

Supplement to: *The 2022 Drought Shows the Importance of Preparedness in European Drought Risk Management*

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Abstract. Droughts in Europe are becoming increasingly frequent and severe, with the 2022 drought surpassing previous records and causing widespread socio-economic impacts. This study, employs a Europe-wide survey that integrates data from 481 respondents from 30 European countries, involved in the management of the 2022 European drought, together with
40 hydroclimatic data (i.e., Standardized Precipitation Evapotranspiration Index; SPEI), to provide a holistic assessment of the effect of drought preparedness on response effectiveness and timeliness during the 2022 drought through statistical methods.

It specifically assesses the role of forecasting systems and Drought Management Plans (DMPs) in improving preparedness and in facilitating more effective and timely responses. Additionally, the study investigates how drought management practices and awareness have evolved as a consequence of the 2018 European drought and how recent experiences shape water managers' perceptions. The findings emphasize the urgent need for a standardized, continent-wide drought risk management coordination to address the multifaceted nature of drought risk by integrating climatic and societal factors, and advocates for a Drought Directive as a means to achieve it. This research aims to inform policy development towards sustainable and holistic drought risk management, highlighting the crucial roles of preparedness, awareness, and adaptive strategies in mitigating future drought impacts.

This study and its companion paper *The 2022 Drought Needs to be a Turning Point for European Drought Risk Management* are the result of a study carried out by the Drought in the Anthropocene (DitA) network.

S1. Questionnaire

S1.1. Content of the questionnaire

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Impacts and response during the 2022 European drought - questionnaire

Over the span of just five years, Europe has been hit by two major drought events, the 2018-2019 drought, and 2022 drought which is still ongoing in parts of Europe. In particular, the latter has been reported as being the worst drought hitting the continent in 500 years. While drought risk has risen on the agenda in many European countries, Europe is still largely unprepared to manage severe, spatially large and recurring drought events with no European-wide drought management schemes in place.

The Panta Rhei Drought in the Anthropocene working group is an interdisciplinary organization of researchers investigating drought impact and management. This questionnaire was devised to collect information from water managers and managers of drought-affected sectors that can be used to further our knowledge of drought impact and management from a European perspective. With your collaboration you will be contributing to the advancement of the knowledge on drought in Europe. By responding to this questionnaire you are giving your consent to use this data for scientific purpose. Please, take 15 minutes of your time to answer to this questionnaire.

1. What type of organization do you belong to?

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2. At which level does your organization operate?

3. In which country is your organization located?

75 4. In which municipality/region do you operate (name, region, country)?

5.a. How does your organization identify that drought is happening?

- Based on analysis of indices (e.g. SPEI; SPI...)
- Based on observed impact
- 80 · Based on external reporting (e.g. bulletin from the meteorological service)
- Based on internal reporting
- My organization doesn't have a systematic way to define it
- I don't know

85 5.b. Does your organization use a forecasting system?

- Yes, seasonal forecast (1-7 months)
- Yes, sub-seasonal (0-5 weeks)
- Yes, both seasonal and sub-seasonal
- No

90 · I don't know

I. Impacted sectors

The following questions regard the sectors which are present in your area of operations, or that your organization manages directly. For multiple choice questions, you can leave the non-relevant sectors empty.

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6. Which sectors does your organization operate in?

- Agriculture and Livestock Farming
- Forestry
- Freshwater Aquaculture and Fisheries
- Energy and Industry
- Waterborne transportation
- Tourism and Recreation
- Public Water Supply
- Water Quality

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- Freshwater ecosystems: habitats, plants and wildlife
- Terrestrial ecosystems: habitats, plants and wildlife
- Soil system
- Wildfires
- Air quality

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- Human health and public safety
- Conflicts
- Other

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7. How severe was the impact of the 2022 drought on a scale from 1 (Not affected) to 5 (Severe)?

8. How severe was the impact of the 2022 drought compared to the 2018-2019 drought event?

- Less severe
- Same
- More severe
- I so not know
- Not relevant

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9. When was the impact first seen (month)?

- Before March 2022
- March 2022
- April 2022
- May 2022
- June 2022
- July 2022
- August 2022

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10. Which sectors were prioritized in the distribution of water resources?

- Low priority
- 135 · Medium Priority
- High priority
- I do not know

II. Cascading hazards

140 Sometimes, droughts can trigger other related hazards. You can leave the non-relevant hazards empty.

11. Have you observed any other hazard connected to the drought? When did it take place compared to the start of the drought?

- Coastal flooding
- Heavy rains
- 145 · Cold spell
- Disease outbreak
- Hail
- Heatwave
- Landslides
- 150 · Riverine flooding
- Smog
- Strong winds
- Wildfires

155 11.a. Write here if you observed hazards which are not on the list (optional)

III. Drought management

Drought management measures are aimed at mitigating drought risk or impact. These measures can be both proactive (if taken before the onset of the drought) or reactive (if taken after the onset). One example of drought management measure taken is the reduction of output of a power plant to reduce the temperature in the cooling tower due scarcity of cooling water.

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12. What were the main measures taken by your organization?

13. When did your organization take measures to mitigate the impact of the 2022 drought?

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14. How effective were the measures taken?

- Very effective
- Not effective
- I do not know
- 170 · Not relevant

IV. Drought management plan

A drought management plan is a framework for enacting drought management within an organization. This can either be specific for drought, or drought can be one of the risks present in a multi-hazard plan. Plans can be either designed for short-term response to drought, or management strategies aimed at making the organization more resilient to drought in the long term.

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15. Does your organization have a drought management plan or a contingency plan for droughts both for the short-term response and the long-term (multi-year) management?

