



Supplement of

An inventory of Alpine drought impact reports to explore past droughts in a mountain region

Ruth Stephan et al.

Correspondence to: Ruth Stephan (ruth.stephan@hydrology.uni-freiburg.de)

The copyright of individual parts of the supplement might differ from the article licence.

The Supplementary material is divided in two Sections: Sect. 1 comprises one Table about all impact categories and subtypes that originated from the EDII and the corresponding Reference. Sect. 2 presents a short summary on the effect of our update with four supplementary Figures showing the applied analysis with EDIIs' archived impact reports before our update (i.e. status of EDII from September 2019).

1 Impact categories and subtypes

Table S1. All impact categories and subtypes defined by Stahl et al. (2016) and their assignment to soil-moisture drought (D_{SM}) and hydrological drought (D_H).

Impact category	Impact subtype		Drought	
			type	
	ID	Description	Dsм	Dн
Agriculture and	1.1	Reduced productivity of annual crop cultivation: crop losses, damage to crop quality or crop failure due to dieback, premature ripening,	Х	
livestock farming		drought-induced pest infestations or diseases etc.		
	1.2	Reduced productivity of permanent crop cultivation	Х	
	1.3	Agricultural yield losses \geq 30% of normal production (EU compensation treshold)	Х	
	1.4	Reduced availability of irrigation water		Х
	1.5	Reduced productivity of livestock farming (e.g. reduced yields or quality of milk, reduced stock weights)		
	1.6	Forced reduction of stock(early selling/slaughtering)		
	1.7	Regional shortage of feed/water for livestock	Х	Х
	1.8	Other		
	1.9	Increased costs/economic losses		
Forestry	2.1	Reduced tree growth and vitality	Х	
	2.2	Decrease in annual non-timber products from forest trees (e.g. cork, pine nuts, mushrooms, berries, etc.)		
	2.3	Increased occurrence of water stress indicators and damage symptoms (e.g. premature ripening, seasoning checks, defoliation, worsened	Х	
		crown conditions etc.)		
	2.4	Increase of pest/disease attacks on trees (please specify species in the description field!)		
	2.5	Increased dieback of trees	Х	
	2.6	Increased dieback of planted tree seedlings (in nurseries or afforested area)	Х	
	2.7	Damage to short rotation forestry plantations (energy forestry)	Х	
	2.8	Other		
	2.9	Increased costs/economic losses		
Freshwater	3.1	Reduced (freshwater) fishery production (please specify fish species in the description field)		Х
aquaculture and	3.2	Reduced aquaculture production (please specify fish species in the description field)		Х
fisheries	3.3	Other		
	3.4	Increased costs/economic losses		
Energy and	4.1	Reduced hydropower production		
industry	4.2	Impaired production/shut down of thermal/nuclear power plants (due to a lack of cooling water and/or environmental legislation for		
		discharges into streams)		
	4.3	Restriction/disruption of industrial production process (due to a lack of process water and/or environmental legislation/restrictions for		
		discharges into streams)		
	4.4	Other		
	4.5	Increased costs/economic losses		
Waterborne	5.1	Impaired navigability of streams (reduction of load, increased need of interim storage of goods at ports)		Х
transportation	5.2	Stream closed for navigation		Х
	5.3	Other		

	5.4	Increased costs/economic losses	
Tourism and	6.1	Reduced number of short-stay-tourists	
recreation	6.2	Reduced number of long-stay-tourists	
	6.3	Sport/recreation facilities affected by a lack of water	Х
	6.4	Impaired use/navigability of surface waters for water sport activities (including bans)	Х
	6.5	Other	
	6.6	Increased costs/economic losses	
Public water	7.1	Local water supply shortage / problems (drying up of springs/wells, reservoirs, streams)	Х
supply	7.2	Regional/region-wide water supply shortage/problems (drying up of springs/wells, reservoirs, streams)	Х
	7.3	Bans on domestic and public water use (e.g. car washing, watering the lawn/garden, irrigation of sport fields, filling of swimming pools)	Х
	7.4	Limitations in water supply to households in rural areas (supply cuts, need to ensure water supply by emergency actions)	Х
	7.5	Limitations in water supply to households in urban areas (supply cuts, need to ensure water supply by emergency actions)	Х
	7.6	Other	
	7.7	Increased costs/economic losses	
Water quality	8.1	Increased temperature in surface waters (close to or exceeding critical values)	Х
	8.2	(Temporary) water quality deterioration/problems of surface waters (natural & manmade); e.g. significant change of physio-chemical	Х
		indicators, increased concentrations of pollutants, decreased oxygen saturation levels, eutrophication, algal bloom)	
	8.3	(Temporary) impairment of ecological status of surface waters (according to EU Water Framework Directive)	Х
	8.4	(Temporary) impairment of chemical status of surface waters (according to EU Water Framework Directive)	Х
	8.5	Increased salinity of surface waters (saltwater intrusion and estuarine effects)	Х
	8.6	Problems with groundwater quality	Х
	8.7	Increased salinity of groundwater	Х
	8.8	Problems with drinking water quality (e.g., increased treatment, violation of standards)	Х
	8.9	Problems with bathing water quality	Х
	8.10	Problems with irrigation water quality	Х
	8.11	Problems with water quality for use in industrial production processes	Х
	8.12	Other	
	8.13	Increased costs/economic losses	
Freshwater	9.1	Increased mortality of aquatic species	Х
ecosystems:	9.2	Increased species concentration near water	
habitats, plants	9.3	Migration and concentration (loss of wildlife in some areas and too many in others)	
and wildlife	9.4	Increased populations of invasive (exotic) aquatic species	
	9.5	Observation of adverse impacts on populations of rare/endangered (protected) riparian species	
	9.6	Observation of adverse impacts on populations of rare/endangered (protected) species of wetlands	
	9.7	Loss of biodiversity (decrease in species diversity)	
	9.8	Danger for or actual violation of minimum flow or environmental flow requirements	Х
	9.9	Drying up of shallow water areas, weed growth or algae bloom	Х
	9.10	Drying up of perennial stream sections	Х
	9.11	Drying up of lakes and reservoirs (which have a habitat function)	Х
	9.12	(Mid-/Long-term) deterioration of wetlands	Х
	9.13	Irreversible deterioration/loss of wetlands	Х
	9.14	Other	
	9.15	Increased costs/economic losses	

