

Supplemental Online Materials for

Climate Communication in the Hybrid Media System: Media and Stakeholder Logics on Social Media

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Appendix 1.*Media and stakeholder profiles on social media*

Media and Stakeholder groups	Account	Platforms			
		FB	IG	TT	YT
News agencies	Agence France-Presse (AFP)	X	-	-	X
	Deutsche Presse Agentur (DPA)	X	X	-	X
	Reuters	-	-	-	X
Public broadcasters	Deutsche Welle	X	X	-	X
	Tagesschau	X	X	X	X
	ZDF heute	X	X	-	X
Quality newspapers	Die Zeit / Zeit Online	X	X	X	X
	Frankfurter Allgemeine Zeitung (FAZ)	X	X	X	X
	Süddeutsche Zeitung (SZ)	X	X	-	-
	Die Tageszeitung (taz)	X	X	X	-
	Welt	X	X	-	X
Tabloids	BILD	X	X	-	X
Political Magazines	Focus	X	X	-	-
	Der Spiegel	X	X	-	X
Alternative Media	Compact	X	-	-	X
	Junge Freiheit	X	X	X	X
	Neues Deutschland	X	X	-	X
Political Satire formats	Extra 3	X	X	X	X
	Heute Show	X	X	X	X
	ZDF Magazin Royale	X	X	-	X
Political Parties	CDU	X	X	X	X
	CDU Parliamentary Group	X	X	X	X
	CSU	X	X	X	X
	CSU Parliamentary Group	X	X	-	X
	SPD	X	X	-	X
	SPD Parliamentary Group	X	X	X	X
	Alliance 90/The Greens	X	X	-	X
	Alliance 90/The Greens Parliamentary Group	X	X	-	X
	Die Linke	X	X	X	X
	Die Linke Parliamentary Group	X	X	X	X
	FDP	X	X	-	X
	FDP Parliamentary Group	X	X	X	X
	AfD	X	X	-	X
	AfD Parliamentary Group	X	X	X	X
Politicians (federal)	Frank-Walter Steinmeier (<i>Federal president</i>)	-	-	-	-
	Chancellor account Olaf Scholz	-	X	-	-
	Olaf Scholz (<i>Chancellor</i>)	X	X	-	X
	Annalena Baerbock (<i>Minister for Foreign Affairs</i>)	X	X	-	X
	Steffi Lemke (<i>Minister for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection</i>)	-	X	-	-
	Robert Habeck (<i>Minister for Economic Affairs and Climate Action</i>)	-	X	-	X
	Christian Lindner (<i>Minister of Finance</i>)	X	X	-	X
	Nancy Faeser (<i>Minister of the Interior and Community</i>)	X	X	-	-
	Marco Buschmann (<i>Minister of Justice</i>)	X	X	-	X
	Hubertus Heil (<i>Minister of Labour and Social Affairs</i>)	X	X	-	X
	Boris Pistorius (<i>Minister of Defense</i>)	X	X	-	-
	Cem Özdemir (<i>Minister of Food and Agriculture</i>)	X	X	-	-
	Lisa Paus (<i>Minister for Family Affairs, Senior Citizens, Women and Youth</i>)	X	X	-	X

