Drought risk on a pan European scale: integrating the missing piece

UNI FREIBURG

DROUGHT R&SPI

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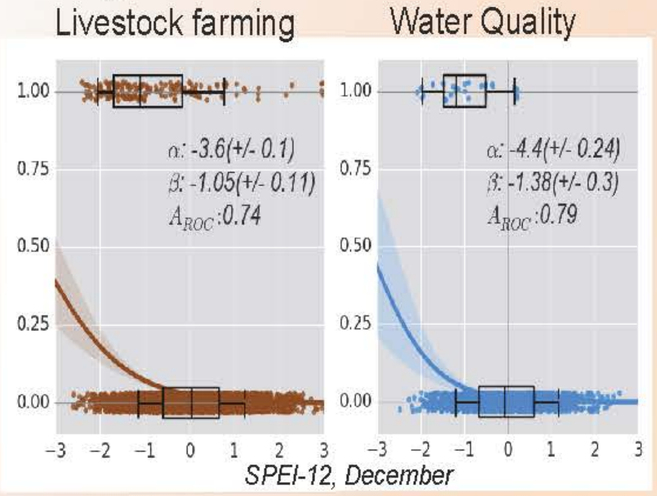
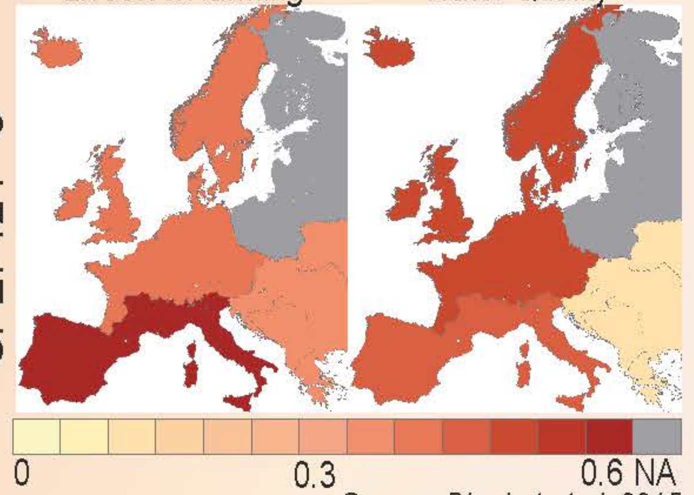
INTRODUCTION

