Friedman School
of Nutrition Science and Policy

Climatic Conditions and Child Height: Sex-Specific Vulnerability and the Protective Effects of Sanitation and Food Markets in Nepal

Prajula Mulmi[a]
Steven A. Block[b]
Gerald E. Shively[c]
William A. Masters[d]

[a] Doctoral candidate, Friedman School of Nutrition Science and Policy, Tufts University (prajula.mulmi@tufts.edu)
[b] Professor and Academic Dean, Fletcher School of Law and Diplomacy, Tufts University (steven.block@tufts.edu)
[c] Professor and Associate Head, Department of Agricultural Economics, Purdue University (shivelyg@purdue.edu)
[d] Professor, Friedman School of Nutrition and Department of Economics, Tufts University (william.masters@tufts.edu)

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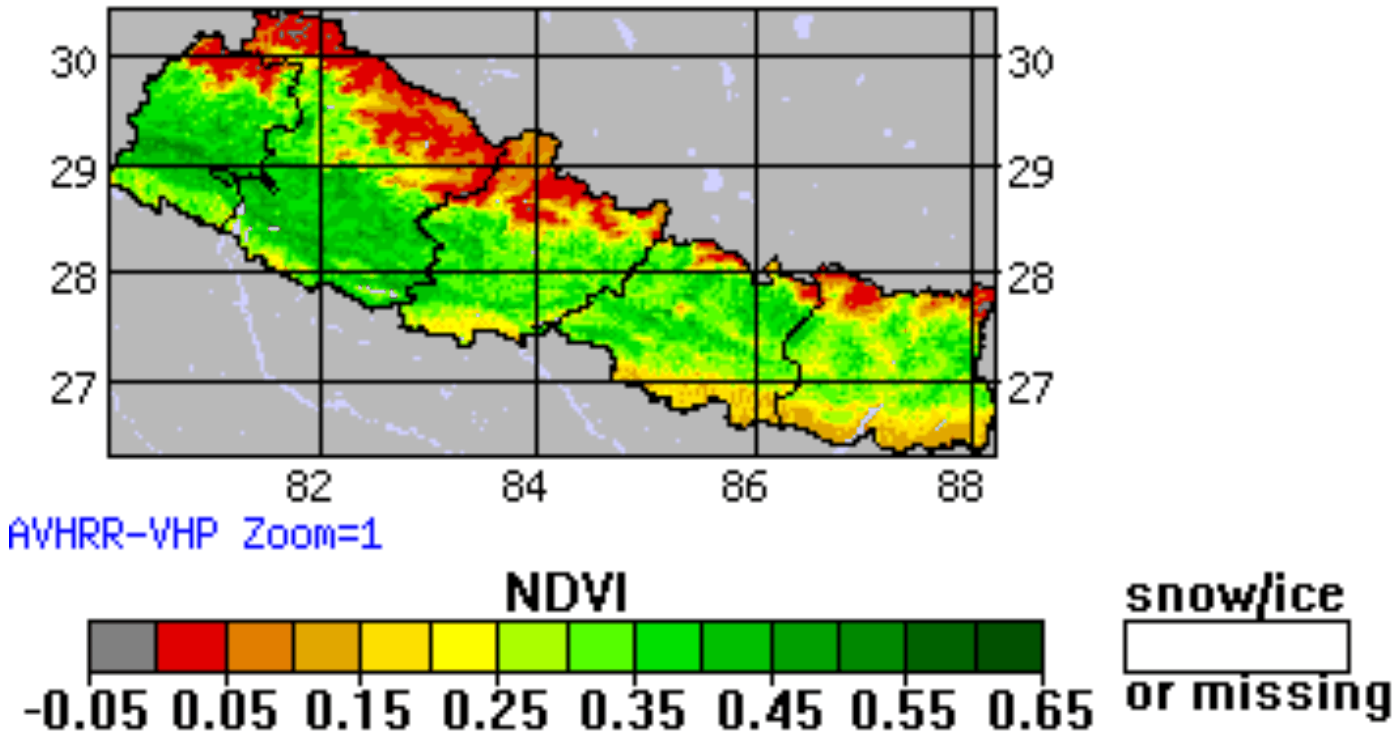
Tufts UNIVERSITY

How does climate affect children?

We use surveys of child heights in 2006 and 2011, and test links to climate experienced during pregnancy and infancy using satellite imagery of "greenness":

Weekly variation of NDVI in Nepal, Jan – Dec 2010



Note: Animation shows week-to-week variation in NDVI from January through December 2010, from NOAA STAR Global Vegetation Data at http://www.star.nesdis.noaa.gov/smcd/emb/vci.

There are many kinds of seasonality

Most studies use month of birth, rainfall or temperature

Month of Birth and Children's Health in India

Michael Lokshin
Sergiy Radyakin

JHR
The Journal of Human Resources
Contents
Volume 47, Number 1
Winter 2012

ABSTRACT

We use data from three waves of India National Family Health Survey to explore the relationship between the month of birth and the health outcomes of young children in India. We find that children born during the monsoon months have lower anthropometric scores compared to children born during the fall-winter months. We propose and test hypotheses that could explain such a correlation. Our results emphasize the importance of seasonal variations in environmental conditions at the time of birth in determining health outcomes of young children in India. Policy interventions that affect these conditions could effectively impact the health and achievements of these children, in a manner similar to nutrition and micronutrient supplementation programs.

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Vol. 48, No. 9, 1323–1341, September 2012
Routledge
Taylor & Francis Group

Prenatal Seasonality, Child Growth, and Schooling Investments: Evidence from Rural Indonesia

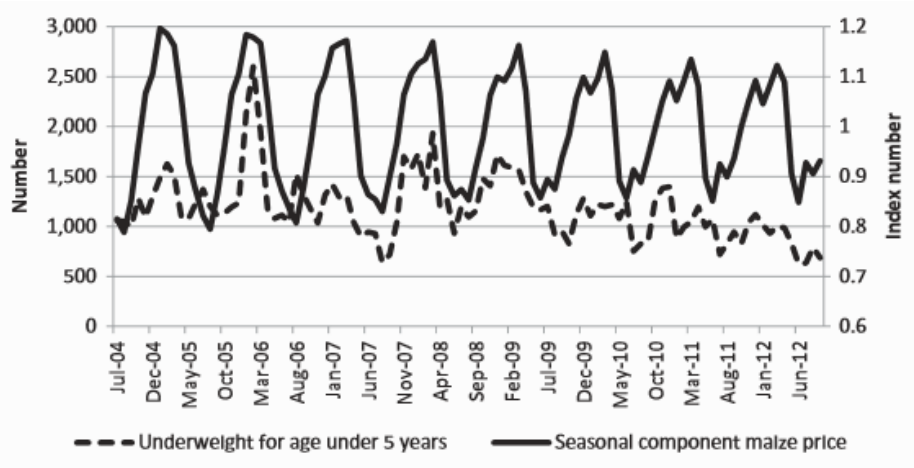
FUTOSHI YAMAUCHI
The World Bank, Washington, DC, USA