	Karl Lauterbach (<i>Minister of Health</i>)	X	X	-	-
	Volker Wissing (<i>Minister for Digital and Transport</i>)	X	X	-	-
	Bettina Stark-Watzinger (<i>Minister of Education and Research</i>)	X	X	-	X
	Svenja Schulze (<i>Minister for Economic Cooperation and Development</i>)	X	X	-	X
	Klara Geywitz (<i>Minister for Housing, Urban Development and Building</i>)	-	-	-	-
	Friedrich Merz (<i>CDU Parliamentary group leader</i>)	X	X	X	X
	Rolf Mützenich (<i>SPD Parliamentary group leader</i>)	X	-	-	-
	Katharina Dröge (<i>The Greens Parliamentary group leader</i>)	X	X	-	X
	Britta Haßelmann (<i>The Greens Parliamentary group leader</i>)	X	X	-	X
	Christian Dürr (<i>FDP Parliamentary group leader</i>)	X	X	X	X
	Alice Weidel (<i>AfD Parliamentary group leader</i>)	X	X	X	X
	Tino Chrupalla (<i>AfD Parliamentary group leader</i>)	X	X	X	X
	Amira Mohamed Ali (<i>Die Linke Parliamentary group leader</i>)	X	X	-	-
	Dietmar Bartsch (<i>Die Linke Parliamentary group leader</i>)	X	-	X	-
	Sahra Wagenknecht (<i>Die Linke/BSW</i>)	X	X	X	X
Politicians (Committee on the Environment, Nature Conservation, Nuclear Safety and Consumer Protection)	Harald Ebner (The Greens)	X	X	-	X
	Jakob Blankenburg (SPD)	X	X	X	X
	Axel Echeverria (SPD)	X	X	-	X
	Nadine Heselhaus (SPD)	X	X	X	X
	Franziska Kersten (SPD)	X	X	-	-
	Helmut Kleebank (SPD)	X	X	-	X
	Dunja Kreiser (SPD)	X	X	-	X
	Daniel Rinkert (SPD)	X	X	X	-
	Daniel Schneider (SPD)	X	X	-	X
	Lina Seitzl (SPD)	X	X	-	X
	Michael Thews (SPD)	X	X	-	X
	Carsten Träger (SPD)	X	X	-	X
	Astrid Damerow (CDU/CSU)	X	X	-	X
	Alexander Engelhard (CDU/CSU)	X	X	-	X
	Oliver Grundmann (CDU/CSU)	X	X	X	X
	Christian Hirte (CDU/CSU)	X	X	-	X
	Anja Karliczek (CDU/CSU)	X	X	-	X
	Klaus Mack (CDU/CSU)	X	X	-	X
	Volker Mayer-Lay (CDU/CSU)	X	X	X	X
	Björn Simon (CDU/CSU)	X	X	X	X
	Anja Weisgerber (CDU/CSU)	X	X	-	X
	Klaus Wiener (CDU/CSU)	X	X	-	X
	Tessa Ganserer (The Greens)	X	X	X	X
	Jan-Niclas Gesenhues (The Greens)	X	X	-	-
	Armin Grau (The Greens)	X	X	-	-
	Linda Heitmann (The Greens)	X	X	-	-
	Tabea Rößner (The Greens)	X	X	X	X
	Muhanad Al-Halak (FDP)	X	X	X	X
	Nils Gründer (FDP)	X	X	X	-
	Ulrike Harzer (FDP)	X	X	-	-
	Olaf in der Beek (FDP)	X	X	-	X
	Judith Skudelny (FDP)	X	X	X	-
	Andreas Bleck (AfD)	X	X	-	-
	Jürgen Braun (AfD)	X	X	X	X
	Thomas Ehrhorn (AfD)	X	X	X	X
	Rainer Kraft (AfD)	X	-	-	X

