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The consequences of climate change-related disasters on the access to drinking water in low- and middle-income countries

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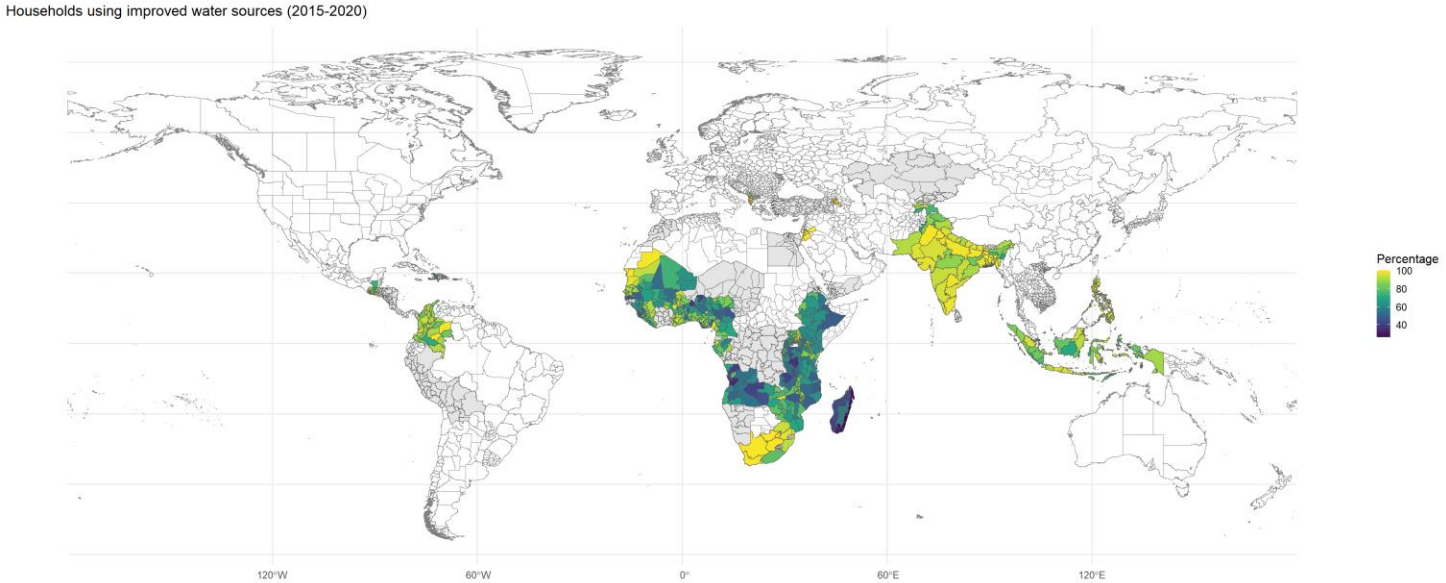
Summary



- Disasters have been found to negatively affect a wide range of health outcomes, especially in the emergency phase
- Lack of research on mid- to long-term health effects and indirect effects through social determinants of health, such as access to safe drinking water
- Analysis of the interaction effects of disaster presence, local state capacity, and climate change severity on the availability of safe drinking water

Summary

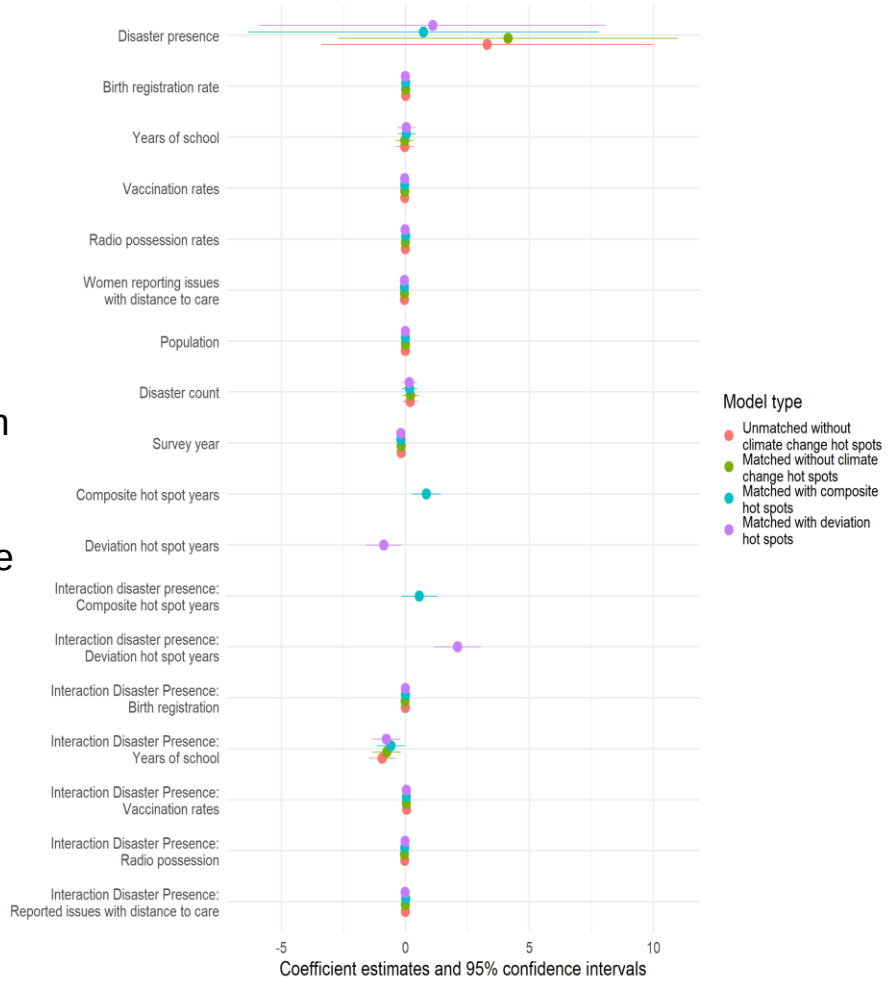
How do local state capacity and climate impacts affect the consequences of disasters on the access to safe drinking water across the Global South?