ABSTRACT *This article examines the impacts of prenatal conditions on child growth using recent data from Indonesia. There is seasonality in birthweight: this measure is significantly higher immediately after the main rice harvest in the country. The empirical results show that an increase in birthweight improves child growth outcomes as measured by the height and weight z-scores, as well as schooling performance as measured by age at start of schooling and number of grades repeated. The interactions of ecological variations affect early childhood human capital formation and can have long-term impacts on children's outcomes.*

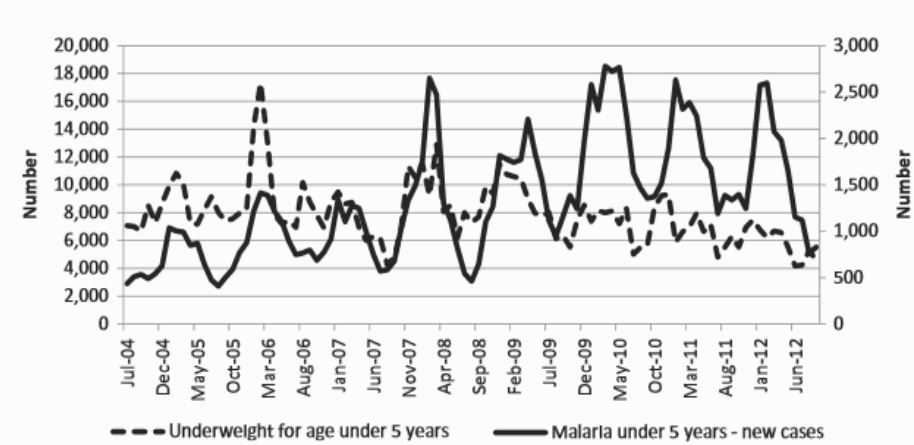
Seasonality can affect both diets & disease

For example, in Malawi:

Fluctuations in food markets
(here, seasonality in maize prices)



Fluctuations in disease
(here, seasonality in malaria cases)



Source: Maria Sassi (2015), Seasonality and Trends in Child Malnutrition: Time-Series Analysis of Health Clinic Data from the Dowa District of Malawi, *Journal of Development Studies*, 51(12): 1667-1682.

Many mechanisms link climate to health

Diet and disease effects are mediated by other factors

ELSEVIER
Economics and Human Biology
journal homepage: http://www.elsevier.com/locate/ehb

Early life height and weight production functions with endogenous energy and protein inputs

Esteban Puentes[a,1,*], Fan Wang[b], Jere R. Behrman[c], Flavio Cunha[d], John Hoddinott[e], John A. Maluccio[f], Linda S. Adair[g], Judith B. Borja[h], Reynaldo Martorell[i], Aryeh D. Stein[i]

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doi:10.

Multi-country analysis of the effects of diarrhoea on childhood stunting

William Checkley,[1]* Gillian Buckley,[1] Robert H Gilman,[1] Ana MO Assis,[2] Richard L Guer
Saul S Morris,[4] Kåre Mølbak,[5] Palle Valentiner-Branth,[5,6] Claudio F Lanata[7], Robert E Bl
and The Childhood Malnutrition and Infection Network

6 May 2008

Diarrhoea is an important cause of death and illness a
dren in developing countries; however, it remains contr
to whether diarrhoea leads to stunting. We conducted
analysis of nine studies that collected daily diarrhoea mo
longitudinal anthropometry to determine the effects of

Children's diets, nutrition knowledge and access to markets

Kalle Hirvonen (IFPRI – Ethiopia Strategy Support Program)
John Hoddinott (Cornell University, USA)
Bart Minten (IFPRI – Ethiopia Strategy Support Program)
David Stifel (Lafayette College, USA)

THE LANCET
Volume 374, Issue 9694, 19–25 September 2009, Pages 1032–1035

Viewpoint

Child undernutrition, tropical enteropathy, toilets, and handwashing

Dr Jean H Humphrey, ScD[a, b]
Show more

doi:10.1016/S0140-6736(09)60950-8

Of the 555 million preschool children in developing countries, 32% are stunte
are underweight.[1] Child underweight or stunting causes about 20% of all mor
children younger than 5 years of age and leads to long-term cognitive deficits,
performance in school and fewer years of completed schooling, and lower ad

What can we learn from the Nepal data?

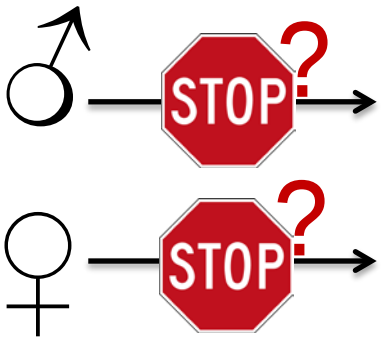
We isolate the *timing* and *sex-specificity* of effects and test for resilience from sanitation and food markets

Timing of exposure to varying NDVI

Pregnancy
- First trimester
- Second trimester
- Third trimester

Infancy
- 0-2 months
- 3-5 months
- 6-8 months
- 9-11 months

Sex of child in utero & infancy



Outcome after one year

- **Height-for-age** Z score (HAZ) at 12-59 months

Effect modifiers:

- Sanitation (toilets in the household)
- Food markets (use in the district)

We match past NDVI with each survey

We isolate the *timing* and *sex-specificity* of effects and test for resilience from sanitation and food markets

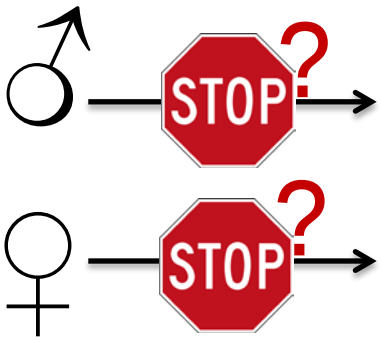
NASA, 2000-12: Historical NDVI at 5 km grid cells around survey site