	Ralph Lenkert (Die Linke)	X	X	-	-
	Amira Mohamed Ali (Die Linke)	X	X	-	-
Activist groups	Extinction Rebellion Germany	X	X	X	X
	Fridays-For-Future Germany	X	X	X	X
	Last Generation	X	X	X	X
	Scientists for Future	X	X	-	X
Individual activists	Luisa Neubauer (Fridays-For-Future)	-	X	X	-
	Carla Reemtsma (Fridays-For-Future)	-	X	X	-
	Aimée van Baalen (Last Generation)	-	X	X	-
	Carla Hinrichs (Last Generation)	-	X	-	-
Climate Skeptics	Europäisches Institut für Klima und Energie (EIKE)	X	X	-	X
Environmental Organizations	Greenpeace Germany	X	X	X	X
	WWF Germany	X	X	X	X
	Bund für Umwelt und Naturschutz	X	X	-	X
	NABU Bundesverband	X	X	X	X
	Deutsche Umwelthilfe	X	X	X	X
	Deutscher Naturschutzring	-	X	-	X
	ROBIN WOOD	X	X	-	X
Federal environmental institutions	Bundesregierung	X	X	-	-
	Bundesamt für Naturschutz	-	-	-	X
	Bundesamt für Strahlenschutz	-	X	-	X
	Bundesanstalt für Geowissenschaften und Rohstoffe	-	-	-	X
	Bundesanstalt für Gewässerkunde	-	-	-	X
	Bundesanstalt für Landwirtschaft und Ernährung (BLE)	-	-	-	X
	Bundesinformationszentrum Landwirtschaft (BZL)	-	X	-	X
	Deutscher Wetterdienst	X	X	-	X
	Umweltbundesamt	X	X	-	X
	Umweltrat	-	-	-	-
	Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU)	-	-	-	X
Science	PIK Potsdam Institut für Klimafolgenforschung	-	-	-	X
	Alfred-Wegener-Institut (Helmholtz-Zentrum für Polar- und Meeresforschung)	X	X	-	X
	Deutsches Biomasseforschungszentrum (DBFZ)	-	-	-	
	Julius Kühn-Institut (Bundesforschungsinstitut für Kulturpflanzen)	-	-	-	X
	Thünen-Institut (Bundesforschungsinstitut für Ländliche Räume)	-	-	-	X
	Fraunhofer-Gesellschaft	X	X	-	X
	Helmholtz-Zentrum für Umweltforschung (UFZ)	-	X	-	X
	GEOMAR Helmholtz-Zentrum für #Ozeanforschung	X	X	-	X
	Forschungszentrum Jülich (Institut für Physik der Atmosphäre)	X	X	-	X
	Deutsches GeoForschungsZentrum GFZ	-	X	-	X

Notes. An X symbolizes that the actor has a profile on the respective platform that was included in the analysis. FB = Facebook, IG = Instagram, TT = TikTok, YT = Youtube.

Appendix 2.

Data access and limitations

The social media posts from media organizations and climate stakeholders were collected using the official YouTube and TikTok APIs and third-party data collection tool CrowdTangle and securely stored on servers managed by the university. Only data from public accounts listed (see Appendix 1) were collected.

The data was collected and published in compliance with the terms and conditions of TikTok's Research API (<https://www.tiktok.com/legal/page/global/terms-of-service-research-api/en>), YouTube API (<https://developers.google.com/youtube/terms/api-services-terms-of-service-emea>), and CrowdTangle.

According to the platform guidelines on publishing research outputs and dealing with personal data, we do not share any raw data or any information that could make individual users identifiable. Consequently, the dataset includes only custom IDs from our database, publication date, platform, account type (media or stakeholder referred from the profile on social media), and a coding table for content analysis.

To ensure the dataset closely mirrors real-time data, scraping occurred daily throughout the data collection period (November 27 to December 16, 2023, including the time of the climate conference and three days before and after). Due to platform-specific scraping limits (1000 requests per day for TikTok, 50,000 units according to extended quota for YouTube and 2 calls / minute for CrowdTangle), the frequency of data collection varied: every two hours for Facebook and Instagram, every 12 hours for YouTube, and once daily for TikTok. For TikTok, there was a three-day delay in data collection due to API access limitations.

Reactions to posts were collected ten days after each post's publication. If any posts were deleted within that time frame, their reactions were considered as NA.

Our research involves only information published by public accounts, and the situations in which the data is expected to be observed by strangers. More specifically, our account list only includes public persons and climate-related organizations oriented towards the public, implying that post authors expect to be observed by broad audiences without direct interaction. Also, we analyze data in an aggregated manner, which does not make it possible to identify inferences about individual subjects, to protect personal data. Our data collection approach is approved by the Institutional Review Board of the university.