Hypotheses:

- In the aftermath of disasters, there will be a reduction in the use of improved water sources in affected areas.
- The negative effect of disasters on improved water sources will be exacerbated in areas where the state has lower reach/capacity.
- The negative effect of disasters on improved water sources will be exacerbated in areas that are adversely affected by climate change.

Methods:

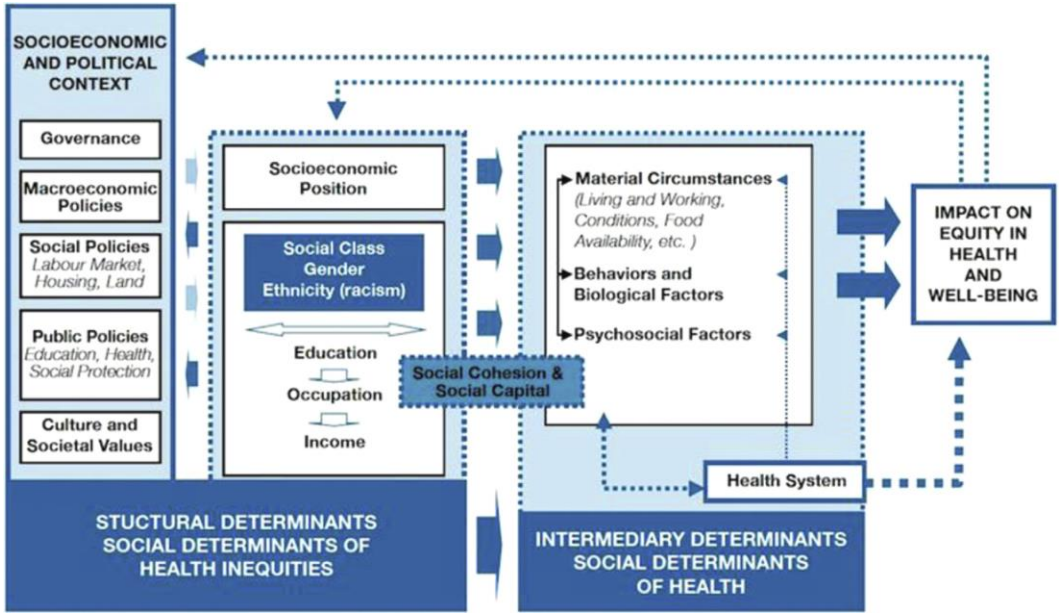
- Propensity score matching on disaster presence
- Getis-Ord G_i* hot spots of climate change



Background

- Research highlights adverse health outcomes in the immediate emergency phase after a disaster:
  - Mortality
  - Displacement
- Health effects also identified for the reconstruction phase after the immediate disaster event, including:
  - Mortality rates
  - Hospital admission rates
  - Infectious and parasitic diseases
  - Nutritional diseases
- Lack of research on the effect of disasters on the underlying social determinants of health, such as access to safe drinking water

Social determinants of mid- to long-term disaster effects on health



Source: Solar & Irwin, 2010, in: Nomura et al., 2016

Social structures, policies, and norms as macro-level non-medical factors (i.e., determinants) affecting health outcomes, among others related to:

- Education
- Health care systems
- Housing
- Income
- Labour market
- Water and sanitation
- Working conditions