Timing of exposure to varying NDVI

Pregnancy
- First trimester
- Second trimester
- Third trimester

Infancy
- 0-2 months
- 3-5 months
- 6-8 months
- 9-11 months

Sex of child in utero & infancy



NDHS, 2006 & 2011 Survey data

Outcome after one year

- **Height-for-age** Z score (HAZ) at 12-59 months

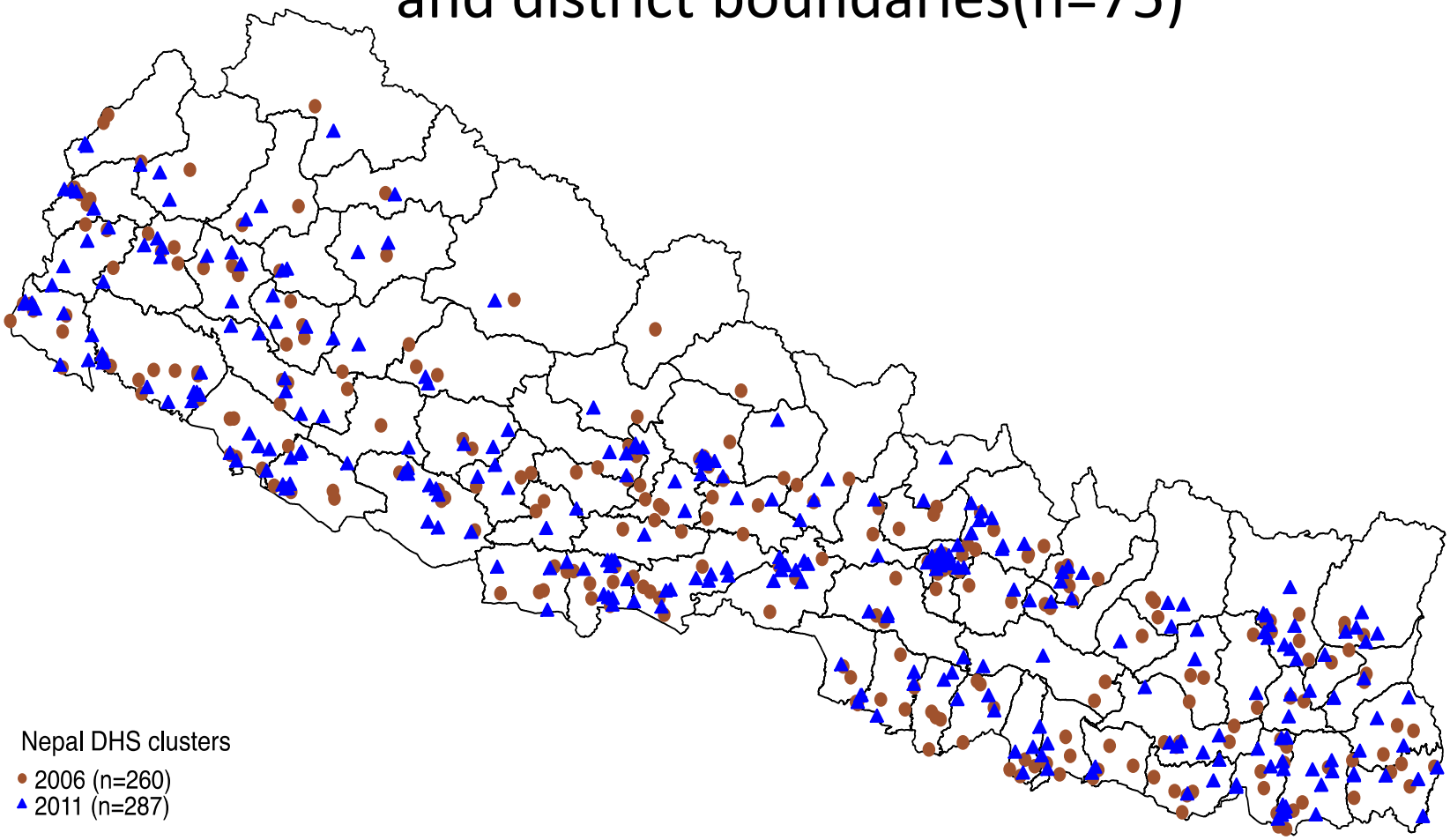
Effect modifiers:

- Sanitation (toilets in the household)
- Food markets (use in the district)