Terrestrial	10.1	Increased species mortality		
ecosystems:	10.2	Changes in species biology/ecology		
habitats, plants	10.3	Loss of biodiversity (decrease in species diversity)		
and wildlife	10.4	Shift in species composition		
	10.5	Reduced plant growth		Х
	10.6	(Mid-/Long-term) deterioration of habitats		
	10.7	Irreversible deterioration/loss of habitats		
	10.8	Lack of feed/water for terrestrial wildlife	Х	Х
	10.9	Increased attacks of pests and diseases		
	10.10	Increased contact of wild animals under stress (shortage of feed and water) with humans		
	10.11	Other		
	10.12	Increased costs/economic losses		
Soil system	11.1	Drought-related erosion processes (loss of soil fertility)	Excluc	ded
	11.2	Structural damage to private property due to soil subsidence/shrinkage	from E	DII-
	11.3	Structural damages on infrastructures due to soil subsidence/shrinkage	ALP	S
	11.4	Other		
	11.5	Increased costs/economic losses		
Wildfires	12.1	Increased burned area	Excluc	ded
	12.2	Increased number of wildfires	from E	DII-
	12.3	Increased severity of wildfires	ALP	S
	12.5	Increased costs/economic losses		
	12.6	Other		
Air quality	13.1	Air quality pollution effects/problems (dust bowl effect, wildfires, substitution of hydropower production by fossil energy)	Х	
	13.2	Other		
	13.3	Increases costs/economic losses		
Human health	14.1	Heat stress problems (if drought is associated with a heatwave)		
and public safety	14.2	Increased respiratory ailments (heat wave and air quality)		
	14.3	Excess mortality during heat waves		
	14.4	Drought induced public-safety issues (e.g. increased risk of structural damages)		
	14.5	Other		
	14.6	Increases costs/economic losses		
Conflicts	15.1	Water allocation conflicts – international		
	15.2	Regional/local user conflicts		
	15.3	Other		
	15.4	Increased costs/economic losses		

References

Stahl, K., Kohn, I., Blauhut, V., Urquijo, J., De Stefano, L., Acácio, V., Dias, S., Stagge, J. H., Tallaksen, L. M., Kampragou, E., van Loon, A. F., Barker, L. J., Melsen, L. A., Bifulco, C., Musolino, D., de Carli, A., Massarutto, A., Assimacopoulos, D., and van Lanen, H. A. J.: Impacts of European drought events: insights from an international database of text-based reports, Nat. Hazards Earth Syst. Sci., 16, 801–819, https://doi.org/10.5194/nhess-16-801-2016, 2016.

2 Status of EDII from September 2019

This part presents the applied analysis described in the manuscript with the EDII before our update (i.e. status of the EDII from September 2019) to enable insights of the effect of our impact report collection focused on the Alpine Space and therefore presenting EDIIALPS. We raised the number of reported drought impacts located in the Alpine Space from 1412 to 3243. Further EDIIEU, was updated with more than 3,300 reported impacts with more than half of them by our focus on the Alpine Space (compare Fig. S1b with 2b). For the EDIIALPS we could add missing drought impact reports especially located in Austria, Slovenia, Italy and France (compare Fig. S1a with 2a, and Fig. S2b with Fig. 3b) with most reports from newspaper articles, web pages, governmental reports, scientific articles and the investigated specialty databases Unwetterchronik, DMCSEE, Drought.ch, and Propluvia). Our update altered the impact categories fractions especially in the French part (compare Fig. S1a with 2a). Reports located there were mainly on Agriculture and livestock farming, as well as on Public water supply, as the French platform "Propluvia" informed on water restrictions in drought periods most often affecting the agriculture and water supply.