Theoretical framework

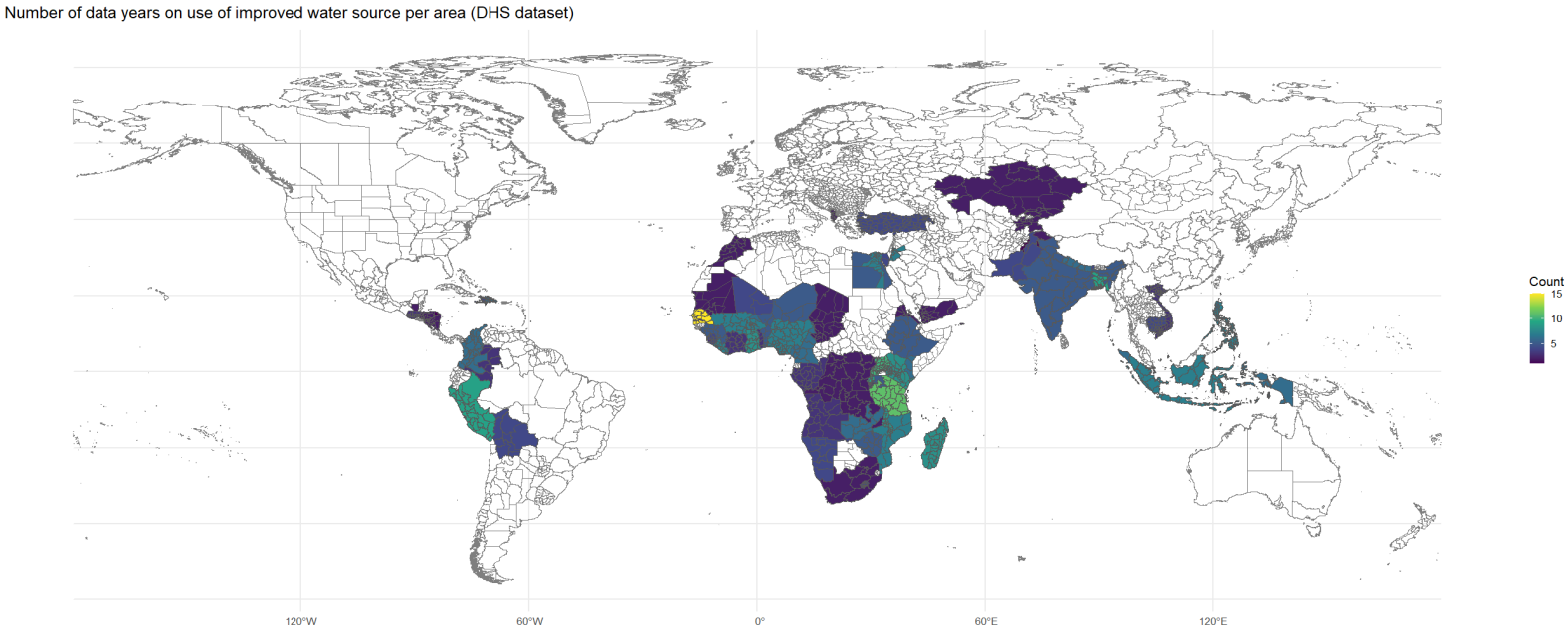
RQ: How do local state capacity and climate impacts affect the consequences of disasters on the access to safe drinking water across the Global South?

- H1: In the aftermath of disasters, there will be a reduction in the use of improved water sources in affected areas.
- H2: The negative effect of disasters on improved water sources will be exacerbated in areas where the state has lower reach/capacity.
- H3: The negative effect of disasters on improved water sources will be exacerbated in areas that are adversely affected by climate change.

Data: DHS Survey data

- DHS: Demographic and Health Surveys published by IPUMS, the Integrated Public Use Microdata Series
- Aggregated data on admin1-level (harmonized to GADM dataset):
  - Used as outcome variable:
    - Percentage of households using an improved water source
  - Proxies for local state capacity:
    - Percentage of children having their birth registered
    - Average years of education
    - Percentage of children having received standard vaccinations according to national vaccination schedules
    - Percentage of households possessing a radio
    - Percentage of women reporting issues to access health care due to distance to health care facilities