NLSS, 2003-04 & 2010-11 for food market use by district

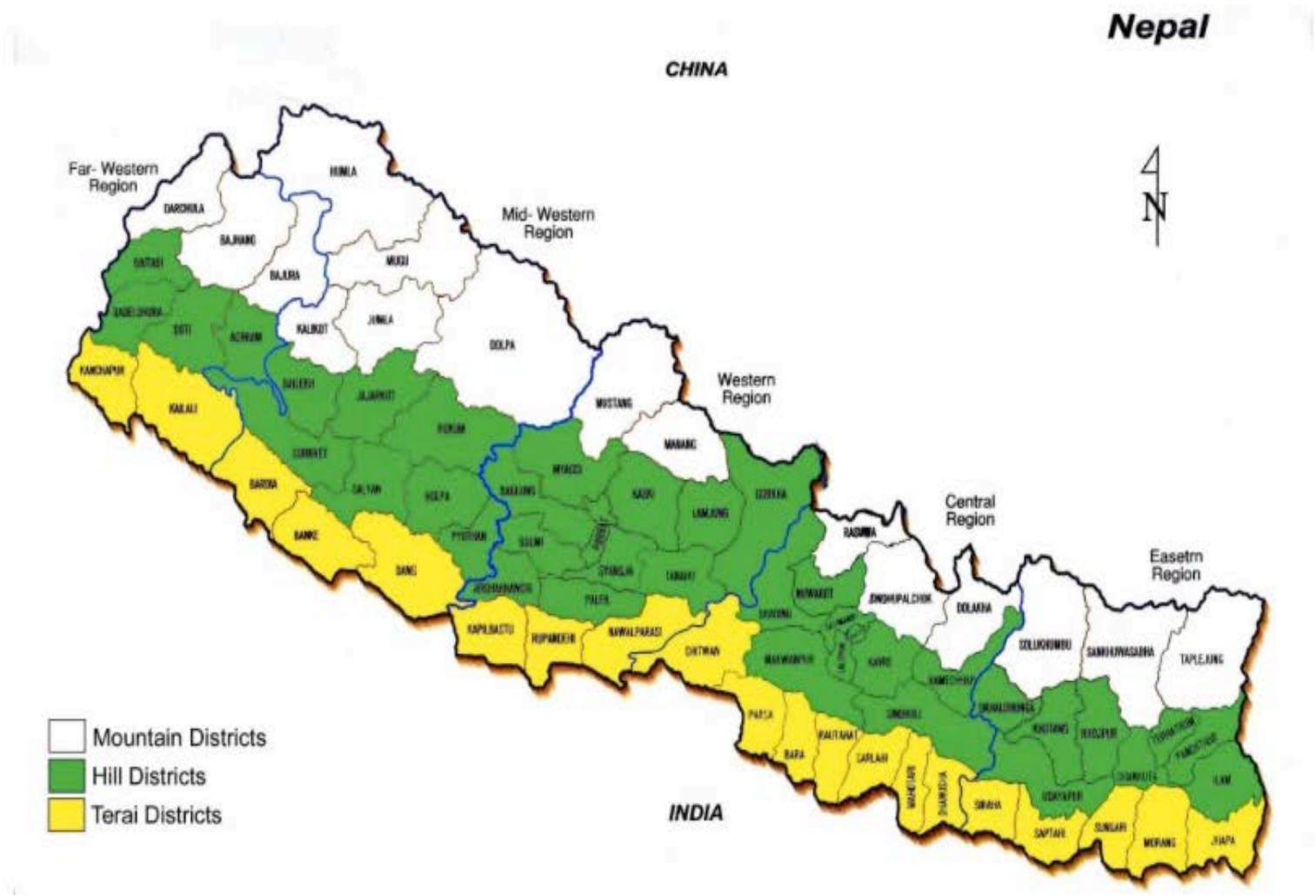
All results control for district fixed effects

Location of survey clusters (n=547)
and district boundaries(n=75)



Authors' map from jittered DHS data on cluster location; district boundaries are from Govt. of Nepal, at www.arcgis.com.

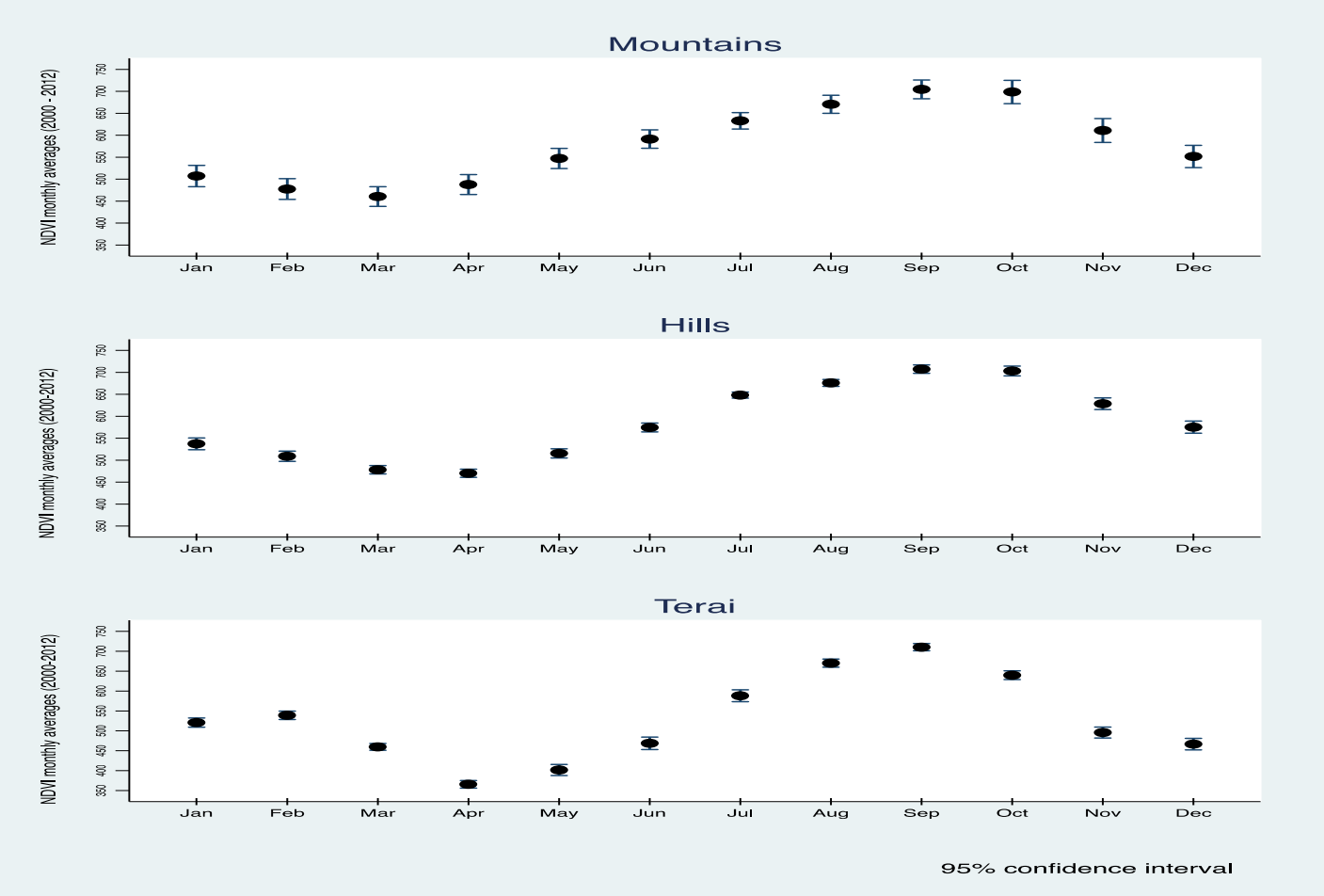
Results also control for altitude and zone



Source: www.mof.gov.np

Seasonality is predictable – and avoidable?

Mean of monthly NDVI (2000-2012) by zone



Note: The height of each line represents confidence interval and the point symbols represent mean of monthly NDVI from years 2000-2012 in 547 DHS clusters by regions; 87 clusters in Mountains, 226 clusters in Hills, and 234 clusters in Terai.