Likelihood of impact occurrence





Source: Blauhut et al. 2015

PROXY APPROACH

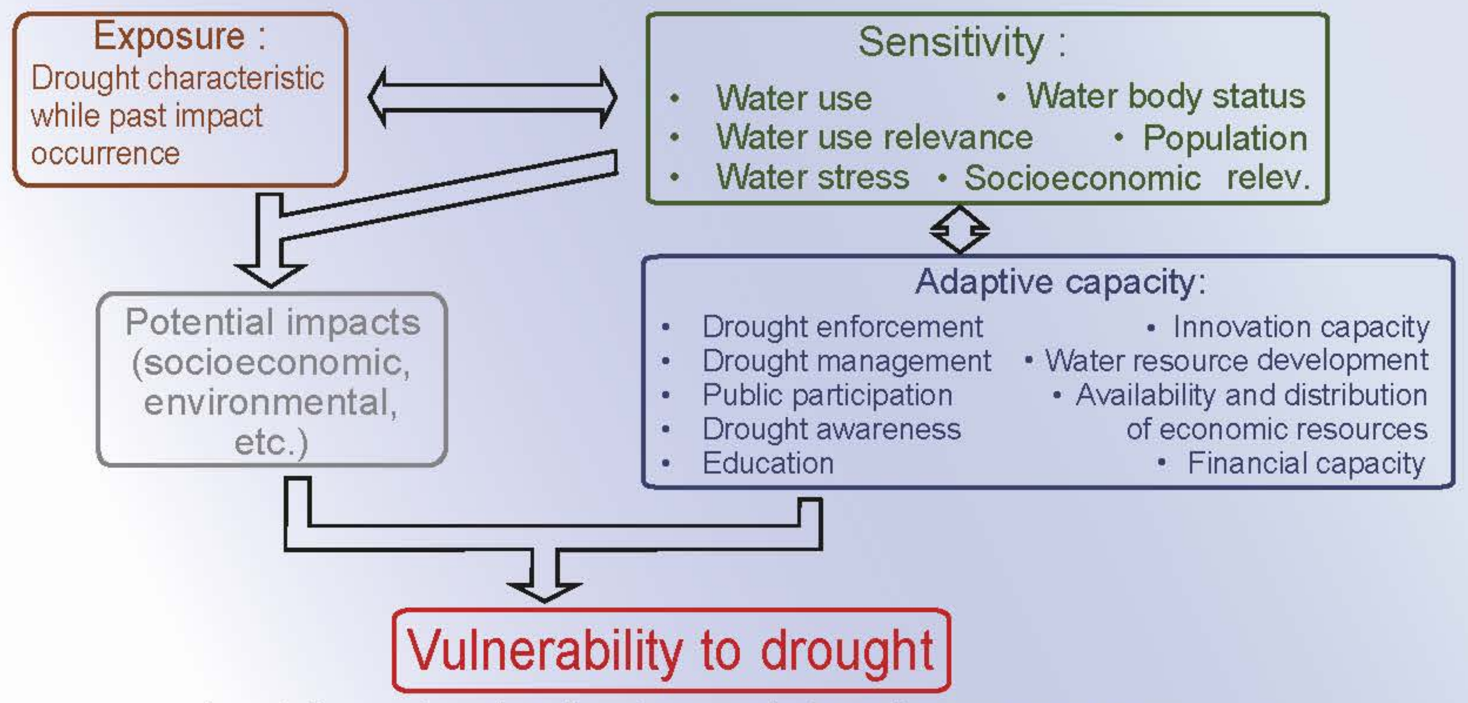
The risk of natural disasters in a very general sense is a combination of hazard and vulnerability. Commonly, the drought hazard is described by one or a set of drought indicators, mostly based on hydro-meteorological information. Recently, Blauhut et al. (2015) developed and empirical approach using past impact data from the European Drought Impact report Inventory (EDII) as an indicator for vulnerability to drought, assuming that a systems has been vulnerable if it has been impacted: the 'proxy approach'(top). Based on statistical modelling of the likelihood of impact occurrence in the past by the drought hazard indicator SPEI, a first generation of sector- specific drought risk maps for selected hazard levels at the scale of European macro regions has been presented.

VULNERABILTY FACTORS
DROUGHT INDICES
DROUGHT IMPACTS } = **DROUGHT RISK**

FACTOR APPROACH

In contrary to that, vulnerability to drought is typically estimated by a combination of relevant vulnerability factors aggregated to indices of Exposure, Sensitivity(S) and Adaptive Capacity(AC): the 'factor approach'. These non sector specific, epistemic approaches require explicit information on physical, ecological, institutional and socioeconomic parameters (bottom). Nevertheless, both approaches are limited due to the nature of their construction.

This work adds the missing piece to risk analyses: a direct integration of vulnerability factors, drought indices and past drought impacts for the next generation of drought risk maps on a pan –European scale.

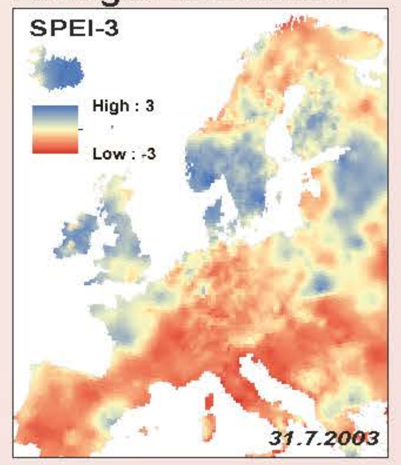


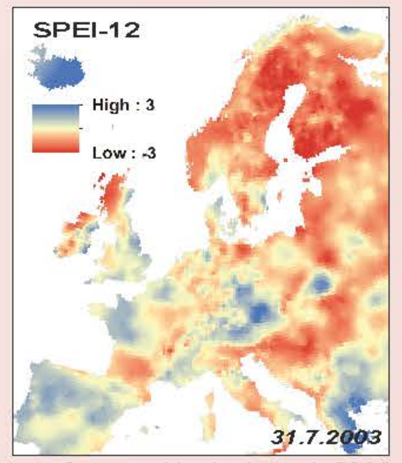
Assessing vulnerability to drought: identifying underlying factors across Europe
Julia Urquijo et al., Wed, 15 Apr, 17:30–19:00 / Blue Posters