- 180 · Yes, both short-term response and long-term management plans
- Yes, only short-term response plan
- Yes, only long-term management plan
- No, we do not have either

- 185 · I don't know
16. Has your organization introduced or updated its drought management plan and/or contingency plan since 2018?
- Yes, both plans have been introduced after 2018
 - Yes, only short-term response plan has been introduced after 2018
 - Yes, only long-term management plan has been introduced after 2018
- 190 · No, we already had both plans before 2018
- No, we do not have any plan
 - I don't know

V. Drought risk

195 Drought risk is the likelihood that a drought will cause damage and losses. It depends on the interactions between the severity of the drought event and how much society and the environment are susceptible and exposed to said drought.

17. Compared to the 2018-2019 drought, your organization was...
- (More , same , less , I do not know)
- 200 · Aware
- Prepared
 - Effective in the response

18. Do you think that the risk posed by droughts is...
- 205 · Increasing
- Unchanged
 - Decreasing
 - I do not know

210 18.a. Elaborate (optional)

19. Do you expect the drought to become a more significant risk to manage for your organization in the future?
- Yes
 - No
- 215 · I do not know

19.a. If yes, how is drought management changing in your organization (optional)

220 Thank you for your contribution!

S1.2. Links to questionnaires

Below are listed the links to the questionnaires that were created in all the available languages.

225 English:

<https://docs.google.com/forms/d/e/1FAIpQLSeomRgskDrjK1WBYaMSWvGudv7ZhcfDFnkHk5vGAFEWohy3FQ/viewform?usp=sharing>

German:

230 https://docs.google.com/forms/d/e/1FAIpQLScy3fTctPfb9KPlj6iHj6o_wXqyd5hGtU2orJ9X1QvEcuVvbg/viewform?usp=sharing

Italian:

<https://docs.google.com/forms/d/e/1FAIpQLScy6IcBFfodRK8vePD0A1eYBOIaVcfTPO63QHgyr2PzAkhbtA/viewform?usp=sharing>

Dutch (NL):

235 <https://docs.google.com/forms/d/e/1FAIpQLScT2dUAV36-IPb3WO0vbmakJGsGIkT9o9rMzl-rsENw8Th-Qw/viewform?usp=sharing>

Ukrainian:

240 <https://docs.google.com/forms/d/e/1FAIpQLSfIGvSapTqRi80sd9TfTNvd1ED2I9jSp4jnLxn4BoAYtxCO3A/viewform?usp=sharing>

Hungarian:

https://docs.google.com/forms/d/e/1FAIpQLSd0Gbvg5mjHT2U_3bZoTuohvGUBcr7dgr6g_vRUIm-OsWwbQ/viewform?usp=sharing

Turkish:

245 https://docs.google.com/forms/d/e/1FAIpQLSdKlcdVYBjcX0l4zfoRaf3ejTx3rmm1q0xN5WSbV3_ehRYKeA/viewform?usp=sharing

Portuguese:

250 https://docs.google.com/forms/d/e/1FAIpQLSec3IOPMSG0qSQS_Cp4fwI3VIUhp-IQ7Tm7JAWpoMSa3Dadew/viewform?usp=sharing

French:

<https://docs.google.com/forms/d/e/1FAIpQLScIjfR63i1Fy7exMetX--icIRdc2Cx3aWovox2ynGAM4L-bQ/viewform?usp=sharing>

Polish:

255 <https://docs.google.com/forms/d/e/1FAIpQLSd3VU7k5ImWaNf4VQP8v7h5MKbqsis0n-KJzccK7Zr3MZbCcA/viewform?usp=sharing>

Spanish:

<https://docs.google.com/forms/d/e/1FAIpQLSd3VU7k5ImWaNf4VQP8v7h5MKbqsis0n-KJzccK7Zr3MZbCcA/viewform?usp=sharing>

Swedish:

260 https://docs.google.com/forms/d/e/1FAIpQLSfWdMLtuI3gzHm9MvrGuc6tw4E5A0RYhkjdIpoRoyU_6tKGqg/viewform?usp=sharing

Romanian:

https://docs.google.com/forms/d/e/1FAIpQLSfMyCX1Fyp_fY6guwMAPGX4n1Dn4t4j0v1e1JYvvZcZXxFABw/viewform?usp=sharing

265 Czech:

https://docs.google.com/forms/d/e/1FAIpQLSfMyCX1Fyp_fY6guwMAPGX4n1Dn4t4j0v1e1JYvvZcZXxFABw/viewform?usp=sharing

Croatian, Bosnian, and Montenegrin:

270 https://docs.google.com/forms/d/e/1FAIpQLSfMyCX1Fyp_fY6guwMAPGX4n1Dn4t4j0v1e1JYvvZcZXxFABw/viewform?usp=sharing

