Appendix 1: Data and methods

To assess the impact of rainfall anomalies on the nutritional status of children in Kerala, we combine two datasets: 1) 2015-16 round of the Demographic and Health Surveys (DHS) for India and 2) gridded climate data from the Climatic Research Unit (CRU) at the University of East Anglia.

The DHS surveys draw on nationally representative samples of households and women of reproductive age. We use the 2015-16 children's record and construct binary indicators for stunting and wasting based on anthropometric data for children aged under five. Stunting and wasting are defined as height-for-age and weight-for-height z scores more than two standard deviations below the WHO Child Growth Standards medians for the respective age groups. Stunting indicates chronic childhood malnutrition which impairs growth and development in children. Wasting indicates acute weight loss over a short period of time.

We use the Standardized Precipitation and Evapotranspiration Index (SPEI) to measure climatic conditions. SPEI combines data on precipitation and potential evapotranspiration due to temperature. It measures monthly variations in the net values of precipitation minus potential evapotranspiration compared to the corresponding long-term mean. SPEI contains both negative values, indicating drought conditions, and positive values, indicating wet conditions. SPEI values close to 0 indicate near-normal conditions (see Table A1 for a classification of climatic conditions based on the SPEI index).

Table A1: SPEI classification (based on Bischiniotis et al., 2018)[1]

Range	Condition
SPEI ≤ -2	Extremely dry
-2 < SPEI ≤ -1.5	Severely dry
-1.5 < SPEI ≤ -1	Moderetely dry
-1 < SPEI ≤ 1	Near normal

[1] Bischiniotis, Konstantinos, Bart Van Den Hurk, Brenden Jongman, Erin Coughlan De Perez, Ted Veldkamp, Hans De Moel, and Jeroen Aerts. 2018. "The Influence of Antecedent Conditions on Flood Risk in Sub-Saharan Africa." *Hazards Earth Syst. Sci* 18: 271–85.

1 < SPEI ≤ 1.5	Moderately wet
1.5 < SPEI ≤ 2	Severely wet
SPEI > 2	Extremely wet

SPEI can be calculated at different time scales (from 1 to 48 months) to account for the cumulative effect of deficient precipitation and/or excessive evapotranspiration over previous months. Although SPEI is better known as a measure of droughts, recent studies have emphasised its potential to detect floods, especially when measured at shorter time-scales (1- to 3-months)[2].

The R package 'SPEI' is used to generate monthly SPEI values based on input temperature and precipitation data from the Climatic Research Unit's (CRU) time-series 3.25 (Harris et al. 2014)[3]. The CRU data are available for the whole globe at 0.5° spatial resolution and cover the period from 1901 until 2016. We generate 1-month SPEI values, which detect flood developments more accurately than longer time-scales.

The DHS data are then merged with the SPEI data using the GPS coordinates of household clusters, available in the more recent DHS rounds. DHS keeps the identity of survey participants confidential by shifting the location of household clusters in a random direction by 2km for urban areas, 5km for rural areas, and additional 10km for 5% of all clusters. To account for this shift, we create a 10km radius around each cluster and take the average SPEI value for all grid cells that fall within the buffered area.