Data: DHS Survey

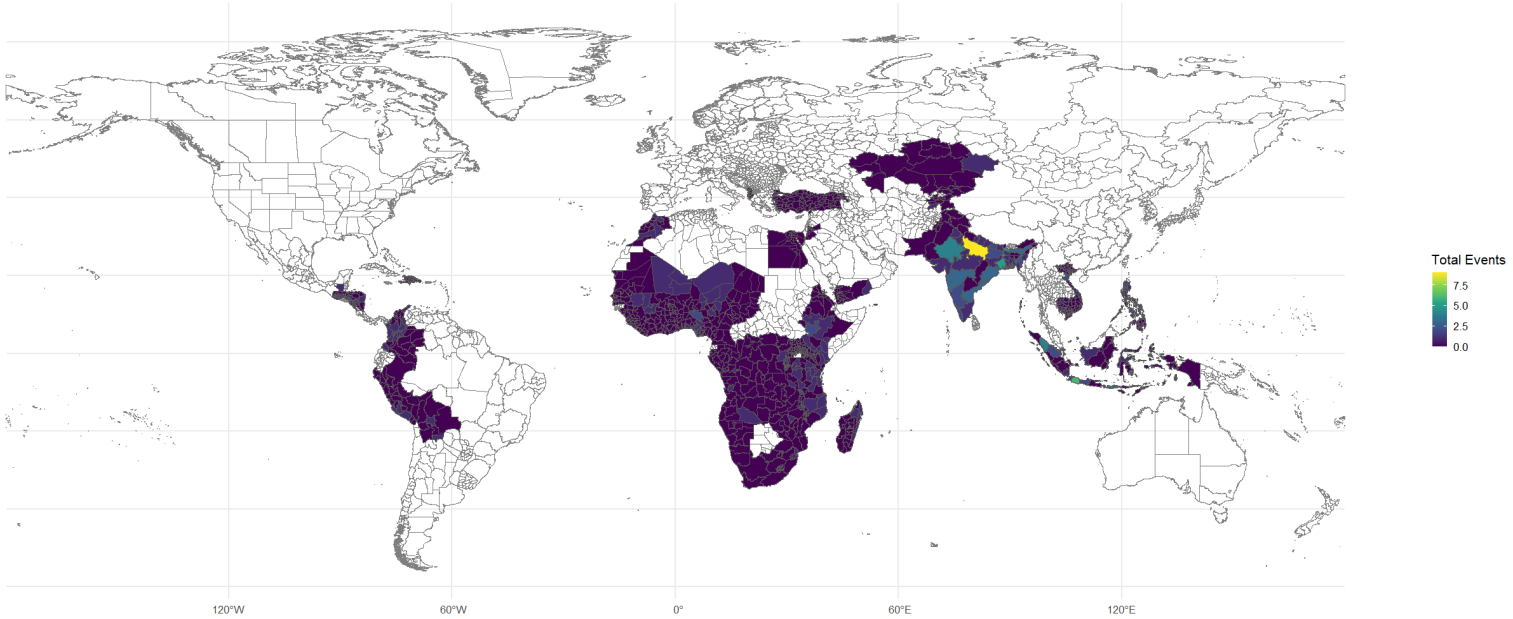


64 lower- and middle-income countries with:

- At least two different survey years
- Data on the first subnational administrative level

Data: Disaster Data

Number of disaster events by region in 2018



Geocoded Disaster (GDIS) dataset by Rosvold & Buhaug, 2021:

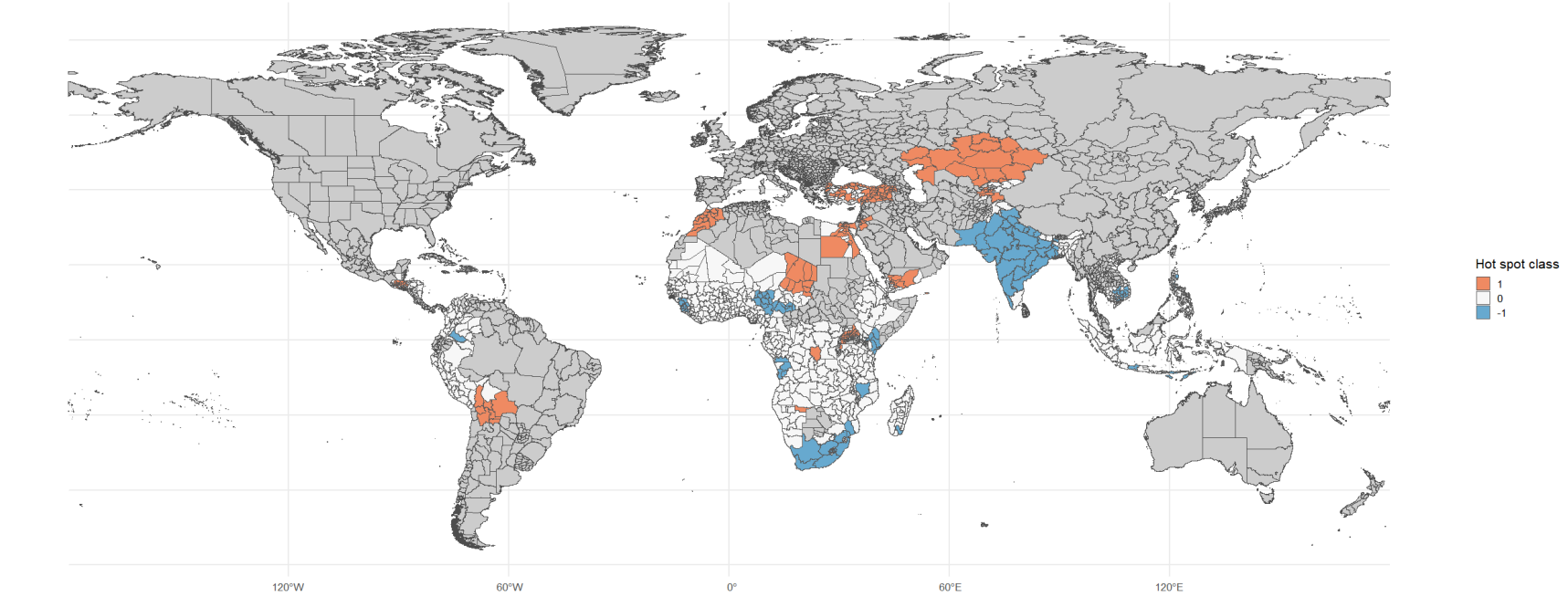
- Annual disaster count of disaster events at admin-1 level (since 1990)
- Dichotomization to variable on disaster presence

Data: Underlying climate data

- Use of monthly aggregated temperature and precipitaton data of ERA5 reanalysis dataset
- Calculation of annual average temperature values and annual total precipitation for admin-1 areas for 1990 to 2023
- Calculation of annual deviation values for temperature and precipitation for 1990 to 2023 compared to reference period 1960 to 1989
- Calculation of Getis-Ord Gi* hot spots for:
  - Annual average temperature
  - Annual total precipitation
  - Annual temperature deviation
  - Annual precipitation deviation
- Addition of hot spot layers to a composite:
  - Composite hot spots including those four parameters,
  - Deviation hot spots only including deviation parameters