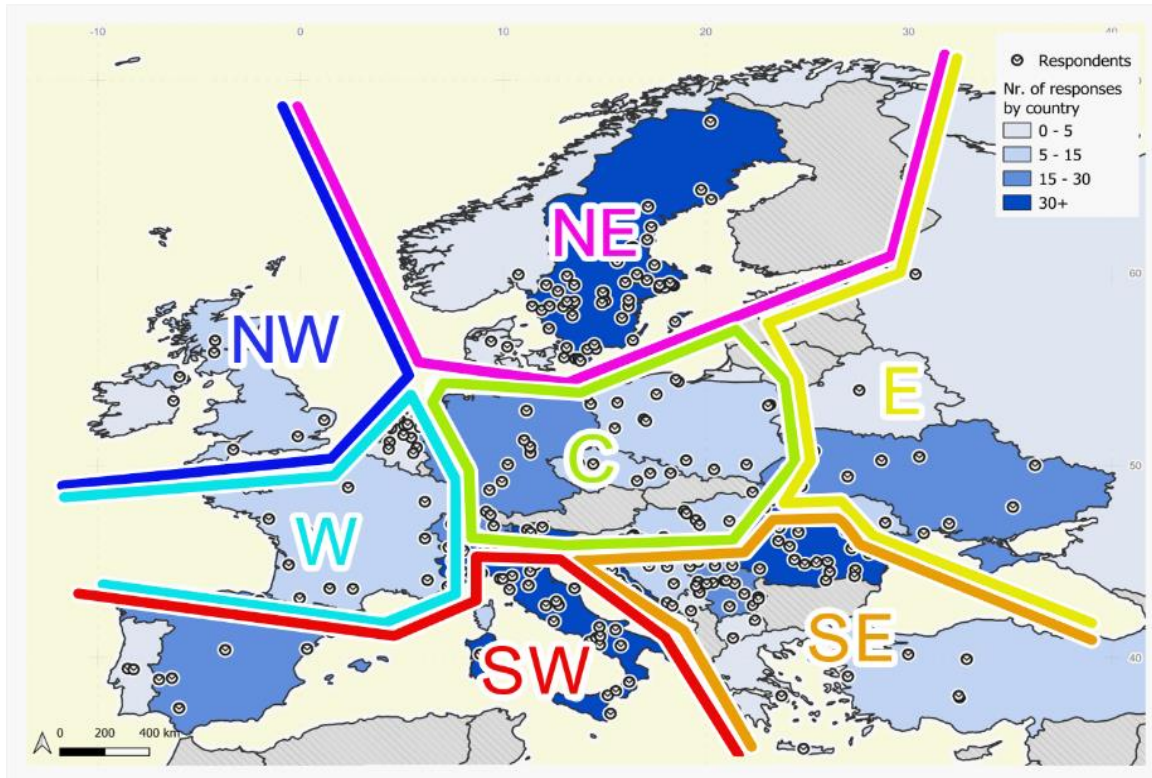
Russian:

<https://docs.google.com/forms/d/e/1FAIpQLSdpp-NnENqs0Kzk-rH3jZr-UJaBsHLnJUf0BK8BzOEWqqWrUA/viewform?usp=sharing>

Serbian:

275 <https://docs.google.com/forms/d/e/1FAIpQLSdpp-NnENqs0Kzk-rH3jZr-UJaBsHLnJUf0BK8BzOEwqWrUA/viewform?usp=sharing>

S2. Overview of the distribution of respondents by region



280 **Fig. S1:** Overview of the distribution of respondents by European region (adapted from those used in The World Factbook), including north-western (NW), north-eastern (NE), western (W), central (C), eastern (E), south-western (SW) and south-eastern (SE) Europe.

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Table S1: List of countries represented by the responders to the questionnaire, the corresponding country code, English country names, the corresponding European Regions (according to this study, see Fig S1 for explanation of regions), and the number of responses for each region and country.

Country/ Region			Country/ Region				
Code	Name	N	Code	Name	N		
North-Western Europe Total		17	North-Eastern Europe Total		61		
NW	IE	Ireland	3	NE	DK	Denmark	3
	GB	United Kingdom of Great Britain and Northern Ireland	14		NO	Norway	2
					SE	Sweden	56
Central Europe Total		74	Eastern Europe Total		38		
	CH	Switzerland	16		BY	Belarus	5
	CZ	Czechia	7	E	MD	Moldova, Republic of	7
C	DE	Germany	24		RU	Russian Federation	1
	HU	Hungary	11		UA	Ukraine	25
	PL	Poland	15	South-Eastern Europe Total		134	
	SI	Slovenia	1	BA	Bosnia and Herzegovina	7	
Western Europe Total		47	GR	Greece	3		
W	BE	Belgium	4	HR	Croatia	44	
	FR	France	15	SE	ME	Montenegro	1
	NL	Netherlands, Kingdom of the	28	MK	North Macedonia	2	
South-Western Europe Total		110	RO	Romania	35		
SW	ES	Spain	19	RS	Serbia	29	
	IT	Italy	87	TR	Turkey	10	
	PT	Portugal	4		Other	3	
Europe (total) = 481							

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S3. Overview of preparedness

S3.1. Regional patterns in preparedness

Table S2: Use of forecasting across respondents by region and country.

Region	Country	Yes, seasonal and sub-seasonal	Yes, seasonal	Yes, sub-seasonal	Yes, other	No	I don't know	Grand Total
SW	ES	6	5			7	1	19
	IT	14	10	9	5	48		86
SE	HR	12	6	3	1	12	9	43
	RS	11	2	4		12		29
	RO	6	4	3	1	20	1	35
	TR	3	3		1	3		10
E	UA	2	3	1		16	2	24

C	PL	2	1	4	1	4	3	15
	HU	2		1	2	6		11
	DE	3	2	4		13	2	24
	CH	4		6		5	1	16
W	NL	8		10		9	1	28
	FR	5	2	1		6	1	15
NW	GB	5	1		1	6	1	14
NE	SE		1	5		7		13
Grand Total		92	46	61	14	194	25	432

Table S3: Use of DMPs across respondents by region and country.

Region	Country	Yes, both	Yes, only short-term	Yes, only long-term	No, we do not have either	I don't know	Grand Total
SW	ES	15			4		19
	IT	24	6	10	43	2	85
SE	HR	9	4	3	11	12	39
	RS	3	1	5	15	2	26
	RO	12	1	3	11	5	32
	TR	6			3	1	10
E	UA	1	2	3	14	3	23
C	PL	1	2	1	10	1	15
	HU	5			3	1	9
	DE	3	3	3	10	2	21
	CH	4	2	4	4	2	16
W	NL	14	4	6	3		27
	FR	8	2	1	3	1	15
NW	GB	6		1	5	2	14
NE	SE	6		7	33	10	56
Grand Total		125	32	54	194	49	454

Table S4: Timing of introduction of update of DMPs across respondents by region and country.