Further, we added previously missed impact reports for several years, especially for the periods in-between the selected drought events and after 2010 to better cover the more recent years (compare Fig. S2b with Fig. 3b). Regarding the selected drought events 1976, 2003, 2015, and 2018, the majority of our added reports related to 2018 and to the subtype 'Reduced availability of irrigation water' (1.4) from the category *Agriculture and livestock farming*. The better impact data completeness enabled the applied seasonal and spatial analysis across the study region (compare Fig. S3 with Fig. 4). Due to fewer reports before our update, the existence of one report in another subtype or category could affect the whole season. For example,

before our update EDII archived one report about 'air quality pollution effects/problems' (13.1) and two reports affecting 'Changes in species biology/ecology' (10.2) in winter in the Southern region. As only six reported impacts had been archived in total for the winter season, these impacts had been represented with 50 % (see Fig. S3f). During the update, we classified almost 300 reported impacts in the Southern region occurring in winter mainly from the categories Agriculture and livestock farming, followed by Public water supply and Tourism. Subsequently, the fraction of the categories Terrestrial ecosystems and Air quality decreased substantially. Subsequently, the added impact reports strengthened the categorical representation of drought impacts especially in subregions and seasons. In addition, the updated impact collection supported the analysis on the drought type impact regimes (compare Fig. S4 with Fig. 5). Especially, the added impacts located in the Highaltitude and Southern region increased the number of D_{SM} and D_H impacts with smaller effects on the relative fraction of the different impact categories and subtypes, but with a substantial effect on the monthly development of D_{SM} impacts and D_H impacts (compare Fig. S4d,f with Fig. 5d,f). Due to our update, the maximum of the D_{SM} impact regime shifted from autumn to summer in both domains, the D_H impact regimes started already in January and both regimes showed a clearer pattern by the loess curves with smaller standard errors (compare Fig. S4d, f with Fig. 5d, f).

To conclude, the update during this study was substantial as it supported the analyses of the $EDII_{ALPS}$ and the comparison with the $EDII_{EU}$ in all parts. Therefore, we aim to add further drought impact reports fulfilling all requirements in order to strengthen the value of the inventory further and especially at the regional and local scale to reduce potential gaps of missed impact information.



Figure S1. Reported impacts archived in the EDII before our update (i.e. status of the EDII from September 2019). Archived impacts in 13 coloured categories by region (n = total no. of reports per region). (a) Fraction of impact category per country. Darker grey shading relates to a higher count of reports per NUTS 2 region. (b) Fraction of impact categories (coloured) covering several subtypes (faint lines) for the domains. Subtypes with a fraction \geq 10 % per domain are labeled.



Figure S2. Reported impacts archived in the EDII before our update (i.e. status of the EDII from September 2019). Archived impacts categories between 1975 and 2020. (a) Number of reports per year and identified drought events (red dotted line) with significantly different years labeled. (b) Number of all reports per country and year. (c) Fraction of impact categories (coloured) and their subtypes (faint lines) for drought events Subtypes with a fraction \geq 10 % per region are labeled. Colours see Fig. S1.



Figure S3. Reported impacts archived in the EDII before our update (i.e. status of the EDII from September 2019). Annual distribution of reported impact categories per month (line diagrams) and season (bar plots) for the (a) $EDII_{ALPS}$, (b) $EDII_{EU}$, (c) pre-Alpine region, (d) high-altitude region, (e) Northern region, (f) Southern region. Monthly percentages relate to the sum of all impacts per month and category with 100 % corresponding to the month with most impacts. Total counts of each season are given on top of the bars, the fraction in brackets relates to the amount of impacts assigned to the season. Subtypes with a fraction \geq 10 % per season are labeled. Colours see Fig. S1.



Figure S4. Reported impacts archived in the EDII before our update (i.e. status of the EDII from September 2019). Impact subtypes assigned to D_{SM} (yellow) or D_H types (blue). D_{SM} and D_H impacts aggregated per month (line diagram) and drought type (bar plot) for the (a)EDII_{ALPS}, (b) EDII_{EU}, (c) pre-Alpine region, (d) high-altitude region, (e) Northern region, (f) Southern region. Seasonal regimes for D_{SM} (yellow lines) and D_H impacts (blue lines) are loess curves with standard errors (dotted line with coloured shape). Monthly percentages (solid lines) relate to the sum of all impacts per month and subtype with 100 % corresponding to the month with most impacts. Total counts of D_{SM} and D_H impacts are given on top of the bars, the fraction in brackets relates to the amount of impacts assigned to the season. Subtypes with a fraction ≥ 5 % are labeled. Colours see Fig. S1.