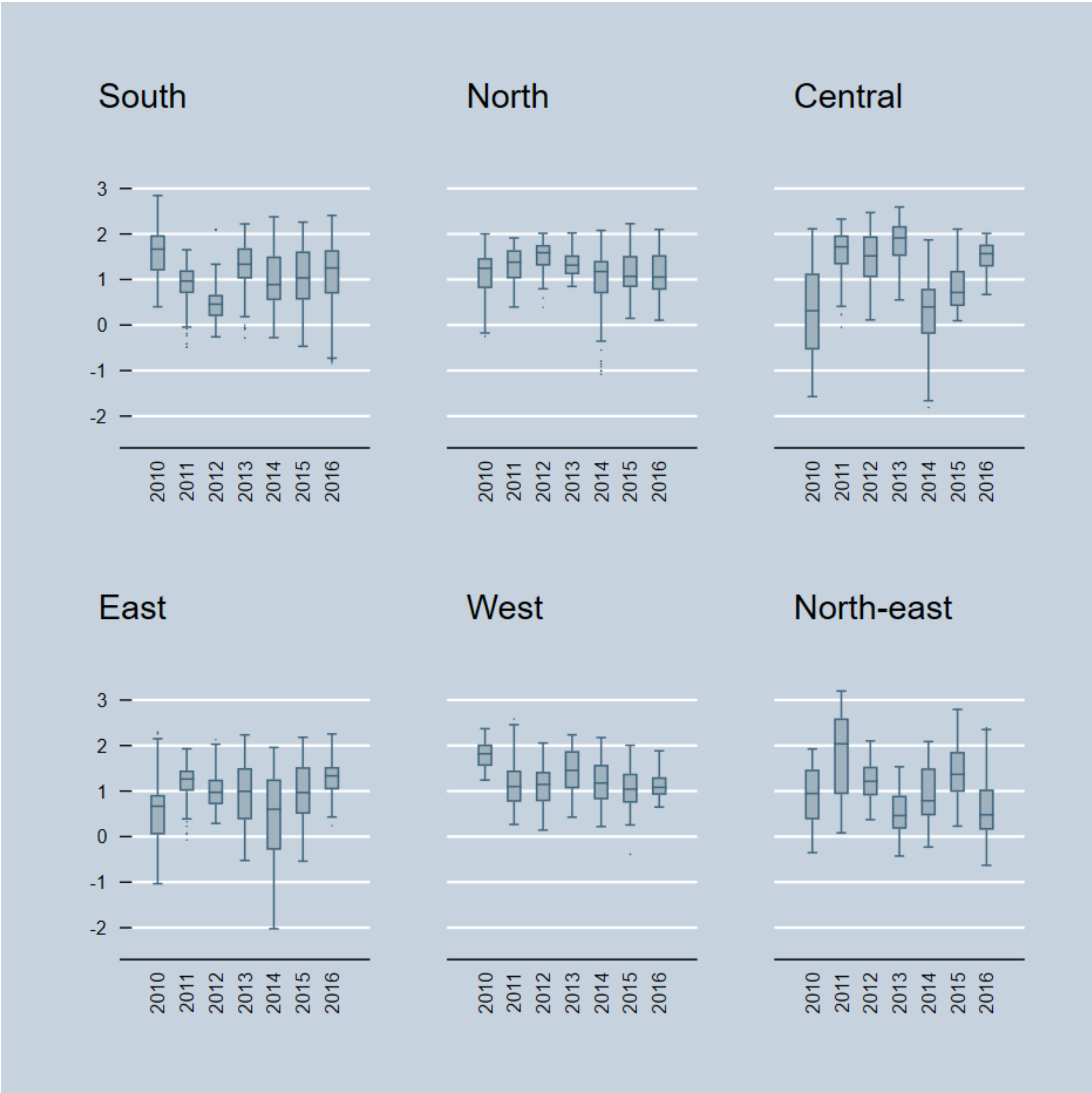
[2] See: Bischiniotis, Konstantinos, Bart Van Den Hurk, Brenden Jongman, Erin Coughlan De Perez, Ted Veldkamp, Hans De Moel, and Jeroen Aerts. 2018. "The Influence of Antecedent Conditions on Flood Risk in Sub-Saharan Africa." *Hazards Earth Syst. Sci* 18: 271–85; Seiler, R A, M Hayes, and L Bressan. 2002. "Using the Standardized Precipitation Index for Flood Risk Monitoring." *International Journal of Climatology* 22: 1365–76.

[3] Harris, I., P.D. Jones, T.J. Osborn, and D.H. Lister. 2014. "Updated High-Resolution Grids of Monthly Climatic Observations - the CRU TS3.10 Dataset." *International Journal of Climatology* 34 (3). Wiley-Blackwell: 623–42.

We consider different periods during which exposure to floods can be critical for the children's physical development. For stunting, the critical period extends from the year of birth up until age 5. For wasting, we consider a much shorter period of exposure - up to three months before the child's anthropometric measures were taken.