Region	Country	DMP in place before 2018	Both introduced after 2018	Only short-term after 2018	Only long-term after 2018	No DMP	I don't know	Grand Total
SW	ES	3	7		1	3	1	15
	IT	17	9	6	3	42	4	81
SE	HR		4		2	1	27	34
	RS		2	1	9		13	25
	RO		9	2	3	10	8	32
	TR	1	3	1	1	3	1	10
E	UA	13			5		3	21
C	PL	2	1			8	3	14
	HU		4		1	3	1	9
	DE		1	3	3		10	17
	CH		2	1	5		4	12
W	NL		9	5	5		7	26
	FR	2	4	3		2	3	14
NW	GB	3	3	1		4	3	14
NE	SE	5	5			1	3	14

Grand Total	50	66	27	43	97	103	386
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S3.1.2. Organizational Differences

Table S5: Use of forecasting systems across respondents by type of organization and operational scale

		Yes, seasonal and sub-seasonal	Yes, seasonal	Yes, sub-seasonal	Yes, other	No	I don't know	Grand Total
Organization Type	NGO/ Charity	4	1	3	1	9	1	19
	Other	3	4	4		12	1	24
	Private	9	5	3	1	18	1	37
	Public/ Governmental	67	34	51	9	139	21	321
	Scientific	9	2	3	3	15	1	33
	#N/A					1		1
Grand Total		92	46	64	14	194	25	435
Operational Level	International	14	7	3	3	9		36
	National	33	14	20	3	45	15	130
	Regional	45	25	41	8	139	9	267
	#N/A					1	1	2
Grand Total		92	46	64	14	194	25	435

Table S6: Use of DMPs across respondents by y type of organization and operational scale

		Yes, both short-term and long-term	Yes, only long-term	Yes, only short-term	No	I don't know	Grand Total
Organization Type	NGO/ Charity	8	3	1	7		19
	Other	4	3	1	14		22
	Private	9	1	4	21	1	36
	Public/ Governmental	100	23	48	138	44	353
	Scientific	3	3	1	15	4	26
	#N/A	1			7		1
Grand Total		125	33	55	195	49	457
Operational Level	International	12	3	2	12	2	31
	National	33	10	13	41	22	119
	Regional	80	20	38	142	25	305
	#N/A			2			2
Grand Total		49	195	125	33	55	457

Table S7: Use of forecasting systems by type of organization and operational scale

		Both in place before 2018	Both since 2018	Only long-term since 2018	Only short-term since 2018	No	I don't know	Grand Total
Organization Type	NGO/ Charity	1	2	2	2	7	3	17
	Other	4	2	3	2	9	1	21
	Private	4	5	1	2	17	3	32

	Public/ Governmental	36	54	21	34	58	87	290
	Scientific	5	2	1	3	6	11	28
	#N/A		1					1
	Grand Total	50	66	28	43	97	105	389
Operational Level	International	4	4	4	3	9	8	32
	National	13	16	6	13	23	42	113
	Regional	33	46	17	27	65	55	243
	#N/A			1				1
	Grand Total	50	66	28	43	97	105	389

S4. Overview of effectiveness

S4.1. Regional patterns in effectiveness

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Table S8: Perceived effectiveness by region and country.

Region	Country	Mean	1 (not efficient)	2	3 (neutral)	4	5 (very efficient)	I don't know	Not relevant	Grand Total
SW	ES	3.7	1		4	7	3	1	1	17
	IT	3.6	2	9	22	19	18	4	6	80
SE	HR	3.0	4	2	6	4	3	8	11	38
	RS	3.4	1	3	6	9	2	1	4	26
	RO	3.3	2	3	5	5	4	8	5	32
E	UA	3.2		2	2	1	1	8	4	18
C	PL	2.7	1	1	3	1			6	12
	DE	3.2		5	2	5	1	2	6	21
	CH	3.7		1	3	3	2	2	3	14
W	NL	3.7		1	7	11	3	3	1	26
	FR	3.7		1	5	3	3		1	13
NW	GB	3.4		1	6	1	2	2	2	14
NE	SE	4.0			2	6	2	12	24	46
TOTAL		3.4	16	33	86	87	48	63	87	420

S4.2. Organizational differences

Table S9: Perceived effectiveness by type of organization and operational scale

		Mean	1 (not efficient)	2	3 (neutral)	4	5 (very efficient)	I don't know	Not relevant	Grand Total
Organization Type	NGO/ Charity	2.6	3	4	4	1	2	1	2	17
	Other	3.6		4	3	4	5	2	3	21
	Private	3.5	2	3	7	8	6	3	7	36
	Public/ Governmental	3.5	10	21	68	70	35	53	67	324
	Scientific	3.2	1	1	4	5		4	9	24
	#N/A	3.0	3	4	4	1	2	1	2	1
	Grand Total	3.4	16	33	87	88	48	63	88	423
Operational Level	International		1	2	5	8	4	2	8	30
	National		7	6	25	20	9	23	18	108
	Regional		8	24	57	59	35	38	62	283
	#N/A			1		1				2
	Grand Total	3.4	16	33	87	88	48	63	88	423