Data: Hot spots of climate change using Getis-Ord Gi*

Hot and cold spot areas in temperature deviation of DHS survey areas in 2023

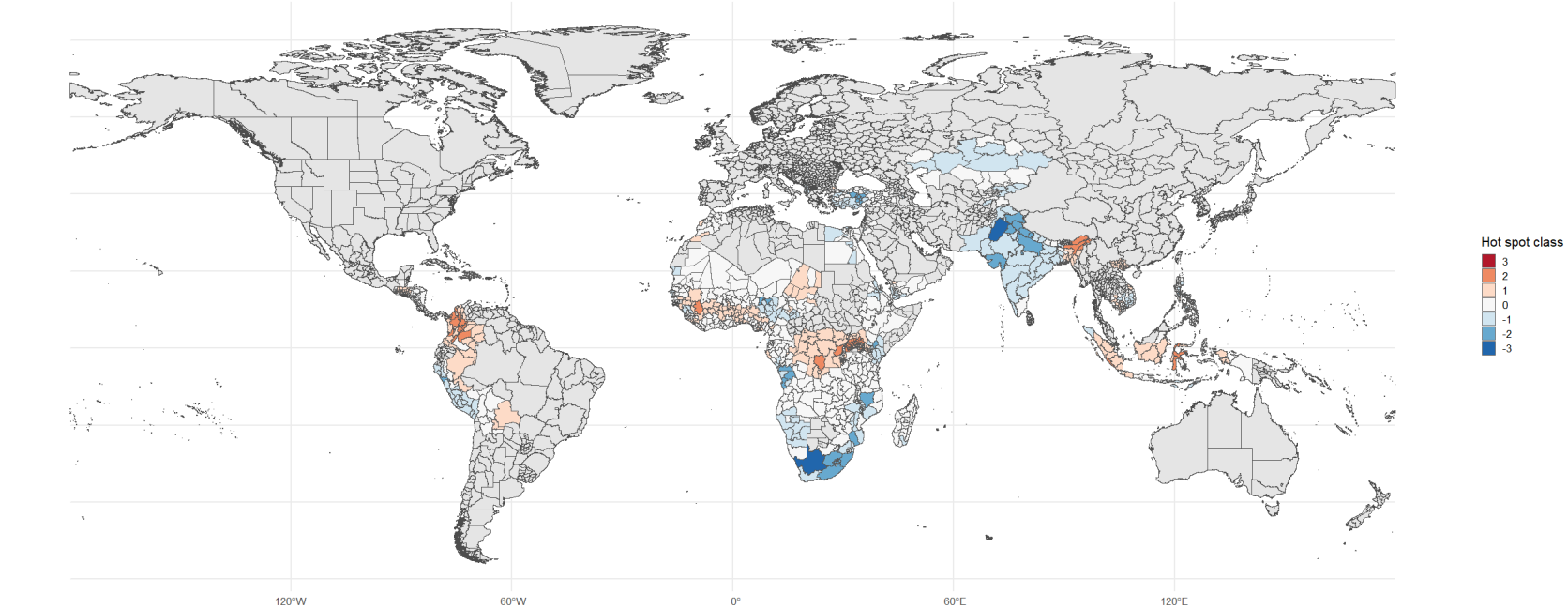


Data: Hot spots of climate change using Getis-Ord Gi*

Label	Composite hot spots	Deviation hot spots
4	Significantly hot and dry climate & warmer/drier year	
3	Significant hot spots in three of the variables	
2	Hot spots in two variables or neutralization of hot/cold spots	Significantly warmer and drier year
1	Hot spot in one variable or neutralization of hot/cold spots	Significantly warmer or drier year
0	Insignificant, no hot or cold spot	Insignificant, no hot or cold spot
-1	Cold spot in one variable or neutralization of cold/hot spot	Significantly colder or wetter year
-2	Cold spots in two variables or neutralization of cold/hot spots	Significantly colder and wetter year
-3	Significant cold spots in three of the variables	
-4	Significantly cold and wet climate & colder/drier year	

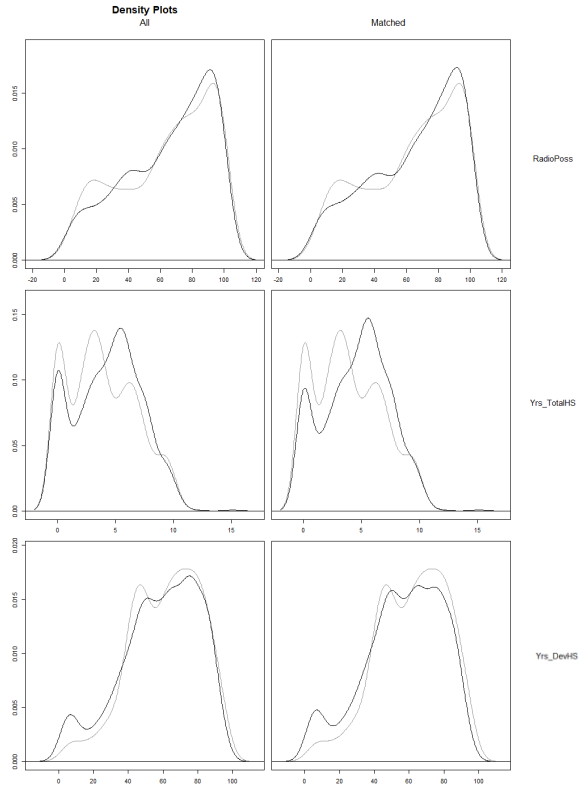
Data: Hot spots of climate change using Getis-Ord Gi*