We find no selection into month of birth

In Nepal, exposure to NDVI is a valid natural experiment

Timing of conception on maternal and household characteristics, by month

	(1) Jan	(2) Feb	(3) Mar	(4) Apr	(5) May	(6) Jun	(7) Jul	(8) Aug	(9) Sep	(10) Oct	(11) Nov
Maternal age (log)	0.026	-0.026	-0.227	-0.197	0.652	0.338	0.397	-0.167	0.350	0.071	0.579
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Maternal primary education	0.157	0.306	0.128	0.450	0.354	0.273	0.483	0.081	0.499	0.194	0.482
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Maternal secondary education	0.046	0.272	0.183	0.101	0.112	0.008	0.166	-0.127	0.116	0.164	-0.059
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Maternal tertiary education	0.110	0.183	0.431	0.063	0.444	0.134	0.560	0.130	0.436	0.002	0.439
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Maternal BMI	-0.042	-0.015	-0.003	-0.041	-0.054	-0.022	-0.005	0.002	0.006	-0.026	0.007
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total children ever born	-0.026	-0.001	0.008	0.041	-0.028	-0.012	0.032	0.032	0.012	0.039	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wealth Quintile	-0.000	-0.044	-0.036	0.070	0.010	0.026	-0.057	0.006	0.003	-0.014	0.037
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Altitude (log)	0.026	0.385	-0.009	0.022	0.123	0.317	0.091	0.285	0.090	0.227	0.018
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2011 DHS observation	-0.046	0.262	-0.138	-0.040	-0.018	-0.169	-0.086	0.135	0.083	-0.046	-0.055
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Hill	0.719	-0.567	0.436	0.323	0.548	-0.895	0.342	0.411	-0.304	0.464	-0.105
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Terai	0.582	0.742	0.348	-0.484	0.831	0.317	0.052	0.387	0.815	0.608	0.049
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.198	-2.716	0.160	0.903	-2.508	-3.062	-2.132	-1.877	-2.398	-1.692	-2.664
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	6,127	6,127	6,127	6,127	6,127	6,127	6,127	6,127	6,127	6,127	6,127

Notes. Unit of observation is individual children between 12 and 60 months of age. Results shown are a multinomial logit model of selection into each month of conception, which is inferred to be 9 months before the observed month of birth (for example, April births imply conception in July.). Robust standard errors in parentheses, clustered on birth year. 2011 DHS observation indicate dummy=1 if the DHS survey was conducted in 2011. Hill and Terai dummies indicate likelihood compared to the Mountain region. *** p<0.01, ** p<0.05, * p<0.1

Our tests use within-district differences

We use OLS to link height with NDVI at each stage of pregnancy and infancy:

$$Y_i = \beta_0 + \beta_{1t} NDVI_{it} + \delta_i Z_i + \nu_i + u_i$$

Outcome Variable:
Height-for-Age Z-score (HAZ)

Agro-climatic conditions in pregnancy:
- First trimester
- Second trimester
- Third trimester

and infancy:
- 0-2 months
- 3-5 months
- 6-8 months
- 9-11 months

Control variables:

Maternal:
- Age, education, BMI

Household:
- Wealth, survey year

Child:
- Sex, age (in months), age squared (in months), year of birth

Geography:
- altitude, ecological zone

District fixed effects

We split the sample to test the sex-specificity of all coefficients

Boys are more vulnerable in the womb, girls after birth

	(1)	(3)	(5)
	Both sexes	Males	Females
NDVI in each period:			
First trimester	–0.102	–0.201	–0.074
Second trimester	0.395**	0.879***	–0.225
Third trimester	0.358	0.451	0.297
0–2 months of age	–0.313*	–0.086	–0.544**
3–5 months of age	–0.123	–0.164	–0.044
6–8 months of age	–0.309*	–0.335	–0.123
9–11 months of age	–0.238	–0.366	–0.179
Observations (n)	6,127	3,129	2,998
R-squared	0.187	0.196	0.207

Dependent variable is HAZ for children aged 12-59 months. Asterisks show p-values at ***p<0.01, **p<0.05, *p<0.1, with standard errors clustered for birth year and district. All results include fixed effects for each of 75 districts plus child's sex, age (months and months squared), number of siblings ever born, maternal age (log), maternal primary education, maternal secondary education, maternal tertiary education, maternal BMI (kg/m2), household wealth (quintile), altitude (log), survey year (1=2011), Hill region, Terai region, urban location and constant

We split the sample to test for differences in vulnerability by sanitation level

Both sexes are more vulnerable in households without toilets

	(1)	(2)	(3)	(4)	(5)	(6)
	Both sexes, No toilet	Both sexes, Has toilet	Male, No toilet	Male, Has toilet	Female, No toilet	Female, Has toilet
NDVI in each period:						
First trimester	–0.071	–0.070	–0.397	0.109	0.100	–0.231
Second trimester	0.522***	0.282*	1.016***	0.586	–0.172	–0.115
Third trimester	0.470	0.168	0.522**	0.275	0.392	0.133
0–2 months of age	–0.445*	–0.010	–0.041	0.003	–0.869***	–0.054
3–5 months of age	–0.179	–0.066	–0.137	–0.201	–0.105	–0.100
6–8 months of age	–0.568*	0.003	–0.691	0.183	–0.230	–0.203
9–11 months of age	–0.299	–0.167	–0.401	–0.209	–0.237	–0.232
Observations (n)	3,329	2,797	1,672	1,457	1,657	1,340
R-squared	0.134	0.221	0.169	0.230	0.143	0.272

Dependent variable is HAZ for children aged 12-59 months. Asterisks show p-values at ***p<0.01, **p<0.05, *p<0.1, with standard errors clustered for birth year and district. All results include fixed effects for each of 75 districts plus child's sex, age (months and months squared), number of siblings ever born, maternal age (log), maternal primary education, maternal secondary education, maternal tertiary education, maternal BMI (kg/m2), household wealth (quintile), altitude (log), survey year (1=2011), Hill region, Terai region, urban location and constant

We split sample to test for differences in vulnerability by use of food markets

Males are more vulnerable where food markets are less used
For females, may see opposite effect