315

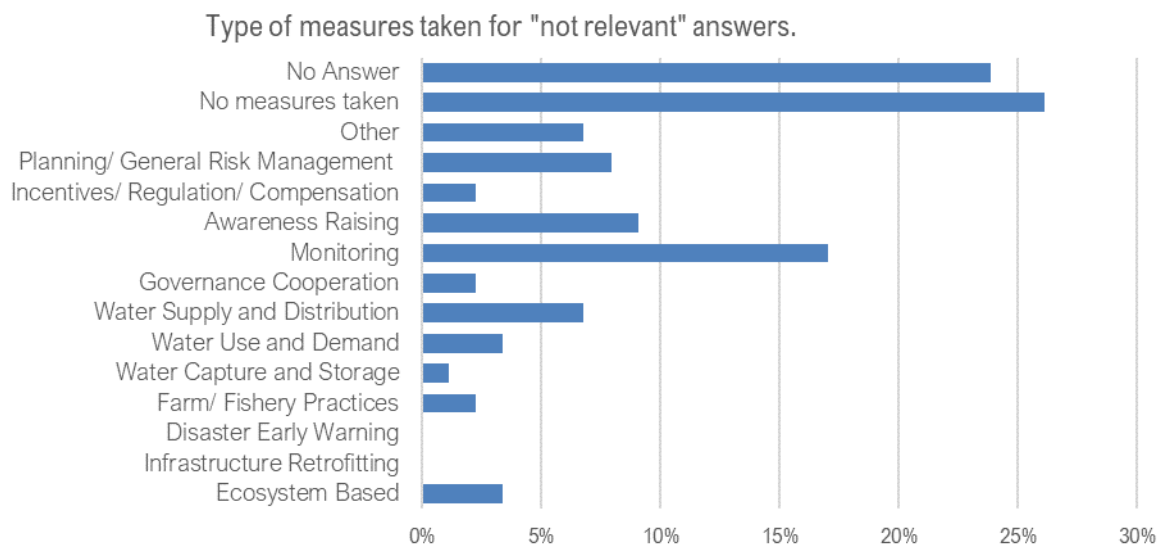


Fig. S2: Type of measures taken by the respondents who selected their measures to be “not relevant” in question 14 of the questionnaire. The type of measure taken is reported in the answer to question 13.

320 S4.3. Influence of Preparedness on effectiveness

Table S10: Effect of preparedness (i.e. forecasting systems and presence of DMPs) on effectiveness of response.

Category	Group	N	MEAN	Yes		No		DIFF (Yes-No)	P Value	
				N	MEAN	N	MEAN			
All		242	3.5	143	3.6	99	3.3	+0.29	0.03	
FORECASTING SYSTEMS	ES	14	3.7	10	3.9	4	3.3	+0.65	**	
	IT	65	3.6	25	3.7	40	3.5	+0.27	0.39	
	HR	15	3.0	12	3.3	3	2	+1.25	**	
	RS	21	3.4	13	3.7	8	2.9	+0.82	**	
	RO	19	3.3	12	3.3	7	3.3	+0.05	**	
	UA	19	3.3	12	3.3	7	3.3	+0.05	**	
	DE	11	3.1	3	3.3	8	3	+0.33	**	
	NL	22	3.7	16	3.7	6	3.8	-0.15	**	
	FR	12	3.7	7	4.3	5	2.8	+1.49	**	
	GB	9	3.6	6	3.7	3	3.3	+0.33	**	
	SE	2	3.5	1	3	1	4	-1.00	**	
	Organization	Public	180	3.5	110	3.6	70	3.3	+0.31	0.04
		Private	25	3.5	12	3.9	13	3.2	+0.69	0.11
Scientific		8	3.4	4	3.8	4	3	+0.75	**	
NGO		12	2.8	8	3.1	4	2.3	+0.88	**	
Other		16	3.6	9	3.2	7	4.1	-0.92	**	
International		19	3.6	16	3.6	3	3.7	-0.04	**	
National		56	3.3	40	3.3	16	3.3	+0.01	0.95	
Regional		166	3.4	87	3.6	79	3.2	+0.42	0.01	
Socio-Economic sectors	Agriculture	155	3.4	94	3.5	61	3.3	+0.26	0,11	
	Forestry	93	3.4	52	3.5	41	3.2	+0.30	0,13	
	Aquaculture	74	3.5	41	3.7	33	3.2	+0.44	0,07	

DROUGHT MANAGEMENT PLANS		Energy and Industry	86	3.5	55	3.7	31	3.1	+0.53	0,03		
		Water Transports	70	3.4	45	3.5	25	3.2	+0.31	0,23		
		Tourism	85	3.6	54	3.8	31	3.2	+0.60	0,01		
		Public Water Supply	149	3.6	82	3.9	67	3.3	+0.54	0,00		
		Water Quality	113	3.6	71	3.7	42	3.3	+0.40	0,02		
		Air Quality	58	3.4	32	3.6	26	3.2	+0.47	0,08		
		Human Health	61	3.4	33	3.6	28	3.2	+0.42	0,12		
		Water Access Conflicts	51	3.4	28	3.6	23	3.2	+0.43	0,13		
		Ecosystems	Freshwater Ecosystems	112	3.4	66	3.6	46	3.2	+0.46	0,01	
			Terrestrial Ecosystems	94	3.4	57	3.6	37	3.1	+0.45	0,02	
			Soil System	86	3.4	50	3.6	36	3.2	+0.39	0,04	
			Wildfires	77	3.4	43	3.6	34	3.2	+0.40	0,06	
		Other	Other	39	3.6	27	3.8	12	3.2	+0.61	0,12	
		All		258	3.4	164	3.6	94	3.1	+0.51	0.00	
		Country responses)	(10+	ES	15	3.7	14	3.8	1	3	+0.79	**
				IT	70	3.6	37	3.9	33	3.2	+0.68	0,01
				HR	16	3.1	10	3.4	6	2.5	+0.90	**
				RS	19	3.3	7	4.1	12	2.8	+1.31	**
				RO	18	3.4	14	3.6	4	2.8	+0.89	**
				DE	11	3.1	7	3.3	4	2.8	+0.54	**
				NL	22	3.7	19	3.9	3	2.7	+1.23	**
				FR	12	3.7	9	3.3	3	4.7	-1.33	**
				UK	9	3.5	7	3.6	2	3	+0.57	**
				SE	8	4.0	2	3	6	4.3	-1.33	**
		Organization		Public	192	3.5	128	3.7	64	3	+0.69	0.00
				Private	26	3.5	14	3.7	12	3.3	+0.46	**
				Scientific	9	3.1	4	3.3	5	3	+0.25	**
			NGO	14	2.6	10	2.9	4	2	+0.90	**	
			Other	16	3.6	7	3	9	4.1	-1.11	**	
			International	17	3.8	12	4	5	3.2	+0.80	**	
			National	62	3.3	42	3.4	20	3	+0.40	0,17	
			Regional	177	3.5	108	3.7	69	3.2	+0.54	0,00	
	Socio-Economic sectors		Agriculture	167	3.4	111	3.6	56	3.1	+0.45	0,01	
			Forestry	98	3.3	62	3.6	36	2.9	+0.70	0,00	
			Aquaculture	79	3.4	52	3.6	27	3	+0.60	0,01	
			Energy and Industry	88	3.5	60	3.8	28	3	+0.80	0,00	
			Water Transports	73	3.4	52	3.6	21	3	+0.53	0,04	
			Tourism	89	3.5	61	3.7	28	3.2	+0.53	0,02	
			Public Water Supply	156	3.7	102	3.9	54	3.2	+0.63	0,00	
			Water Quality	115	3.6	84	3.8	31	3.1	+0.64	0,00	
			Air Quality	60	3.4	39	3.6	21	3.1	+0.52	0,07	
			Human Health	62	3.5	40	3.7	22	3	+0.65	0,02	
			Water Access Conflicts	51	3.4	35	3.6	16	3.1	+0.48	0,15	
	Eco systems		Freshwater Ecosystems	117	3.4	85	3.6	32	3	+0.53	0,01	
			Terrestrial Ecosystems	99	3.4	67	3.6	32	3	+0.60	0,01	
			Soil System	90	3.4	61	3.6	29	3	+0.64	0,00	
			Wildfires	80	3.4	51	3.7	29	3	+0.67	0,01	
	Other		Other	39	3.6	27	3.8	12	3.2	+0.61	0,12	