DATA

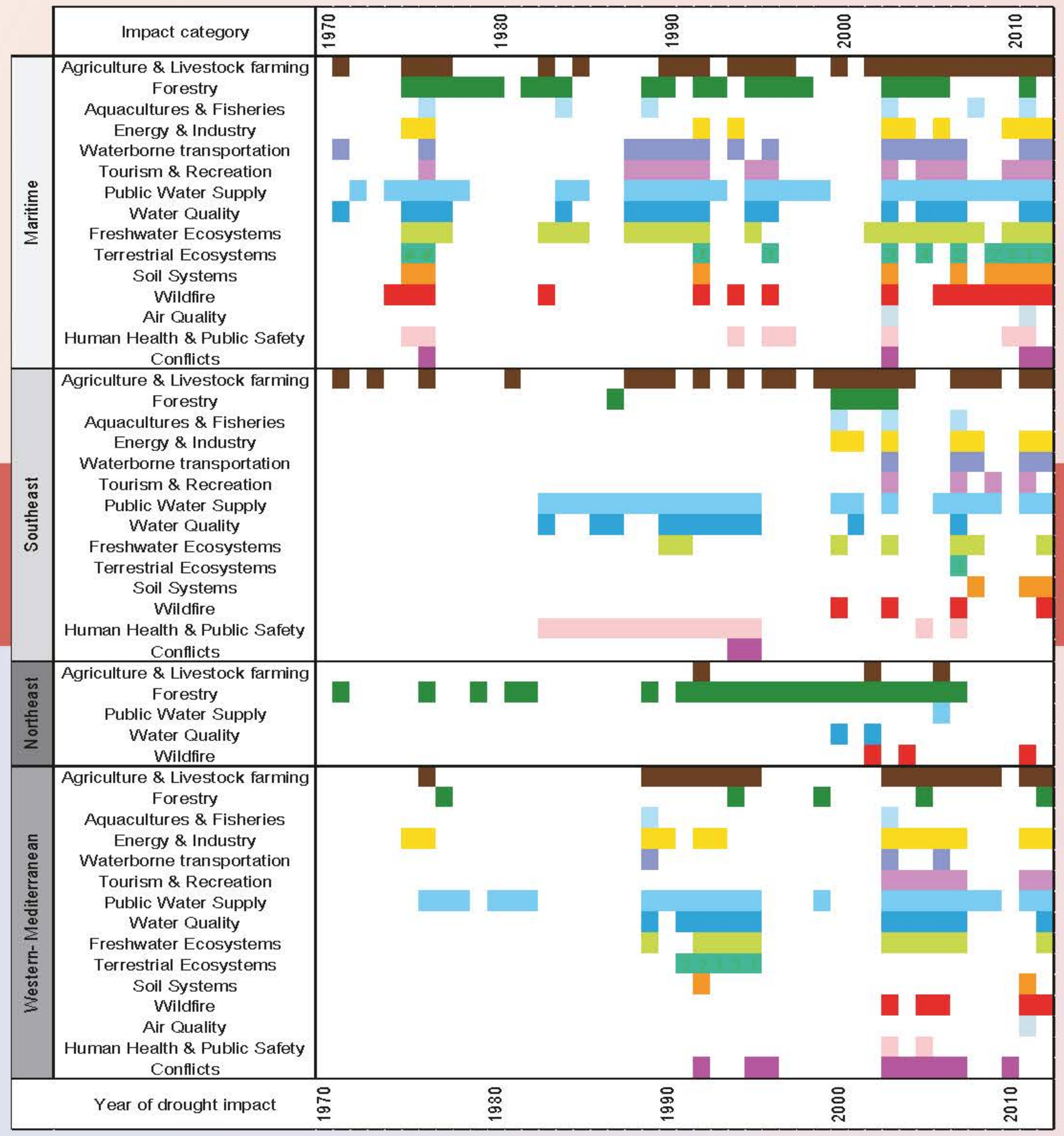
Source: Blauhut et al. 2015

Drought indicators

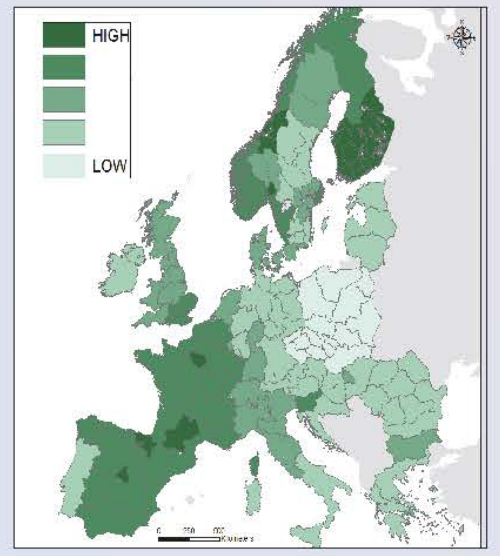




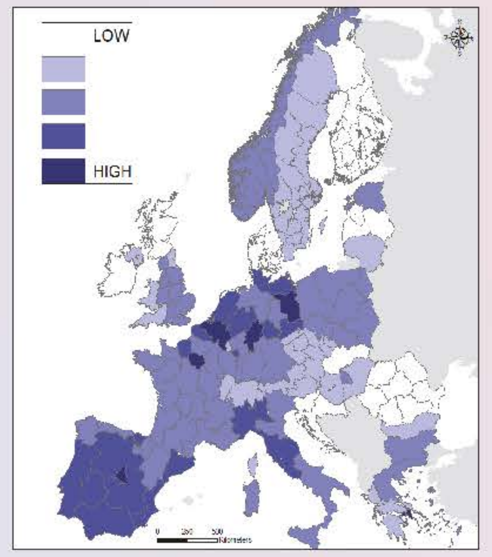
Source: Haylock et al. 2008



SENSITIVITY



ADAPTIVE CAPACITY



Source: de Stefano et al. 2015

METHOD

A statistical model is fitted to estimate the likelihood of drought impact occurrence LIO (drought risk) in each macro region using multivariable logistic regression models (MLRM) as:

$$\log\left(\frac{LIO}{1-LIO}\right) = \alpha_0 + \sum_i (\beta_i \cdot SPEI_i) + \beta_{AC} \cdot AC + \beta_S \cdot S$$

where the left hand side of the equation is known as the logit transformation. The model parameters α and β are estimated using standard regression techniques. This approach considers more than one drought hazard index (i), i.e. SPEI at different aggregation times ($SPEI_i$) as well as the vulnerability components of S and AC to predict drought impact occurrence by a logistic regression model. The significant predictors are marked by '*', model performance was assessed by the area under the ROC curve (with A_{ROC} <0.5 : ☹; A_{ROC}>0.5 : ☺; A_{ROC}=1 : ☺).