	(1)	(2)	(3)	(4)	(5)	(6)
	Both sexes, Low market utilization	Both sexes, High market utilization	Males, Low market utilization	Males, High market utilization	Females, Low market utilization	Females, High market utilization
NDVI in each period:						
First trimester	0.054	–0.292	–0.170	–0.231	0.151	–0.337
Second trimester	0.411*	0.399	1.346***	0.416	–0.610	0.395
Third trimester	0.178	0.446	0.420	0.314	–0.073	0.381
0–2 months of age	–0.211	–0.520	0.137	–0.353	–0.650*	–0.571
3–5 months of age	–0.379	0.048	–0.231	–0.073	–0.485	0.178
6–8 months of age	–0.468**	–0.254	–1.088***	0.254	0.260	–0.801***
9–11 months of age	–0.406	–0.097	–0.501	–0.105	–0.292	–0.041
Observations (n)	3,064	3,063	1,561	1,568	1,503	1,495
R-squared	0.180	0.197	0.212	0.209	0.209	0.228

Dependent variable is HAZ for children aged 12-59 months. Asterisks show p-values at ***p<0.01, **p<0.05, *p<0.1, with standard errors clustered for birth year and district. All results include fixed effects for each of 75 districts plus child's sex, age (months and months squared), number of siblings ever born, maternal age (log), maternal primary education, maternal secondary education, maternal tertiary education, maternal BMI (kg/m2), household wealth (quintile), altitude (log), survey year (1=2011), Hill region, Terai region, urban location and constant

A placebo test: Could our results be an artefact of the method?

Unrelated correlations appear no more often than random

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Age of mother	Maternal primary education	Maternal secondary education	Maternal tertiary education	Maternal BMI (kg/m^2)	Total children ever born	Wealth (quintile)	Urban location
NDVI in each period:								
First trimester	–0.023	–0.202	0.088	0.047	–0.149	0.166	0.074	–0.196**
Second trimester	–0.081***	0.045	–0.018	0.030	–0.042	–0.219	0.075	–0.180
Third trimester	–0.011	–0.031	0.142	–0.021	–0.316	–0.070	–0.526*	0.045
0–2 months of age	0.019	0.064	0.045	0.018	–0.216	–0.165	–0.211	–0.138
3–5 months of age	0.051	0.246**	–0.051	–0.019	0.462	–0.210	–0.388	–0.017
6–8 months of age	0.104**	0.048	0.058	0.004	–0.759	0.094	–0.112	–0.053
9–11 months of age	0.012	–0.048	–0.025	0.037	0.141	–0.064	0.346	–0.279
Observations (n)	6,127	6,127	6,127	6,127	6,127	6,127	6,127	6,127
R-squared	0.586	0.061	0.252	0.109	0.176	0.617	0.558	0.313

Specifications are similar to child height regressions, but dependent variables are predetermined and could not be influenced by NDVI. Significance levels are attributable to chance: of the 56 placebo "treatments", five are significant with a *p*-value <0.1, four effects with a *p*-value <0.05, and one with a *p*-value <0.01.

Summary of results and implications

- We match NDVI in utero and infancy to heights observed at age 1-5
  - Males are more vulnerable in utero
    - Risk is mainly in 2nd trimester of pregnancy, consistent with sex-specificity in gestation
  - Girls are more vulnerable in infancy
    - Risk is mainly at 0-2 months of age, consistent with gender bias after birth
- We find effect modifiers that lead to smoother outcomes
  - Sanitation (household toilets) protects both sexes
    - Could block risk from disease transmission
  - Food markets (district-level use) protects boys
    - Could smooth diets of mothers, but not alter biased infant care practices
- Results have implications for policy and programs:
  - Targeting interventions to places with poor sanitation and low use of markets
    - Antenatal care, especially for boys
    - Postnatal care, especially for girls
  - Identifying the gains from sanitation and food access
    - Value of toilets may be primarily at times and places where climate favors disease transmission
    - Value of food markets may be to smooth shortfalls, as well as to sell surplus

Appendix: Tables and Figures

Height-for-Age Z-Score (HAZ) and Covariates

Summary statistics for all outcome and control variables

	(1) All observations N=6,127 children	(2) Male N= 3,129 children	(3) Female N= 2,998 children	(4) Male vs. Female N= 6,127 (P-value)
Nutritional status outcomes				
HAZ	-2.11 (1.25)	-2.10 (1.24)	-2.12 (1.26)	0.6363
Mother's BMI (kg/m^2)	20.55 (2.74)	20.54 (2.77)	20.57 (2.71)	0.7546
Child characteristics				
Female	48.9%	na	na	na
Child age (months)	35.65 (13.75)	35.89 (13.66)	35.41 (13.85)	0.1736
Total no. of siblings ever born	2.11 (1.96)	2.04 (1.93)	2.17 (1.99)	**0.0088**
Maternal characteristics				
Age (years)	27.42 (6.06)	27.37 (5.90)	27.46 (6.22)	0.5811
Primary education completed	18.0%	18.1%	17.9%	0.857
Secondary educat. completed	21.2%	21.4%	21.1%	0.822
Tertiary education completed	3.3%	3.3%	3.2%	0.846
Household characteristics				
Wealth (quintile)	2.66 (1.42)	2.67 (1.43)	2.65 (1.42)	0.6013
Has toilet	45.7%	46.6%	44.7%	0.146
District-level characteristics				
Food market participation (share of food consumption purchased or donated)	0.52 (0.20)	0.52 (0.20)	0.52 (0.20)	0.6698
Urbanization (pct. rural)	78.2%	78.3%	78.1%	0.863
Altitude (average, in meters)	833.42 (732.18)	846.86 (734.87)	819.38 (729.23)	0.1420

Note: Summary statistics pertain to all observations included in regressions (every measured child aged 12 to 59 months). Data presented in columns 1-3 are means (sd) or %. Column 4 show p-values of comparisons between male and female children using either chi-squared or independent samples t-test as appropriate.