** Pair not suited for Wilcoxon test because of sample size too small (fewer than 16 (Dwivedi et al., 2017))

S4. Overview of Timeliness

S4.1. Regional patterns of timeliness

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Table S11: Perceived timeliness by region and country.

Region	Country	Mean	before March	March	April	May	June	July	August	September	After September	Grand Total
SW	ES	5.3	6			1	4	2			3	16
	IT	4.8	19	6	9	13	16	6	2	1	5	77
SE	HR	6.2	4	3	2	2		6		5	4	26
	RS	4.6	6		4	3	8				1	22
	RO	5.1	8	2		3	2	5		1	3	24
E	UA	6.6	1				3	5	1		1	11
C	DE	4.7	6		2	1	4	3			1	17
	CH	5.8		2	1	1	3	4	1			12
W	NL	4.5	7		5	4	8	2				26
	FR	5.0	3		2	1	3	2		1		12
NW	GB	6.0		1	1	1	3	6				12
NE	SE	5.3	7			3	6	4	1		2	23
Grand Total		5.1	90	21	27	37	65	52	7	8	28	307

S4.2. Organizational differences

330 **Table S12:** Perceived timeliness by type of organization and operational scale

		Before March 2022	March 2022	April 2022	May 2022	June 2022	July 2022	August 2022	Sept 2022	After Sept 2022	Grand Total
Organization Type	NGO/ Charity	6	3	1	1	1	2	1		2	17
	Other	9	1	1	2	5		1			19
	Private	9	3	2	4	5	3			3	29
	Public/ Governmental	62	13	22	30	53	43	3	8	20	254
	Scientific	4	2	1		2	3	2		3	17
	#N/A						1				1
Grand Total		90	22	27	37	66	52	7	8	28	337
Operational Level	International	6	3	1	1	3	3	3		2	22
	National	24	6	6	8	16	13	1	2	13	89
	Regional	59	13	20	28	46	36	3	6	13	224
	#N/A	1				1					2
	Grand Total		90	22	27	37	66	52	7	8	28

S4.3. Influence of preparedness on timeliness

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Table S13: Effect of preparedness (i.e. forecasting systems and presence of DMPs) on timeliness of response.

Category	Group	N	MEAN	Yes		No		DIFF (Yes-No)	P Value
				N	MEAN	N	MEAN		
Grand total		291	5.0	161	4.6	130	5.5	-0.85	0.00
Country (10+ responses)	ES	15	6.0	11	6.5	4	4.8	+1.7	**
	IT	72	5.8	30	5.1	42	6.3	-1.24	0.39
	HR	20	6.1	14	6.4	6	5.5	+0.93	**
	RS	22	5.6	14	5.4	8	6	-0.64	**
	RO	24	6.1	11	5.3	13	6.8	-1.57	**
	UA	10	7.7	2	5	8	8.4	-3.38	**
	DE	15	5.8	7	6.4	8	5.3	+1.18	**
	CH	11	6.8	8	6.4	3	7.7	-1.29	**
	NL	25	5.5	17	5.8	8	5	+0.82	**
	FR	12	6.0	7	6.6	5	5.2	+1.37	**
	UK	11	7.2	6	6.8	5	7.6	-0.77	**
SE	6	6.3	2	5	4	7	-2.00	**	
FORECASTING SYSTEMS Organization	Public	234	6.0	146	6	88	6.1	-0.11	0.00
	Private	28	5.8	14	5	14	6.5	-1.50	**
	Scientific	13	6.9	5	3.6	8	8.9	-5.28	**
	NGO	17	5.6	11	5.2	6	6.3	-1.15	**
	Other	18	5.0	7	4.3	11	5.4	-1.08	**
	International	20	6.0	13	4.7	7	8.4	-3.74	**
	National	75	6.1	46	6	29	6.3	-0.27	0.02
	Regional	192	5.9	101	5.7	91	6.1	-0.33	0.12
Socio-Economic sectors ***	Agriculture	199	0.4	124	0.2	75	0.6	-0.38	0.27
	Forestry	130	-0.2	76	-0.7	54	0.4	-1.12	0.01
	Aquaculture	105	-0.1	63	-0.4	42	0.4	-0.76	0.05
	Energy and Industry	111	-0.4	69	-0.9	42	0.4	-1.31	0.01
	Water	96	-0.8	61	-1.3	35	0.1	-1.43	0.00
	Transports	111	-0.7	70	-1.2	41	0.2	-1.43	0.00
	Tourism	189	-0.4	114	-0.8	75	0.1	-0.83	0.01
	Public Water Supply	142	-0.7	93	-1.1	49	0.1	-1.19	0.00
	Water Quality	81	-0.9	47	-1.7	34	0.2	-1.84	0.00
	Air Quality	84	-1.1	48	-1.9	36	-0.1	-1.74	0.00
	Human Health	68	-0.9	41	-1.4	27	-0.1	-1.29	0.02
Water Access Conflicts									
Ecosystems ***	Freshwater Ecosystems	146	-0.5	96	-0.8	50	0.2	-1.06	0.01
	Terrestrial Ecosystems	126	-0.6	77	-0.9	49	0	-0.92	0.02
	Soil System	114	-0.3	70	-0.8	44	0.5	-1.35	0.00
	Wildfires	107	-0.9	62	-1.2	45	-0.4	-0.82	0.05