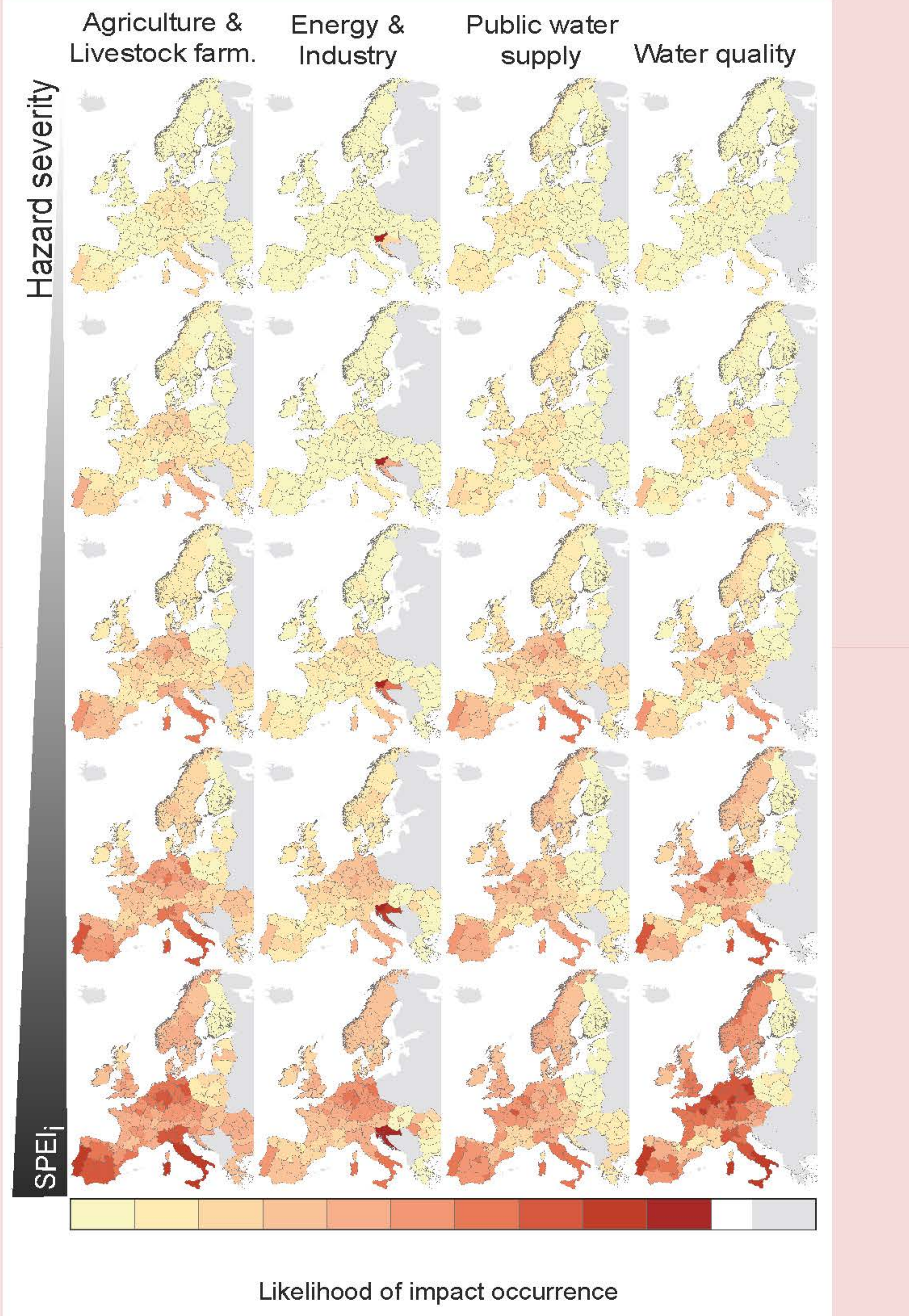
	Impact category	β -1	β-2	β - AC	β - S	A_{ROC}
Maritime	Agriculture & Livestock farming	0.41 *	0.83 *	-1.42 *	-2.74 *	0.78
	Forestry	0.84 *	0.78 *	-2.80 *	-4.61 *	0.86
	Aquacultures & Fisheries	0.53	2.00 *	-1.59	-3.19	0.91
	Energy & Industry	0.57 *	1.11 *	-1.32	-2.24 *	0.82
	Waterborne transportation	0.45 *	0.86 *	-1.48 *	-4.19 *	0.83
	Tourism & Recreation	0.46 *	0.80 *	0.62	-2.72 *	0.81
	Public Water Supply	0.45 *	0.56 *	1.82 *	-1.21 *	0.75
	Water Quality	0.61 *	1.14 *	0.03	-2.93 *	0.86
	Freshwater Ecosystems	0.40 *	0.67 *	1.26 *	-1.73 *	0.76
	Terrestrial Ecosystems	0.35	0.94 *	0.83	-1.40	0.83
	Soil Systems	0.52 *	0.63 *	1.89	-2.90 *	0.81
	Wildfire	1.00 *	0.70 *	-0.14	-0.69	0.83
	Air Quality	0.09	1.72 *	-3.38	-4.63 *	0.91
	Human Health & Public Safety	0.38 *	1.54 *	0.38	-3.55 *	0.90
	Conflicts	1.96 *	1.00 *	-4.52 *	-3.25	0.87
Southeastern	Agriculture & Livestock farming	0.35	0.71 *	1.40	0.77	0.72
	Forestry	0.66	0.38	-5.67	-4.31 *	0.61
	Aquacultures & Fisheries	1.44 *	0.39	45.19 *	21.94 *	0.84
	Energy & Industry	2.03 *	0.34	42.69 *	17.29 *	0.80