Summary statistics of NDVIs over the years 2000-2012

Months	(1) All observations N = 547 clusters	(2) Mountains N = 87 clusters	(3) Hills N = 226 clusters	(4) Terai N = 234 clusters
January	525.38 (99.39)	507.14 (113.56)	537.26 (102.22)	520.70 (89.53)
February	516.78 (92.53)	477.42 (110.93)	508.90 (89.76)	539.03 (81.27)
March	467.39 (77.10)	460.37 (105.54)	478.13 (73.48)	459.62 (66.44)
April	428.22 (95.49)	487.74 (106.22)	470.14 (70.11)	365.60 (74.12)
May	471.73 (115.28)	547.17 (107.24)	515.39 (80.03)	401.51 (108.56)
June	531.78 (115.49)	591.30 (98.33)	574.32 (76.54)	468.56 (122.22)
July	620.03 (93.94)	632.83 (87.79)	648.13 (51.96)	588.13 (115.66)
August	672.56 (75.33)	670.45 (95.99)	675.86 (60.28)	670.16 (79.81)
September	708.05 (76.70)	704.40 (100.18)	707.18 (73.20)	710.24 (69.97)
October	675.26 (97.28)	698.56 (124.39)	703.04 (85.03)	639.75 (85.25)
November	568.88 (125.20)	610.81 (127.77)	628.50 (100.34)	495.71 (107.25)
December	524.98 (121.24)	551.62 (119.18)	575.22 (104.47)	466.55 (111.88)

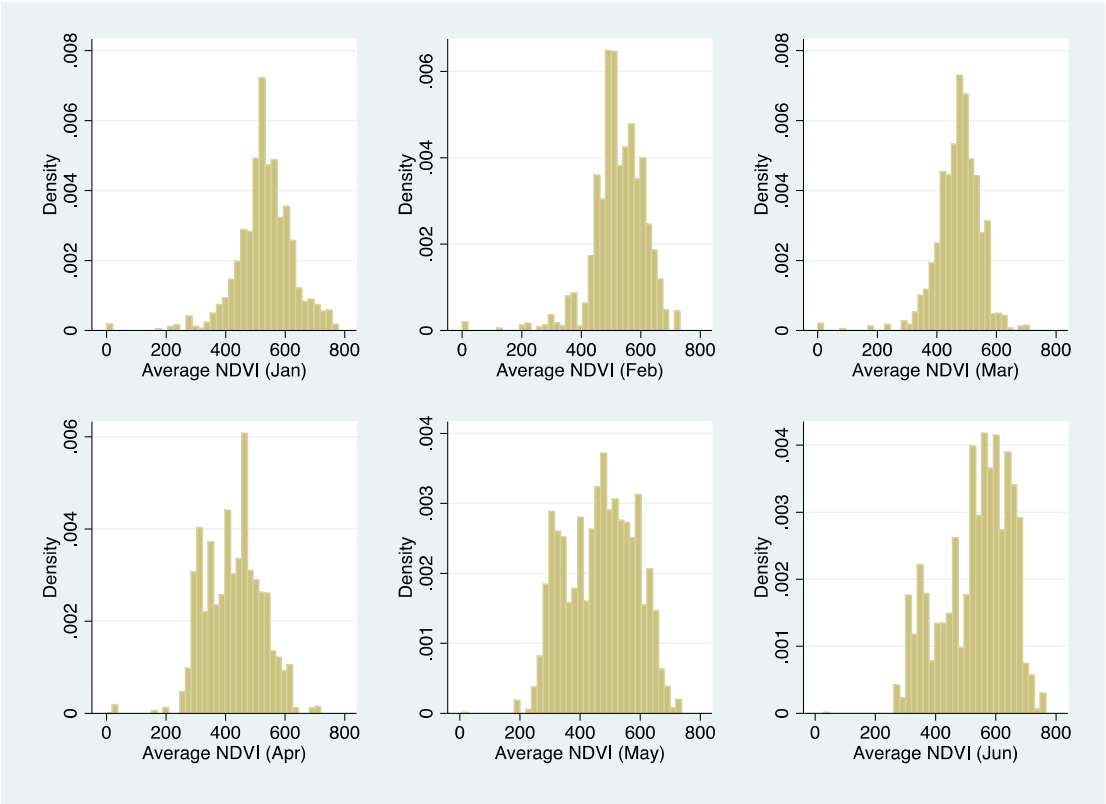
Note: Summary statistics pertain to average NDVIs spanning over the years 2000-2012 in each DHS clusters surveyed in 2006 and 2011. NASA NDVIs are available for DHS clusters in 2006 from Feb 2000- December 2011 and for clusters in 2011 from July 2000- May 2012. Data presented in columns 1-4 are means (sd).

Child height and month of birth

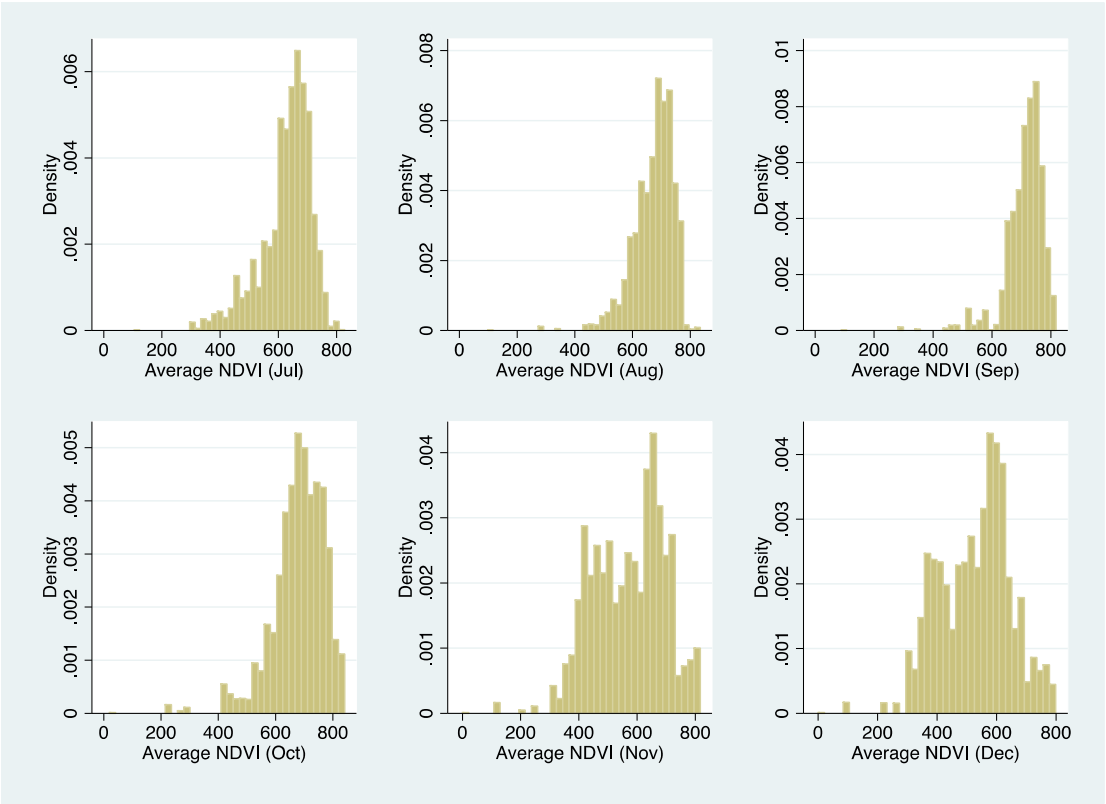
Child height and month of birth by sex, with alternative controls for age