We also aware of the limitations in representativeness of research tools used in our study, especially TikTok API (e.g. errors in reporting reaction metrics <https://www.techpolicy.press/-researcher-data-access-under-the-dsa-lessons-from-tiktoks-api-issues-during-the-2024-european-elections/>). Other issues are addressed in the table below.

Social Media	Data Access	Content Collected	Limitations
Facebook	CrowdTangle	Public posts from feed published by accounts	- only the first image/video available - stories and reels not available - possible post deletions
Instagram	CrowdTangle	Public posts from feed published by accounts	- only the first image/video available - stories and reels not available - possible post deletions
YouTube	YouTube Data API	Public videos and shorts published by accounts	- possible post deletions
TikTok	TikTok Research API	Public videos published by accounts	- only videos up to five minutes collected - possible post deletions

Appendix 3.*Data preparation*

Steps of data sampling and preparation	Media sample (n)	Stakeholder sample (n)	Overall sample (n)
All posts published from media and climate stakeholder profiles between November 27 and December 16, 2023	11,895	2,984	14,879
After selection of a weighted random sample of media posts and of all stakeholder posts	6,000	2,984	8,984
After selection of posts with a post link that worked (not deleted since the scraping)	5,926	2,933	8,859
After selection of posts that contain an image or video	5,923	2,923	8,486
After selection of posts that did not only contain a link to an external website	2,863	2,289	5,152
After selection of posts that refer to climate change	352	698	1,050

Appendix 4.*Reliability scores for each category of the manual quantitative content analysis*

Variables	N	CR_{Holsti}	CR_{BP's Kappa}	Lotus
<i>Coding level: Social media post</i>				
Climate change relevance / COP28 reference	100	.93	.91	.97
Actor type	100	.85	.84	.93
Post type	100	1	1	1
Climate change consequences				
Consequence: increase in temperature	100	.94	.88	.97
Consequence: extreme weather	100	.96	.92	.98
Consequence: melting ice	100	.98	.96	.99
Consequence: extinction of species	100	.99	.98	.99
Consequence: economic opportunities	100	.99	.98	.99
Consequence: economic damage	100	.94	.88	.97
Consequence: social consequences	100	.90	.80	.95
Climate change causes				
Cause: Emissions from manufacturing goods	100	.97	.94	.98
Cause: Colliding national interests	100	.96	.92	.98
Cause: Deforestation	100	.99	.98	.99
Cause: Using transportation	100	.97	.94	.98
Cause: Producing food	100	.99	.98	.99
Cause: Powering buildings	100	.98	.96	.99
Cause: Consuming too much	100	.97	.94	.99
Cause: Specific country	100	.94	.91	.97
Climate change actions				
Action: No action should be taken	100	.95	.90	.97
Action: Clean and renewable energy	100	.83	.66	.88
Action: Mobility	100	.95	.90	.97
Action: Technological Innovation	100	.96	.92	.98
Action: Reforestation/avoided deforestation	100	.96	.92	.98
Action: Adaptation in agricultural production	100	.99	.98	.99
Action: Regulation and agreements on emission reductions	100	.80	.60	.90
Action: Financial assistance to disadvantaged countries	100	.97	.94	.98
Action: Market mechanisms	100	.96	.92	.98
Action: Lifestyle changes	100	.98	.96	.99
Action: Change of the economic system	100	.99	.98	.99
Action: Greenwashing	100	.97	.94	.98
Climate frame	100	.71	.65	.86