	Waterborne transportation	0.05	1.68	9.08	22.85	0.86
	Public Water Supply	0.34	0.45	1.94	-1.07	0.67
	Water Quality	-0.46	0.58	-3.04	-3.51	0.27
	Freshwater Ecosystems	0.65	0.59	16.12 *	8.90 *	0.79
	Wildfire	-0.64	1.34	3.85	4.49	0.16
Northeastern	Agriculture & Livestock farming	1.23 *		-3.83	3.07	0.88
	Forestry	0.47 *		0.41	-1.89	0.61
	Public Water Supply	0.43		-16.46	1.20	0.85
	Water Quality	0.87		-7.06	2.15	0.78
	Wildfire	-0.51		-1.44	9.02	0.61
Western- Mediterranean	Agriculture & Livestock farming	0.93 *	0.49 *	-5.21 *	-3.09 *	0.79
	Forestry	1.53 *	-0.04	-5.97	-4.22	0.74
	Aquacultures & Fisheries	0.78	1.27 *	-1.35	4.58	0.76
	Energy & Industry	1.27 *	0.12	-4.99 *	0.57	0.79
	Waterborne transportation	1.33 *	1.41 *	-7.52	0.66	0.93
	Tourism & Recreation	1.61 *	0.63 *	-9.76 *	3.93	0.92
	Public Water Supply	0.75 *	0.30 *	-3.10 *	-5.03 *	0.75
	Water Quality	1.27 *	0.45 *	-8.08 *	-4.45 *	0.86
	Freshwater Ecosystems	1.08 *	0.17	-2.57 *	-2.93 *	0.75
	Terrestrial Ecosystems	0.54	0.49	-3.48	-5.50	0.73
	Wildfire	1.91 *	0.32	-6.56 *	4.30 *	0.90
	Human Health & Public Safety	2.17 *	0.26	2.18	1.87	0.82
	Conflicts	1.12 *	0.63 *	-8.26 *	-7.67 *	0.83

