (1971-2000) and far future (2071-2099) under the RCP2.6(top), RCP4.5 (middle) and RCP8.5 (bottom) scenarios.

(b) Robustness and signi_x000c_chance of Drought Hazard changes under the RCP2.6 (top), RCP4.5(middle) and RCP8.5 (bottom) scenarios; signi_x000c_cant changes (dark green) are always robust.



Carrao et al., 2017

Projecting drought risk...

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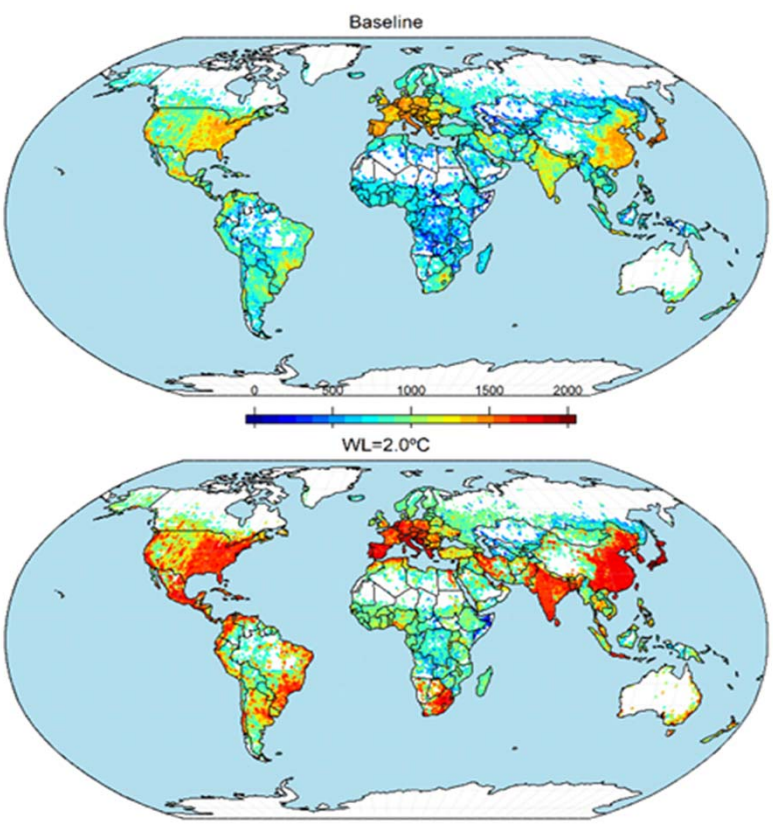
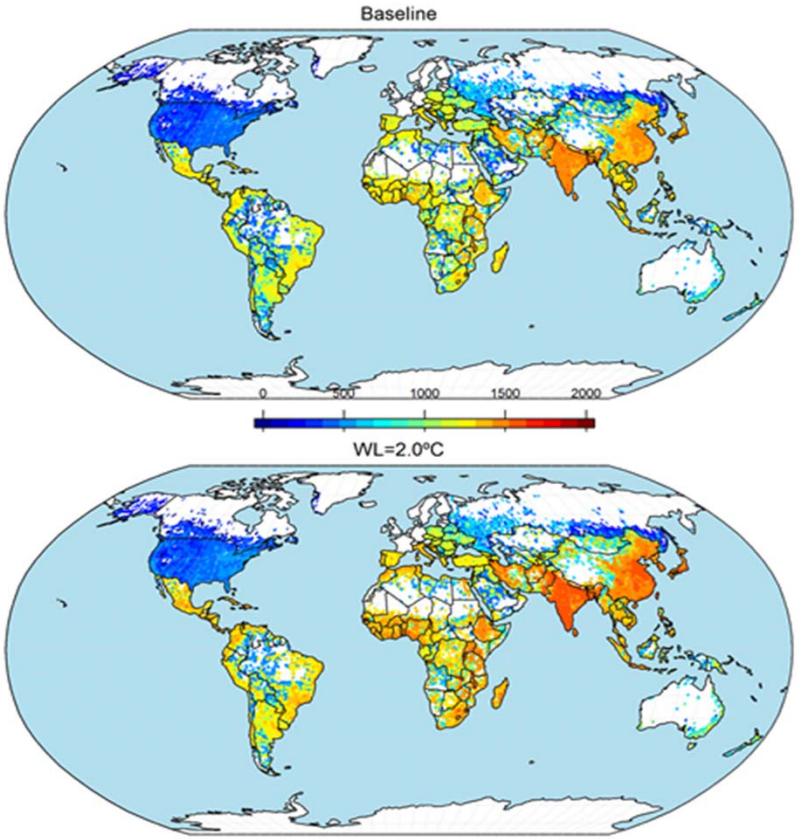
Global assessment of damage and population affected by drought at SWLs: **2/3 of global population will experience a progressive increase in drought conditions with warming.**





Naumann, et al. 2017

Economic annual losses as proportion of GDP density for different periods (baseline and warning level of 2.0° C). [000 US$2010]

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Total population affected by droughts as proportion of population density for different periods (baseline and warming level of 2.0° C).

Conclusions

- Reducing drought impacts requires a paradigm shift from crisis management to risk management
- Drought risk management requires sector specific Drought Risk Assessments
- The impact-based approach suffers from a lack of high-quality, consistent and quantitative impact data
- The collection of qualitative and quantitative impact data is crucial for improving risk assessments
- Adequate spatially and temporally resolved exposure and socio-economic data are crucial for the contextual vulnerability assessments
- The composite approach is scale dependent and includes subjective factor weighting → expert & stakeholder knowledge

Future drought risk challenges

Take away points from Drought in the Anthropocene Workshop, October 2017

- Investigate data (spatial and temporal resolution)
  - especially impact & vulnerability information
- Guidance on data usage & suitability: what are suitable drought indices and vulnerability factors with regard to different impact categories
  - Common overall DRA approach(es?) / impact category specific analyses:
- Communicating drought risk: how to “sell” risk analyses to stakeholders with regard to their specific information needs
- Science – Policy interfacing: get politicians interested
- Implementation of Drought Risk Management to national/ international legislation

Thank you for your attention!

Uyuni, Bolivia
Photo credit Carlos Cruz