<i>Coding level: image</i>				
Image – Climate change consequences				
Image – Consequence: increase in temperature	100	.97	.94	.99
Image – Consequence: extreme weather	100	.98	.96	.99
Image – Consequence: melting ice	100	1	1	1
Image – Consequence: extinction of species	100	.99	.98	.99
Image – Consequence: economic opportunities	100	1	-	1
Image – Consequence: economic damage	100	1	-	1
Image – Consequence: social consequences	100	1	-	1
Image – Climate change causes				
Image – Cause: Emissions from generating power	100	.96	.92	.98
Image – Cause: Emissions from manufacturing goods	100	.99	.98	.99
Image – Cause: Colliding national interests	100	.96	.92	1
Image – Cause: Deforestation	100	.99	.98	1
Image – Cause: Using transportation	100	1	-	.99
Image – Cause: Producing food	100	1	-	1
Image – Cause: Powering buildings	100	.98	.96	1
Image – Cause: Consuming too much	100	1	1	.99
Image – Cause: Specific country	100	1	-	1
Image – Climate change actions				
Image – Action: No action should be taken	100	1	-	1
Image – Action: Clean and renewable energy	100	.92	.84	.96
Image – Action: Mobility	100	.97	.94	.99
Image – Action: Technological Innovation	100	.98	.96	.99
Image – Action: Reforestation/avoided deforestation	100	1	-	1
Image – Action: Adaptation in agricultural production	100	.99	.98	.99
Image – Action: Regulation and agreements on emission reductions	100	1	-	1
Image – Action: Financial assistance to disadvantaged countries	100	1	-	1
Image – Action: Market mechanisms	100	1	-	1
Image – Action: Lifestyle changes	100	1	-	1
Image – Action: Change of the economic system	100	1	-	1
Image – Action: Greenwashing	100	1	-	1
Image – Person				
Image – Person (Visual Personalization)	100	.99	.98	.99
Image – Person: Activity	100	.77	.74	.86
Image – Person: Political actor(s)	100	.96	.92	.93
Image – Person: NGO member(s), activist(s)	100	.91	.82	.98
Image – Person: Business / industry representative(s)	100	.98	.96	.96
Image – Person: Scientist(s)	100	.98	.96	.99
Image – Person: Celebrity(ies)	100	.99	.98	.99

Image – Person: Police and/or security personal	100	.98	.96	.99
Image – Person: ordinary citizens	100	.91	.82	.99
<i>Coding level: caption</i>				
Language	100	.95	.93	.97
Caption – Climate change consequences				
Caption – Consequence: increase in temperature	100	.97	.94	.98
Caption – Consequence: extreme weather	100	.99	.98	.99
Caption – Consequence: melting ice	100	.99	.98	.99
Caption – Consequence: extinction of species	100	.99	.98	.99
Caption – Consequence: economic opportunities	100	.99	.98	.99
Caption – Consequence: economic damage	100	1	1	1
Caption – Consequence: social consequences	100	.95	.90	.97
Caption – Climate change causes				
Caption – Cause: Emissions from generating power	100	.90	.80	.95
Caption – Cause: Emissions from manufacturing goods	100	.99	.98	.99
Caption – Cause: Colliding national interests	100	.97	.94	.98
Caption – Cause: Deforestation	100	.99	.98	.99
Caption – Cause: Using transportation	100	.98	.96	.99
Caption – Cause: Producing food	100	.99	.98	.99
Caption – Cause: Powering buildings	100	.98	.96	.99
Caption – Cause: Consuming too much	100	.98	.96	.99
Caption – Cause: Specific country	100	.95	.93	.98
Caption – Climate change actions				
Caption – Action: No action should be taken	100	.97	.94	.98
Caption – Action: Clean and renewable energy	100	.84	.68	.92
Caption – Action: Mobility	100	.96	.92	.98
Caption – Action: Technological Innovation	100	.98	.96	.99
Caption – Action: Reforestation/avoided deforestation	100	.96	.92	.98
Caption – Action: Adaptation in agricultural production	100	.99	.98	.99
Caption – Action: Regulation and agreements on emission reductions	100	.84	.68	.92
Caption – Action: Financial assistance to disadvantaged countries	100	.99	.98	.99
Caption – Action: Market mechanisms	100	.98	.96	.99
Caption – Action: Lifestyle changes	100	.98	.96	.99
Caption – Action: Change of the economic system	100	.99	.98	.99
Caption – Action: Greenwashing	100	.98	.96	.99

Notes. CR_{Holsti} = Holsti's coder reliability, CR_{BP's kappa} = Brennan and Prediger's kappa coder reliability.