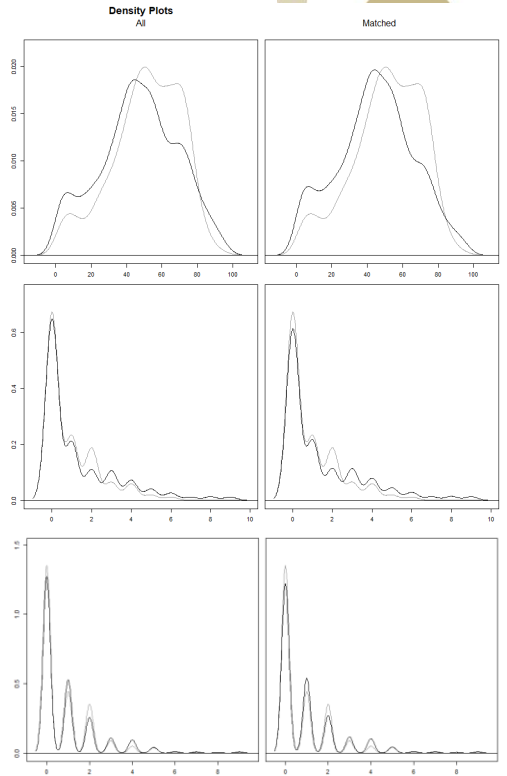
Composite hot spot classification of research area in 2023



Methods: Propensity score matching

- Outcome variable: disaster presence
- Matching variables:
  - Birth registration rate
  - Average years of schooling
  - Vaccination rates
  - Radio possession rates
  - Years of hot spot classification since previous survey year (all climate variables / climate deviation variables)





Methods: Linear regression

- Dependent variable: Change rate in percentage of households using an improved water source since the last survey (based on DHS data)

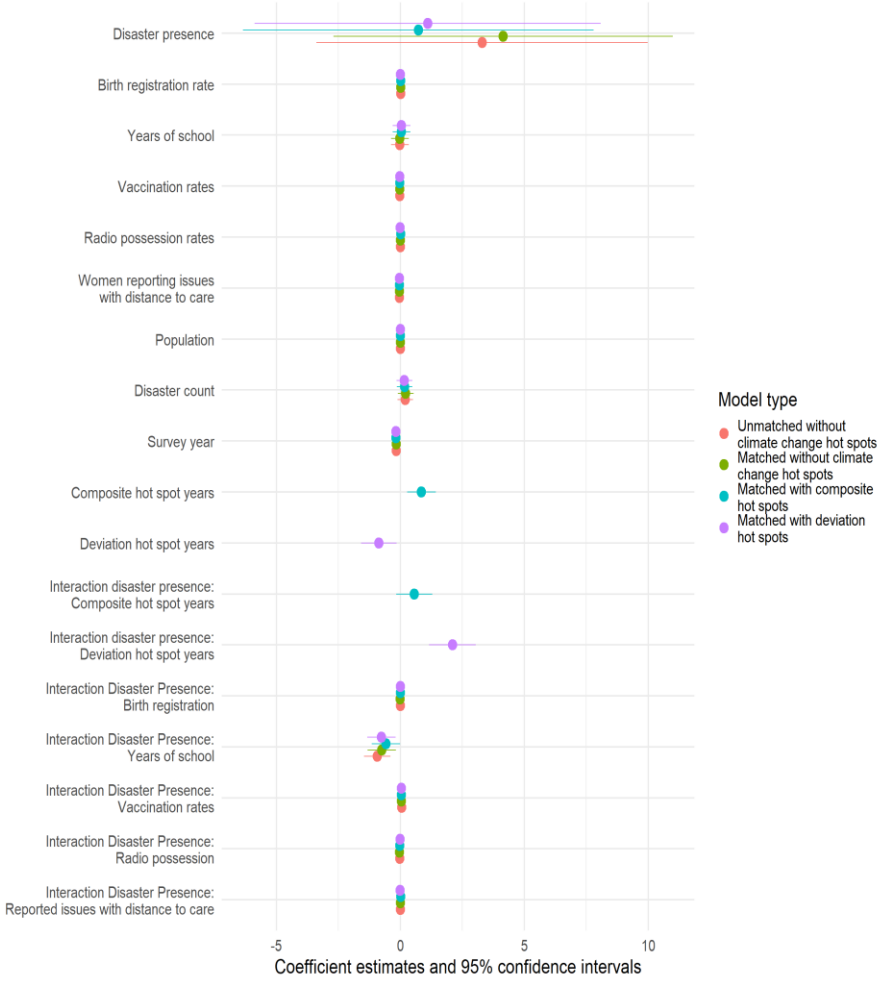
- Independent variables:
  - Binary variable on disaster presence since last DHS survey year (based on GDIS dataset)
  - Local state capacity (DHS data): birth registration rates, vaccination rates, average years of school attendance, radio possession rates, percentage of women reporting issues with distance to healthcare
  - Number of years since last survey in which an area was classified as a climate change hot spot (based on ERA5 reanalysis data)

- Interaction terms of:
  - Disaster presence and variables related to local state capacity
  - Disaster presence and number of hot spot years

Results

Effects on use of improved water sources:

- No significant effect of disaster presence
- No measurable effect of local state capacity variables
- Negative effect of interaction between disaster presence and years of school
- Negative effect of years classified as deviation hot spots
- Positive effect of years classified as composite hot spots and in interaction with disaster presence



Results

Regression results of disaster presence on use of change in percent in use of improved water source