To select the specific drought hazard indicators $SPEI_i$ for each region their significance as predictors was first tested in a simple binary logistic regression. As predictors in MLRM should be independent, only combinations of SPEI indicators were chosen that had a correlation coefficient below 0.5. The table on the right gives an overview of the selected predictors used for modelling.

	Predictor 1	Predictor 2
	SPEI-03 June	SPEI-12 December
	SPEI-03 June	SPEI-09 December
	SPEI-06 September	
	SPEI-06 June	SPEI-09 December

RESULTS

The presented drought risk maps exemplary considered four impact categories for increasing hazard intensities (SPEIi = -1 to SPEIi = -3) on NUTS-combo scale. Merely Maritime Europe has enough data to identify a multi-variable model for each impact category and guarantee good model performance. The drought risk maps show impact sector and region specific sensitivities to drought impacts.



The maps show a number of details, which will require independent validation and comparison with other studies. Nevertheless, the identified models allow a proof-of-concept for quantitative assessment and visualization of regional differences in first-order drought risk across Europe. The approach can serve as a template for further improvements and integration additional data.

Got interested? ...more information at: „Assessing risk by impacts: a probabilistic approach for drought assessment in Europe", Wed, 11:15, G9

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Blauhut, V., Gudmundsson, L., Stahl, K., 2015. Towards pan-European drought risk maps: quantifying the link between drought indices and reported drought impacts. Environ. Res. Lett. 10 014008 doi:10.1088/1748-9326/10/1/014008
Blauhut, V. and Stahl, K. (2015): Mapping Drought Risk in Europe. DROUGHT-R-SPI Technical Report no. 27, Freiburg, Germany, 15 pg.
De Stefano, L., González Tánago, I., Ballesteros, M., Urquijo, J., Blauhut, V., Stagge, J.H and Stahl, K. (2015): Methodological approach considering different factors influencing vulnerability - pan-European scale. DROUGHT-R-SPI Technical Report no. 26, Madrid, Spain, 121 pg.
Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones, M. New. 2008: A European daily high-resolution gridded dataset of surface temperature and precipitation. J. Geophys. Res (Atmospheres), 113, D20119, doi:10.1029/2008JD10201