The monsoon season is the period when children are most likely to experience floods. To study the effect of floods on stunting, we restrict the climate data to the monsoon months only (June to September) and take the maximum SPEI value during each year of the child's life (starting from birth up until age 5). Taking the maximum SPEI value during the monsoon months helps us to identify exposure to wetter than normal conditions. Figure A1 shows the distribution of maximum SPEI values during the monsoon months in India by broad region.

Figure A1: Box plot of maximum SPEI during the monsoon season by broad region in India (2010-2016)



Source: Own calculations based on CRU TS 3.25

We additionally generate binary variables for floods, taking the value of 1 if the maximum SPEI value over the monsoon months exceeded 1.5 and 0 otherwise. We finally average climatic conditions over the child's observed life by taking the average of the above SPEI values (the maximum SPEI values during each monsoon season that the child has experienced).

For wasting, we expect a more immediate impact of floods on children's health. For this reason, we do not restrict our climate data to the monsoon months only, but we look at the last three months before the child was measured. Similar to stunting, we take the highest SPEI value during these three months and generate a variable for floods.

We use logistic regression models to estimate the effect of SPEI on child's nutrition status. The model takes the following form:

$$Health_{i,g} = \beta\, SPEI_{t,g} + \delta_j Z_j + f(age) + grid_g + e_{i,g}$$

where *Health* is a dummy variable, taking the value of 1 if a child *i* in location *g* is stunted/wasted and 0 otherwise. *SPEI* denotes the SPEI value in grid cell *g* during period *t*. For the analysis of stunting, we look at exposure to floods from the year of birth up until the age of measurement. For the analysis of wasting, we focus on exposure to floods during the latest three months before the child was measured since we expect a more immediate effect.

Z is a vector of individual and household characteristics, which are expected to impact the child's nutrition status. We additionally include controls for quarter of birth, quarter of interview and year of interview. *Grid* denotes grid fixed effects. Errors (*e*) are clustered at the grid-cell level. f is a restricted cubic age spline with knots at 6, 12, 18, 24, 36 and 48 months of age.

Appendix 2: Tables

Table A2: Sample descriptive statistics, South India

	Mean	Std. Dev.	Min	Max
Stunted	0.30	0.46	0.00	1.00
Wasted	0.21	0.41	0.00	1.00
Climate variables				
Average SPEI since birth	0.95	0.48	-0.29	2.47
SPEI last 3 months	1.17	0.64	-0.75	2.38
Flood in infancy	0.21	0.41	0.00	1.00
Flood last 3 months	0.33	0.47	0.00	1.00
Control variables				
Child's sex	0.51	0.50	0.00	1.00
Mother's literacy	1.58	0.49	1.00	2.00
Family's wealth	2.25	0.80	1.00	3.00
Residence	1.63	0.48	1.00	2.00
Child is twin	0.02	0.13	0.00	1.00
Mother's age at birth	24.39	4.26	12.00	48.00
Mother's height (cm)	1528.31	60.03	1017.00	2092.00
Household head	1.14	0.34	1.00	2.00
Exposure to mass media	0.93	0.26	0.00	1.00
Caste	2.05	1.17	0.00	3.00
Child's age	2.03	1.40	0.00	4.00
Quarter of birth	2.47	1.12	1.00	4.00
Quarter of interview	1.93	0.58	1.00	4.00

Table A3: Effects of SPEI on likelihood of stunting and wasting

	Stunting		Wasting	
	Coef.	Std. err.	Coef.	Std. err.
SPEI since birth: South	1.177*	(0.09)		
SPEI since birth: North	0.893	(0.05)		
SPEI since birth: Central	1.067*	(0.03)		
SPEI since birth: East	1.068*	(0.03)		
SPEI since birth: West	1.144	(0.12)		
SPEI since birth: North-east	1.039	(0.06)		
SPEI last 3 months: South			1.065	(0.08)
SPEI last 3 months: North			1.118*	(0.06)
SPEI last 3 months: Central			1.193**	(0.07)
SPEI last 3 months: East			1.120	(0.08)
SPEI last 3 months: West			0.918*	(0.04)
SPEI last 3 months: North-east			0.966	(0.09)
South	Ref.		Ref.	
north east	1.021	(0.18)	1.051	(0.19)
Central	0.915	(0.15)	0.781	(0.14)
East	0.877	(0.15)	0.988	(0.19)
West	0.770	(0.15)	1.225	(0.19)
North-east	1.244	(0.26)	1.118	(0.34)
R-squared	0.08		0.04	
N. of cases	196,061		224,181	