Appendix 5.*Number and share of climate posts with different features by climate stakeholders and media organizations*

	Media Organizations (n = 352)		Climate Stakeholders (n = 698)	
	n	%	n	%
<i>Platforms</i>				
YouTube	181	51.1	98	14.0
TikTok	13	3.7	51	7.3
Facebook	81	22.9	325	46.4
Instagram	79	22.3	227	32.4
<i>Media Logic</i>				
COP28 Reference	169	47.6	144	20.5
Frame: Politics	257	72.6	410	58.6
Frame: Consequences	60	16.9	50	7.1
Text CC Consequences	53	15.1	76	11.6
Image CC Consequences	43	12.2	34	4.9
Responsibility	265	74.9	478	68.3
Image Personalization	284	80.2	492	70.3
<i>Political Logic</i>				
Frame: Protest	3	0.8	89	12.7
Frame: Populism	11	3.1	120	17.1
Text CC Causes	88	25.1	204	31.2
Image CC Causes	18	5.1	54	7.7
Text CC Action	140	40.0	350	53.4
Image CC Action	28	7.9	92	13.1

Appendix 6.*Random-intercept negative binomial regression predicting likes*

Predictors	Model 1: Media				Model 2: Stakeholder			
	IRR	95% CI		P Value	IRR	95% CI		P Value
(Intercept)	549.51	191.21	1579.19	< 0.01	67.17	32.61	138.36	< 0.01
<i>Platforms</i>								
YouTube*	0.62	0.32	1.19	0.15	0.54	0.36	0.82	< 0.01
Facebook*	0.24	0.12	0.49	< 0.01	0.46	0.32	0.66	< 0.01
Instagram*	11.79	5.89	23.59	< 0.01	4.83	3.39	6.88	< 0.01
<i>Media Logic</i>								
COP28 Reference	0.98	0.75	1.28	0.88	0.91	0.71	1.17	0.48
Frame: Politics	0.98	0.60	1.60	0.93	1.19	0.76	1.86	0.45
Frame: Consequences	0.98	0.50	1.90	0.94	1.43	0.76	2.71	0.27
Text CC Consequences	0.83	0.53	1.32	0.43	0.94	0.64	1.37	0.73
Image CC Consequences	0.85	0.52	1.39	0.51	1.98	1.24	3.18	< 0.01
Responsibility	1.06	0.72	1.57	0.77	0.99	0.78	1.27	0.97
Image Personalization	0.73	0.52	1.03	0.07	1.07	0.85	1.35	0.54
<i>Political Logic</i>								
Frame: Protest	0.95	0.41	2.22	0.91	1.93	1.11	3.34	0.02
Frame: Populism	9.36	1.10	79.32	0.04	3.02	1.55	5.90	< 0.01
Text CC Causes	1.16	0.85	1.60	0.35	1.01	0.81	1.27	0.92
Image CC Causes	1.15	0.60	2.18	0.67	0.78	0.53	1.15	0.21
Text CC Action	0.77	0.58	1.02	0.07	0.98	0.79	1.21	0.86
Image CC Action	0.66	0.41	1.06	0.09	1.07	0.78	1.48	0.66
Random Effects								
σ^2	0.70				0.67			
τ_{00}	1.36				3.87			
ICC	0.66				0.85			
N	18				78			
Observations	346				649			
Marg. R2 / Cond. R2	0.507 / 0.832				0.204 / 0.883			

Notes. *Reference category: TikTok.