	Other ***	Other	56	-1.3	33	-1.5	23	-0.9	-0.62	0.35
	Grand total		309	3.9	184	3.7	125	4.3	-0.59	0.04
DMPs	Country (10+ responses)	ES	16	5.3	15	5.3	1	6	-0.73	**
		IT	74	4.9	38	4.2	36	5.6	-1.45	0.01
		HR	19	5.4	13	6.7	6	2.5	+4.19	**
		RS	20	4.4	7	4.9	13	4.2	+0.63	**
		RO	22	4.9	15	5.1	7	4.4	+0.64	**
		UA	10	6.6	3	5	7	7.3	-2.29	**
		DE	15	4.6	9	4.4	6	4.8	-0.39	**
		CH	11	5.7	8	5.9	3	5.3	+0.54	**
		NL	26	4.4	23	4.4	3	4.7	-0.23	**
		FR	12	5.0	9	4.6	3	6.3	-1.78	**
	UK	11	6.2	7	6.1	4	6.5	-0.36	**	
	SE	20	5.5	5	5.4	15	5.5	-0.13	**	
	Organization	Public	234	5.0	146	5	88	5.1	-0.11	0.68
		Private	28	4.8	14	4	14	5.5	-1.50	**
		Scientific	13	5.9	5	2.6	8	7.9	-5.28	**
		NGO	17	4.6	11	4.2	6	5.3	-1.15	**
		Other	18	4.0	7	3.3	11	4.4	-1.08	**
		International	20	5.0	13	3.7	7	7.4	-3.74	**
	Socio-Economic Sectors ***	National	75	5.1	46	5	29	5.3	-0.27	0.63
		Regional	192	4.9	101	4.7	91	5.1	-0.33	**
		Agriculture	191	0.3	108	0.1	83	0.5	-0.40	0.36
	Socio-Economic Sectors ***	Forestry	129	-0.3	68	-0.9	61	0.4	-1.35	0.02
		Aquaculture	99	-0.1	52	-0.6	47	0.4	-1.02	0.11
		Energy and Industry	110	-0.5	66	-0.8	44	0	-0.86	0.26
		Water	94	-0.8	55	-1.4	39	0	-1.46	0.01
		Transports	107	-0.7	62	-1.3	45	0.1	-1.43	0.02
		Tourism	181	-0.4	95	-0.8	86	0	-0.82	0.02
Public Water Supply		143	-0.7	82	-1.3	61	0.2	-1.46	0.00	
Water Quality		80	-0.9	41	-2	39	0.2	-2.18	0.00	
Air Quality		84	-1.2	42	-2.1	42	-0.2	-1.93	0.00	
Human Health		69	-0.9	36	-1.7	33	0	-1.75	0.01	
Ecosystems ***	Water Access	69	-0.9	36	-1.7	33	0	-1.75	0.01	
	Conflicts	69	-0.9	36	-1.7	33	0	-1.75	0.01	
	Freshwater Ecosystems	141	-0.5	78	-1	63	0.1	-1.04	0.01	
	Terrestrial Ecosystems	122	-0.6	68	-1.1	54	0.1	-1.27	0.01	
Ecosystems ***	Soil System	112	-0.4	60	-0.9	52	0.2	-1.09	0.08	
	Wildfires	104	-0.8	54	-1.4	50	-0.2	-1.17	0.04	
	Other ***	Other	55	-1.3	25	-2.1	30	-0.57	-1.50	0.08 [#]

*** Timeliness expressed as relative timeliness ($response_{(month)} - impact_{(month)}$)

** Pair not suited for Wilcoxon test because of sample size too small (fewer than 16 (Dwivedi et al., 2017))

[#] Sample normally distributed, p-value from t-test carried out

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S.4. Changes in drought risk management

S4.1. Regional patterns in management shifts

Table S14: Shifts in awareness, preparedness, and effectiveness in the response between 2018 and 2022 by region and country.

Region	Country	Awareness				Preparedness				Effectiveness			
		Less	Same	More	Don't know	Less	Same	More	Don't know	Less	Same	More	Don't know
SW	ES		8	11		8	9		8	8			
	IT	2	31	42	6	1	30	39	7	1	29	39	9
SE	HR	3	11	19	5	3	16	9	4	3	13	13	5
	RS	2	12	9	1	2	11	5	2	1	12	5	3
	RO		10	9	7		11	5	7	1	9	4	7
	TR	1	1	8		2	4	4		2	4	4	
E	UA	3	6	5	2	4	7	3	3	4	7	1	3
C	PL		9	5			9	1	1		9	1	1
	HU		3	6			4	5		1	4	4	
	DE		9	9	1		10	8	2		10	7	2
	CH		8	7	1		8	7	1	1	9	4	2
W	NL		4	22	1		7	19	1		8	16	2
	FR		6	9		1	8	5	1	1	7	6	1
NW	UK	2	3	8	1	1	6	5	2	2	4	6	2
NE	SE			42	14	6	3	1	46	7	1	2	46
Grand total		13	121	211	39	20	142	125	77	24	134	120	83

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S4.2. Organizational differences

Table S15: Shifts in awareness, preparedness, and effectiveness in the response between 2018 and 2022 by organization and operational scale.