Variable	(1) Both sexes, age in months	(2) Both sexes, age in years	(3) Males, age in months	(4) Males, age in years	(5) Females, age in months	(6) Females, age in years
February	−0.010	0.001	−0.042	−0.032	0.020	0.034
	(0.08)	(0.08)	(0.12)	(0.12)	(0.09)	(0.09)
March	−0.077	−0.054	−0.085	−0.067	−0.057	−0.027
	(0.09)	(0.08)	(0.13)	(0.13)	(0.06)	(0.05)
April	−0.198***	−0.321***	−0.188***	−0.279***	−0.213**	−0.349***
	(0.06)	(0.07)	(0.06)	(0.09)	(0.09)	(0.10)
May	−0.036	−0.125	−0.139	−0.208*	0.078	−0.026
	(0.07)	(0.10)	(0.10)	(0.12)	(0.08)	(0.12)
June	−0.143**	−0.211**	−0.235**	−0.287***	−0.059	−0.137
	(0.07)	(0.08)	(0.10)	(0.11)	(0.08)	(0.09)
July	−0.108	−0.161*	−0.091	−0.127	−0.111	−0.175
	(0.08)	(0.09)	(0.10)	(0.10)	(0.09)	(0.12)
August	−0.115	−0.150	−0.144	−0.159	−0.087	−0.142
	(0.09)	(0.11)	(0.10)	(0.12)	(0.12)	(0.13)
September	−0.127	−0.159	−0.277***	−0.288***	0.030	−0.017
	(0.09)	(0.11)	(0.09)	(0.11)	(0.13)	(0.15)
October	−0.090	−0.112	−0.197*	−0.212*	0.002	−0.027
	(0.11)	(0.11)	(0.11)	(0.12)	(0.14)	(0.15)
November	−0.059	−0.076	0.013	0.002	−0.169	−0.193*
	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)
December	−0.099	−0.107	−0.182	−0.181	−0.011	−0.022
	(0.10)	(0.10)	(0.13)	(0.13)	(0.10)	(0.10)
Female	−0.017	−0.013	n.a.	n.a.	n.a.	n.a.
	(0.04)	(0.04)				
Age (months)	−0.067***	n.a.	−0.061***	n.a.	−0.078***	n.a.
	(0.01)		(0.01)		(0.01)	
Age squared (months)	0.001***	n.a.	0.001***	n.a.	0.001***	n.a.
	(0.00)		(0.00)		(0.00)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth	n.a.	0.212***	n.a.	0.156***	n.a.	0.257***
		(0.04)		(0.05)		(0.04)
Constant	−1.392**	−427.182***	−1.715***	−314.317***	−1.160	−516.367***
	(0.55)	(89.35)	(0.63)	(96.70)	(0.76)	(81.48)
Observations (n)	6,127	6,127	3,129	3,129	2,998	2,998
R-squared	0.187	0.187	0.197	0.199	0.209	0.209

Histograms of monthly NDVIs averaged across years 2000-2012



Histograms of monthly NDVIs averaged across years 2000-2012



Crop calendar and crops grown

Crop calendar for main crops grown in Nepal, by ecological zone (source: FAO/WFP, 2007)

Crop	Ecological Zone	Irrigation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season
Paddy	Hills	Partial					TP	TP			H	H			Summer
		Year-round			TP	TP			H	H					Spring
	Terai	Rainfed						TP	TP		H	H	H		Summer
		Year-round			TP	TP			H	H	H				Spring
									TP	TP			H	H	Late Summer*
Maize	Mountains	Irrigated/Rainfed			P	P				H	H	H			Summer
	Hills	Rainfed			P	P				H	H				Summer
		Irrigated		P	P			H	H						Spring
	Terai	Rainfed				H	H			H	H				Summer
		Year-round		P	P			H	H						Spring
				H	H							P	P		Winter
Millet	Mountains	Rainfed				P	P					H	H		Summer
	Hills	Rainfed						P	P			H	H		Summer
Wheat	Mountains	Rainfed					H	H					P	P	Winter
	Hills	Rainfed			H	H	H					P	P	P	Winter
	Terai	Rainfed**			H	H						P	P		Winter
Barley	Mountains	Rainfed				H	H						P	P	Winter
	Hills	Rainfed			H	H						P	P	P	Winter

P = Planting; TP = Trans-Planting; H = Harvesting

* Recent option adopted by some farmers in the Eastern region, allowing two paddy crops a year.

** Supplemental irrigation is practiced in the east.

Note: Ecological zones do not fully reflect existing cropping patterns and the cropping calendar represents the most common practices within each zone.

Moving forward..

- Potentially use mother-fixed effects in regressions

Unique number of mothers in the dataset by siblings under five and survey year

Mothers with child (ren) that have:	NDHS 2006 (N= 5,237)	NDHS 2011 (N= 2,335)
No siblings	2792	1442
One sibling	1098	398
Two siblings	83	31
Three siblings	0	1
Total	**3973**	**1872**

- Look at protective effects of sanitation at neighborhood level
- Ensure location of survey corresponds with location of births of child

Explanatory variable: NDVI

- Green vegetation absorbs red light (RED) and reflects near infrared light (NIR)
- Sparse vegetation reflects more red light (RED) and absorbs NIR
- NDVI is calculated as follows: $$NDVI = \frac{NIR - RED}{NIR + RED}$$
- The dataset includes monthly NDVI values for 12 years (2000 – 2011) for each child's location of birth
- DHS Clusters: 260 in 2006, and 287 in 2011

NLSS: Determining market participation

NLSS District-level means:

1) Value of food purchased in markets
2) Value of food obtained in donations
3) Value of food produced in household farms

We compute:

District's average share of food consumption that is purchased or donated (market use): (1+2/ 1+2+3)

- ‘High market use’ districts = above or equal median market use
- ‘Low market use’ =below median of market use

Strengths and Limitations

- Random assignment to sanitary conditions, food markets and status of women
- Omitted variable bias
- Clear programmatic and policy implications
- Timing of vulnerabilities to seasonal shocks