	Change in use of improved water source			
	Unmatched without climate change hot spots	Matched without climate change hot spots	Matched with composite hot spots	Matched with deviation hot spots
	(1)	(2)	(3)	(4)
Disaster Presence	3.29	4.14	0.73	1.10
	(3.41)	(3.49)	(3.60)	(3.56)
Composite hot spot years			0.85***	
			(0.30)	
Deviation hot spot years				-0.86**
				(0.37)
Birth registration rate	0.01	0.01	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)
Years of school	-0.02	-0.02	0.04	0.05
	(0.18)	(0.18)	(0.18)	(0.18)
Vaccination rates	-0.03	-0.03	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Radio possession rates	0.01	0.01	0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)
Women reporting issues with distance to care	-0.03	-0.03	-0.03	-0.03
	(0.03)	(0.03)	(0.03)	(0.03)
Population	-0.0000	-0.0000	-0.00	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Disaster count since previous survey	0.20	0.21	0.17	0.16
	(0.16)	(0.16)	(0.16)	(0.16)
Survey year	-0.17***	-0.16**	-0.18***	-0.18***
	(0.07)	(0.07)	(0.07)	(0.07)
Interaction Disaster Presence: Composite hot spot years			0.56	
			(0.37)	
Interaction Disaster Presence: Deviation hot spot years				2.10***
				(0.48)
Interaction Disaster Presence: Birth registration	0.001	-0.01	-0.001	-0.004
	(0.02)	(0.03)	(0.03)	(0.03)
Interaction Disaster Presence: Years of school	-0.93***	-0.75**	-0.58**	-0.76***
	(0.27)	(0.29)	(0.29)	(0.29)
Interaction Disaster Presence: Vaccination rates	0.06*	0.04	0.04	0.04
	(0.03)	(0.03)	(0.03)	(0.03)
Interaction Disaster Presence: Radio possession	-0.03	-0.04	-0.03	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Interaction Disaster Presence: Reported issues with distance to care	-0.004	-0.002	0.01	-0.01
	(0.04)	(0.05)	(0.05)	(0.05)
Constant	349.17***	335.47**	360.68***	364.51***
	(132.32)	(133.99)	(132.51)	(133.73)
Observations	1,837	1,761	1,764	1,762
R^2	0.03	0.02	0.05	0.03
Adjusted R^2	0.02	0.01	0.04	0.03
Residual Std. Error	12.48 (df = 1822)	12.55 (df = 1746)	12.39 (df = 1747)	12.49 (df = 1745)
F Statistic	3.84*** (df = 14; 1822)	2.69*** (df = 14; 1746)	5.82*** (df = 16; 1747)	3.83*** (df = 16; 1745)
Note:				*p<0.1; **p<0.05; ***p<0.01

Results

- H1: The results indicate no significant effect of disaster presence on the use of safe drinking water.
- H2: The only significant effect of state capacity measured is a negative effect of the interaction of disaster presence and years of schooling.
- H3: The effect of years with adverse climatic deviations is indeed negative, while its interaction with the presence of disasters is positive.

Sensitivity Test: Residuals of expected use of improved water source

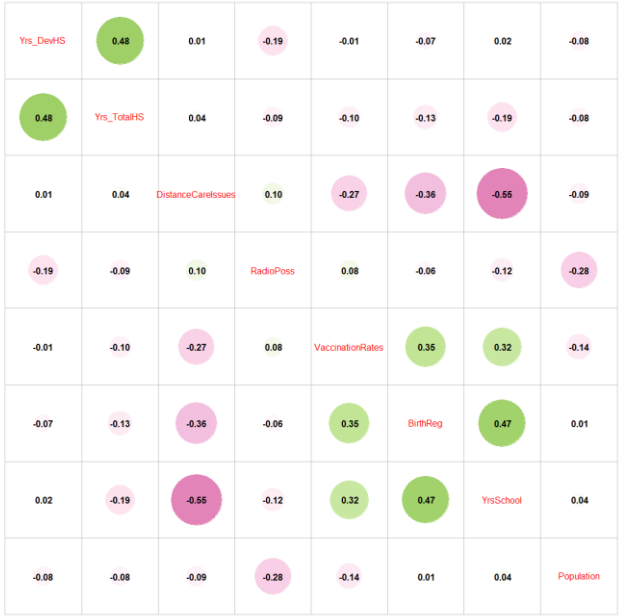
Method used by Krampe et al. (2025):

- Calculation of expected rate of use of improved water source based on proxies of state capacity and calculation of residual difference between expected and actual use of improved water source

- Ensures comparability across cases and isolates the disaster presence from the other variables (i.e., social/state capacity) affecting the use of improved water sources

Sensitivity Test: Residuals of expected use of improved water source

Condition 1: No collinearity between the variables predicting use of improved water source (cutoff value in Krampe et al. 2025: 0.7)