* p<0.05, ** p<0.01, *** p<0.001

Notes: Cell entries are log odds with robust standard errors in parenthesis. Controls included but not displayed: child's sex, child is twin, number of children under 5 in household, mother's literacy, mother's age at birth, mother's height, household wealth¸ household head, mass-media exposure, caste, age splines, quarter of birth, quarter of interview, year of interview, grid fixed effects.

Table A4: Effects of floods during infancy on likelihood of stunting

	Model 1	Model 2	Model 3	Model 4
Flood in infancy: Female	1.142*			
	(0.07)			
Flood in infancy: Male	1.095			
	(0.07)			
Flood in infancy: Urban		1.117		
		(0.08)		
Flood in infancy: Rural		1.118		
		(0.07)		
Flood in infancy: Poor			1.066	
			(0.09)	
Flood in infancy: Middle			1.153	
			(0.09)	
Flood in infancy: Rich			1.121	
			(0.08)	
Flood in infancy: Not literate				1.203**
				(0.08)
Flood in infancy: Literate				1.097
				(0.06)
Female	Ref.			
Male	1.116**			
	(0.04)			
Urban		Ref.		
Rural		1.024		
		(0.04)		
Poor			Ref.	
Middle			0.839**	
			(0.05)	
Rich			0.638***	
			(0.04)	
Not literate				Ref.
Literate				0.799***
				(0.04)
R-squared	0.08	0.08	0.08	0.08
N. of cases	20,928	20,928	20,928	20,928

* p<0.05, ** p<0.01, *** p<0.001

Notes: Cell entries are log odds with robust standard errors in parenthesis. Floods are defined as SPEI>1.5. Controls included but not displayed: child's sex, child is twin, number of children under 5 in household, mother's literacy, mother's age at birth, mother's height, household wealth¸ household head, mass-media exposure, caste, age splines, quarter of birth, quarter of interview, year of interview, grid fixed effects.

Table A5: Effects of floods in the last three months prior to measurement on likelihood of wasting

	Model 1	Model 2	Model 3	Model 4
Flood in last 3 months: Female	1.256*			
	(0.12)			
Flood in last 3 months: Male	1.186*			
	(0.09)			
Flood in last 3 months: Urban		1.206		
		(0.13)		
Flood in last 3 months: Rural		1.229*		
		(0.10)		
Flood in last 3 months: Poor			1.106	
			(0.11)	
Flood in last 3 months: Middle			1.198*	
			(0.11)	
Flood in last 3 months: Rich			1.282*	
			(0.13)	
Flood in last 3 months: Not literate				1.194
				(0.14)
Flood in last 3 months: Literate				1.224**
				(0.09)
Female	Ref.			
Male	1.164***			
	(0.05)			
Urban		Ref.		
Rural		0.948		
		(0.06)		
Poor			Ref.	
Middle			0.872*	
			(0.06)	
Rich			0.754***	
			(0.05)	
Not literate				Ref.
Literate				0.974
				(0.05)
R-squared	0.03	0.03	0.03	0.03
N. of cases	21232	21232	21232	21232

* p<0.05, ** p<0.01, *** p<0.001

Notes: Cell entries are log odds with robust standard errors in parenthesis. Floods are defined as SPEI>1. Controls included but not displayed: child's sex, child is twin, number of children under 5 in household, mother's literacy, mother's age at birth, mother's height, household wealth¸ household head, mass-media exposure, caste, age splines, quarter of birth, quarter of interview, year of interview, grid fixed effects.