		Awareness				Preparedness				Effectiveness			
		Less	Same	More	Don't know	Less	Same	More	Don't know	Less	Same	More	Don't know
	NGO/ Charity		5	10	1	1	8	5	1	1	6	6	1
	Other	1	7	11	2		8	9	3	1	7	10	2
Organisatio	Private		16	19	1		21	10	2		16	12	4
n Type	Public/ Gov.	11	103	176	39	20	110	108	74	22	113	98	81
	Scientific	1	10	15	3	1	12	9	6		13	8	6
	#N/A			1			1			1			
Grand total		13	141	232	46	22	160	141	86	25	155	134	94
	International		15	16	1		20	10	1		15	12	1
Operational	National	4	36	59	14	7	47	39	17	8	46	37	18
Level	Regional	9	90	155	31	15	92	92	68	17	93	85	75
	#N/A			2			1				1		
Grand total		13	141	232	46	22	160	141	86	25	155	134	94

S4.3. Influence of preparedness on perceived shifts in management

350 **Table S16:** Comparison of awareness, preparedness, and effectiveness in the response in drought risk management between 2018 and 2022 by function of preparedness of the respondents. “Yes, any type” means any type of forecasting system and drought management plan that could be selected in the questionnaire. The graph only shows valid answers, meaning that “I don’t know” and “NA” are excluded.

	Answer	Awareness					Preparedness					Effective							
		More	Same	Less	I don't know	#N/A	Total	More	Same	Less	I don't know	#N/A	Total	More	Same	Less	I don't know	#N/A	Total
FORECASTING SYSTEMS	Yes, any	120	62	4	7	23	216	93	74	4	13	32	216	91	71	5	19	30	216
	No	71	70	8	2	23	194	40	76	13	28	37	194	35	73	15	31	40	194
	Yes, both seasonal and sub-seasonal	55	28		1	8	92	39	37	1	3	12	92	41	33	2	6	10	92
	Yes, seasonal forecast (1-7 months)	16	16	3	3	8	46	13	19	3	3	8	46	14	18	1	3	10	46
	Yes, sub-seasonal (0-5 weeks)	40	14		3	7	64	34	13		7	10	64	30	16	1	10	7	64
	Other	9	4	1			14	7	5			2	14	6	4	1		3	14
	I don't know	9	9	1	5	1	25	7	8	1	8	1	25	5	11	1	7	1	25
	#N/A	32			12	2	46	1	2	4	37	2	46	3		4	37	2	46
	Total	232	141	13	46	49	481	141	160	22	86	72	481	134	155	25	94	73	481
DROUGHT MANAGEMENT	Yes, any	127	58	3	7	18	213	91	75	3	17	27	213	88	75	8	21	21	213
	No	84	64	7	23	17	195	36	70	15	47	27	195	33	66	13	50	33	195
	Yes, both short-term and	79	31	2	4	9	125	65	39	2	9	10	125	66	36	4	11	8	125

long-term

Yes, only long-term

Yes, only short-term

I don't know

#N/A

Total 232 141 13 46 49 481 141 160 22 86 72 481 134 155 25 94 73 481

INTRODUCTION OF DROUGHT MANAGEMENT PLANS

Both plans were already in place before 2018

Yes, plans (any) since 2018

Both plans since 2018

Only long-term plan since 2018

18	9	1	1	4	33	12	12	1		8	33	9	16	1		7	33
30	18		2	5	55	14	24		8	9	55	13	23	3	10	6	55
14	16	2	15	2	49	10	11	3	20	5	49	8	12	3	21	5	49
7	3	1	1	12	24	4	4	1	2	13	24	5	2	1	2	14	24

23	16	2	2	7	50	16	17	3	7	7	50	15	17	2	7	9	50
87	36	4	2	8	137	68	46	3	7	13	137	62	44	9	10	12	137
45	14	1	2	4	66	39	17		5	5	66	40	11	4	7	4	66
18	9			1	28	15	9	1		3	28	9	15	2		2	28

Only short-term plan since 2018	24	13	3		3	43	14	20	2	2	5	43	13	18	3	3	6	43
We do not have any plan	38	40	1	12	6	97	25	42	2	15	13	97	22	39	2	18	16	97
I don't know	37	37	5	14	12	105	22	40	7	20	16	105	22	44	5	21	13	105
#N/A	47	12	1	16	16	92	10	15	7	37	23	92	13	11	7	38	23	92
Total	232	141	13	46	49	481	141	160	22	86	72	481	134	155	25	94	73	481

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Table S17: Results of the chi-squared test between respondents with and without drought management plans and forecasts, and those that introduced drought management plans before and after 2018 across the dimensions of perceived awareness, preparedness, and effectiveness in the response.

More	Same or Less	Aware			Prepared			Effective		
		N	χ^2	p-value	N	χ^2	p-value	N	χ^2	p-value
Yes, any type of DMP	No DMP	335	9.60	0.00	300	16.3	0.00	290	19.5	0.00
Yes, any type of forecast	No forecast	343	6.41	0.01	290	16.6	0.00	283	13.4	0.00
DMPs since 2018	DMPs before 2018	168	1.64	0.20	153	2.08	0.15	149	1.01	0.65

360

References

365 Dwivedi, A. K., Mallawaarachchi, I., & Alvarado, L. A. (2017). Analysis of small sample size studies using nonparametric bootstrap test with pooled resampling method. <https://doi.org/10.1002/sim.7263>