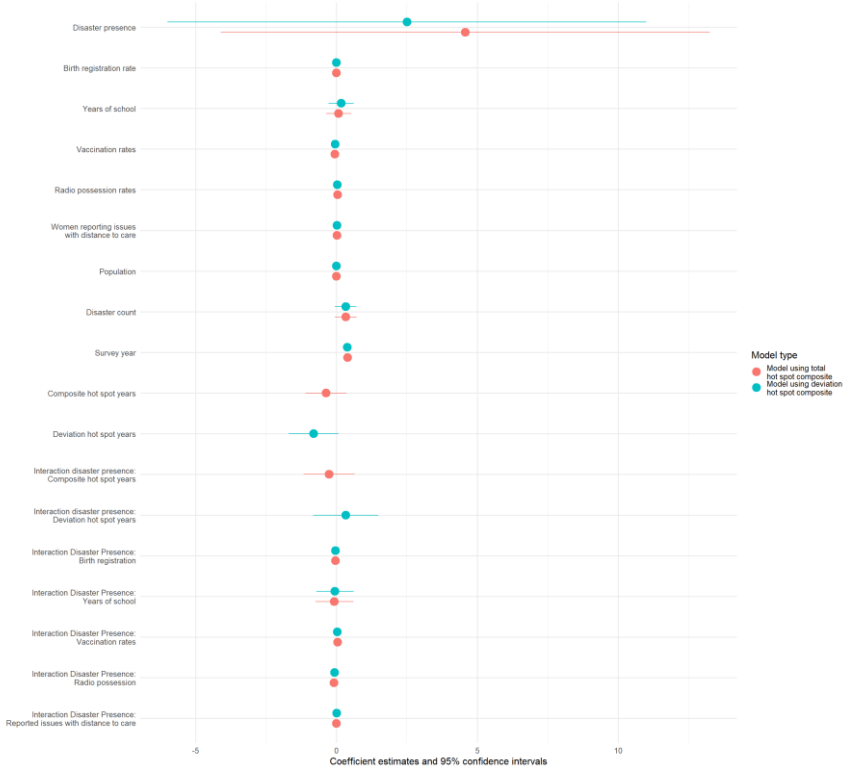
Sensitivity Test: Residuals of expected use of improved water source

Condition 2: Statistical significance and best-fitting model to explain use of improved water source

Regression results of state capacity on reported use of improved water source

	Rate of use of an improved water source	
	All state capacity variables (1)	Best model with significant variables (2)
Birth registration rate	0.21***	0.21***
	(0.01)	(0.01)
Years of school	2.10***	2.12***
	(0.16)	(0.16)
Vaccination rates	0.16***	0.16***
	(0.02)	(0.02)
Radio possession rates	-0.02	
	(0.02)	
Women reporting issues with distance to care	-0.10***	-0.11***
	(0.03)	(0.03)
Population	0.0000***	0.0000***
	(0.0000)	(0.0000)
Constant	48.59***	47.76***
	(1.99)	(1.82)
Observations	1,967	1,967
R^2	0.43	0.43
Adjusted R^2	0.43	0.43
Residual Std. Error	15.61 (df = 1960)	15.61 (df = 1961)
F Statistic	246.75*** (df = 6; 1960)	295.87*** (df = 5; 1961)
Note:		*p<0.1; **p<0.05; ***p<0.01

Sensitivity Test: Residuals of expected use of improved water source



Regression results of disaster presence on difference between expected and actual use of improved water source

	Difference in expected and actual use of improved water source	
	Model using total hot spot composite (1)	Model using deviation hot spot composite (2)
Disaster Presence	4.57	2.50
	(4.42)	(4.33)
Composite hot spot years	-0.37	
	(0.37)	
Deviation hot spot years		-0.81*
		(0.45)
Birth registration rate	-0.002	-0.01
	(0.02)	(0.02)
Years of school	0.08	0.17
	(0.23)	(0.23)
Vaccination rates	-0.05*	-0.05*
	(0.03)	(0.03)
Radio possession rates	0.05*	0.03
	(0.03)	(0.03)
Women reporting issues with distance to care	0.02	0.02
	(0.04)	(0.04)
Population	-0.0000*	-0.0000
	(0.0000)	(0.0000)
Disaster count since previous survey	0.33*	0.33*
	(0.20)	(0.20)
Survey year	0.39***	0.38***
	(0.08)	(0.08)
Interaction Disaster Presence: Composite hot spot years	-0.26	
	(0.46)	
Interaction Disaster Presence: Deviation hot spot years		0.33
		(0.59)
Interaction Disaster Presence: Birth registration	-0.04	-0.03
	(0.03)	(0.03)
Interaction Disaster Presence: Years of school	-0.07	-0.05
	(0.34)	(0.34)
Interaction Disaster Presence: Vaccination rates	0.04	0.04
	(0.04)	(0.04)
Interaction Disaster Presence: Radio possession	-0.09**	-0.07*
	(0.04)	(0.04)
Interaction Disaster Presence: Reported issues with distance to care	0.004	0.01
	(0.06)	(0.06)
Constant	-791.37***	-767.54***
	(164.02)	(164.31)
Observations	1,837	1,837
R^2	0.02	0.02
Adjusted R^2	0.02	0.01
Residual Std. Error (df = 1820)	15.45	15.46
F Statistic (df = 16; 1820)	2.80***	2.70***
Note:		*p<0.1; **p<0.05; ***p<0.01

Conclusion

- H1: The results indicate no significant effect of disaster presence on the change in use of safe drinking water.
- H2: The only significant effect of state capacity measured is a negative effect of the interaction of disaster presence and years of schooling.
- H3: The effect of years with adverse climatic deviations is indeed negative, while its interaction with the presence of disasters is positive.
- Unanswered questions: Role of disaster aid? Disaster severity?

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Thank you for your attention!

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Paper abstract: