



# Monsoon Babies

## Rainfall Shocks and Child Nutrition in Nepal

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# Motivation

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- ▶ Rural households in poor countries face considerable uninsured income risk.
- ▶ Policy response has emphasized expansion of social safety nets and promotion of crop and weather insurance schemes.
- ▶ An important concern is whether investments in human capital of children are protected.
  - ▶ Foster (1995)
  - ▶ Jacoby and Skoufias (1997)
  - ▶ Jensen(2000)
  - ▶ Maccini and Yang (2009)

# Research Question

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- ▶ Do household consumption-smoothing strategies in poor countries entail significant longer term costs in terms of reduced human capital for children?

# Relationship to Existing Literature

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- ▶ Shares features with the two major strands of work in this area..
  - ▶ **Short run focused:** Foster(1995), Jacoby and Skoufias (1997), Jensen (2000) that find significant effects of transitory shocks/current economic conditions on child weight and school attendance.
  - ▶ **Long run focused:** Maccini and Yang (2009) for example, finds that shocks in the early years of life have persistent effect into adulthood (height/schooling);
- ▶ ...but is the first to bridge the gap between the two. For the same sample of children we can assess:
  - ▶ *Mechanisms or channels* through which rainfall affects children's human capital and quantify “true” income effect.
  - ▶ Degree to which these impacts *persist* into the future.

# Setting and Data

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- ▶ Nepal (hilly terrain, agriculture remains rainfall dependent, 80% precipitation during monsoon)

## Data

- ▶ Repeated cross section of DHS data from 2001 and 2006 and 2011 for temporal variation.
- ▶ All three rounds have GPS coordinates of each survey cluster.
- ▶ Child anthropometric data, together with key household characteristics (mother's education, occupation, asset index of the HH etc.)

# Weight-for-height

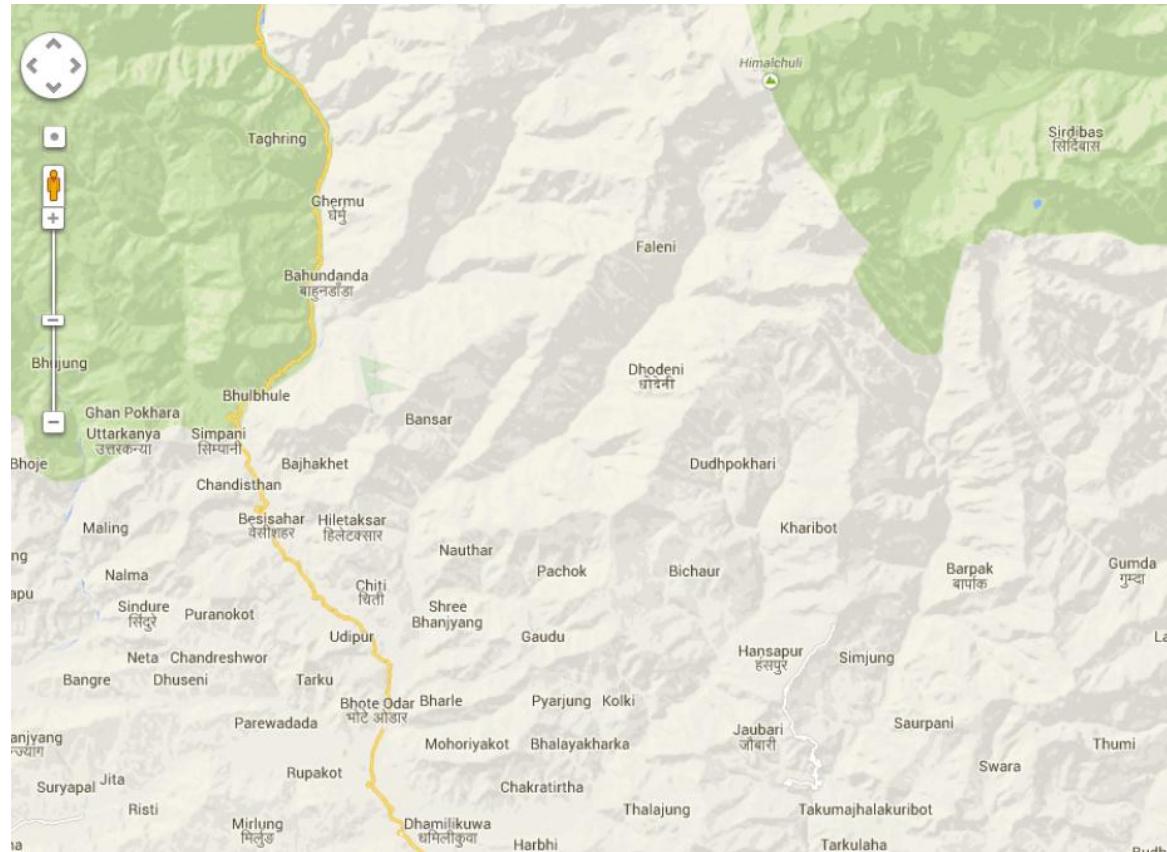
|       |          |       | Gender       |       | Age in months |       |       |       |       |
|-------|----------|-------|--------------|-------|---------------|-------|-------|-------|-------|
|       |          |       | All children | Boys  | Girls         | 0-11  | 12-23 | 24-35 | 36-47 |
| 2001  | Mean     | -0.73 | -0.74        | -0.73 | -0.78         | -1.09 | -0.65 | -0.54 | -0.61 |
|       | St. Dev. | 1.08  | 1.12         | 1.03  | 1.29          | 1.09  | 0.99  | 0.94  | 0.94  |
|       | Wasting  | 0.11  | 0.12         | 0.10  | 0.16          | 0.18  | 0.08  | 0.06  | 0.06  |
|       | Obs      | 6228  | 3080         | 3148  | 1232          | 1279  | 1200  | 1275  | 1242  |
| 2006  | Mean     | -0.85 | -0.85        | -0.71 | -0.91         | -1.13 | -0.78 | -0.70 | -0.74 |
|       | St. Dev. | 1.06  | 1.12         | 1.01  | 1.29          | 1.04  | 1.03  | 0.96  | 0.93  |
|       | Wasting  | 0.13  | 0.13         | 0.12  | 0.18          | 0.19  | 0.12  | 0.08  | 0.09  |
|       | Obs      | 5109  | 2582         | 2527  | 950           | 1011  | 1085  | 1000  | 1063  |
| 2011  | Mean     | -0.67 | -0.71        | -0.63 | -0.74         | -0.87 | -0.59 | -0.55 | -0.62 |
|       | St. Dev. | 1.13  | 1.17         | 1.09  | 1.38          | 1.16  | 1.07  | 1.02  | 0.99  |
|       | Wasting  | 0.11  | 0.12         | 0.10  | 0.16          | 0.16  | 0.09  | 0.08  | 0.07  |
|       | Obs      | 2345  | 1218         | 1127  | 454           | 448   | 487   | 501   | 455   |
| Total | Mean     | -0.77 | -0.78        | -0.76 | -0.82         | -1.07 | -0.69 | -0.60 | -0.66 |
|       | St. Dev. | 1.08  | 1.13         | 1.04  | 1.31          | 1.09  | 1.03  | 0.97  | 0.95  |
|       | Wasting  | 0.12  | 0.12         | 0.11  | 0.17          | 0.18  | 0.09  | 0.07  | 0.07  |
|       | Obs      | 13682 | 6880         | 6802  | 2636          | 2738  | 2772  | 2776  | 2760  |

# Height-for-age

|       |          | All children | Gender |       | Age in months |       |       |       |       |
|-------|----------|--------------|--------|-------|---------------|-------|-------|-------|-------|
|       |          |              | Boys   | Girls | 0-11          | 12-23 | 24-35 | 36-47 | 48-59 |
| 2001  | Mean     | -2.16        | -2.17  | -2.15 | -1.16         | -2.19 | -2.54 | -2.53 | -2.38 |
|       | St. Dev. | 1.37         | 1.37   | 1.37  | 1.43          | 1.28  | 1.25  | 1.24  | 1.15  |
|       | Stunted  | 56.7         | 57.1   | 56.3  | 26.8          | 55.3  | 68.2  | 69.7  | 63.6  |
|       | Obs      | 6214         | 3070   | 3144  | 1239          | 1276  | 1193  | 1265  | 1241  |
| 2006  | Mean     | -1.94        | -1.96  | -1.92 | -0.93         | -1.94 | -2.24 | -2.31 | -2.22 |
|       | St. Dev. | 1.36         | 1.36   | 1.36  | 1.43          | 1.31  | 1.22  | 1.19  | 1.18  |
|       | Stunted  | 50.5         | 50.7   | 50.1  | 21.8          | 48.5  | 59.8  | 61.8  | 57.9  |
|       | Obs      | 5123         | 2593   | 1125  | 964           | 1014  | 1086  | 998   | 1061  |
| 2011  | Mean     | -1.69        | -1.72  | -1.66 | -0.76         | -1.55 | -2.05 | -2.12 | -1.89 |
|       | St. Dev. | 1.42         | 1.43   | 1.41  | 1.55          | 1.42  | 1.27  | 1.18  | 1.22  |
|       | Stunted  | 41.9         | 42.6   | 41.1  | 18.1          | 36.8  | 52.4  | 53.7  | 46.4  |
|       | Obs      | 2346         | 1221   | 1125  | 458           | 445   | 490   | 499   | 454   |
| Total | Mean     | -1.99        | -1.99  | -1.99 | -1.01         | -1.99 | -2.34 | -2.38 | -2.23 |
|       | St. Dev. | 1.38         | 1.38   | 1.38  | 1.45          | 1.33  | 1.25  | 1.22  | 1.18  |
|       | Stunted  | 51.8         | 51.9   | 51.7  | 23.5          | 49.8  | 62.1  | 63.9  | 58.6  |
|       | Obs      | 13683        | 6884   | 6799  | 2661          | 2735  | 2769  | 2762  | 2756  |

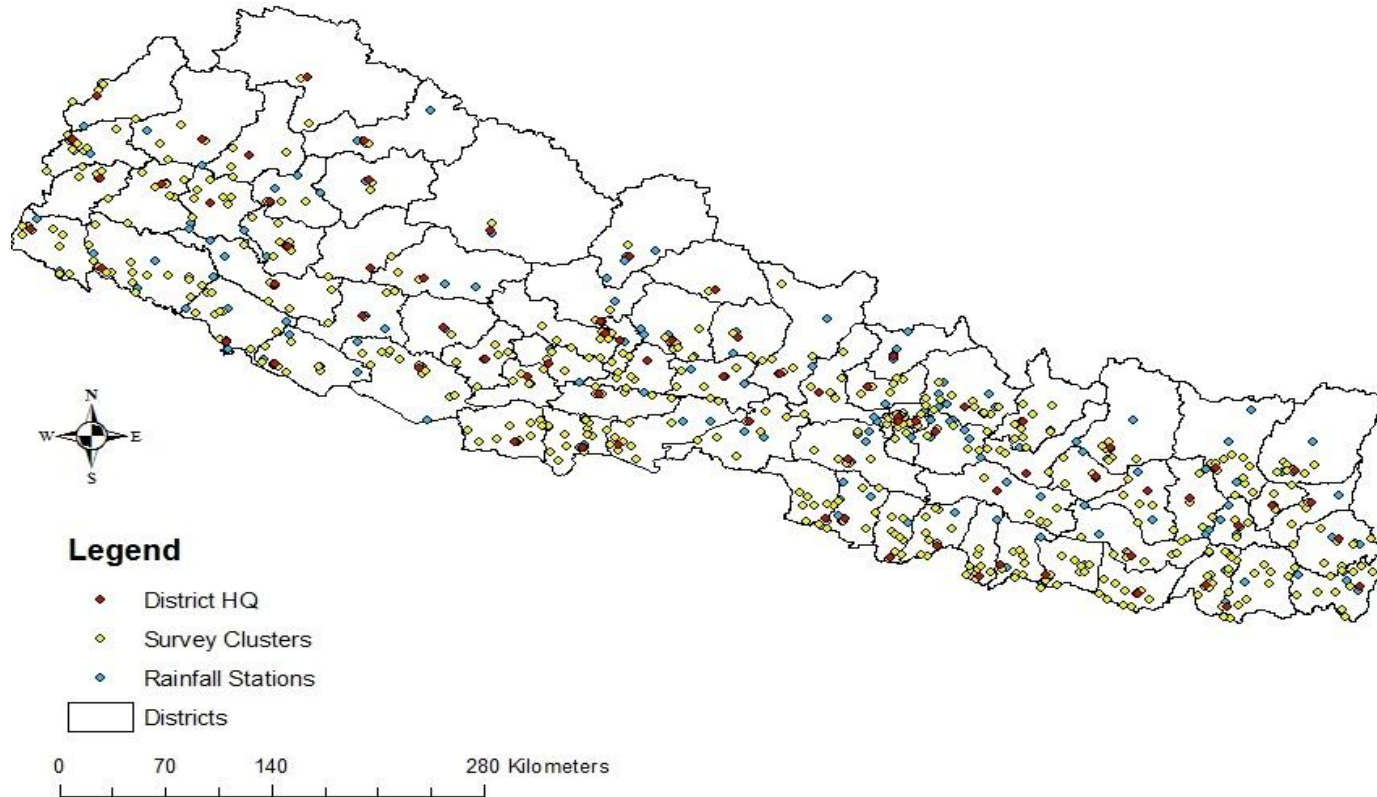
# Interpolating Rainfall Variables

- ▶ Standard way in which this is done in the literature is by matching the closest station.





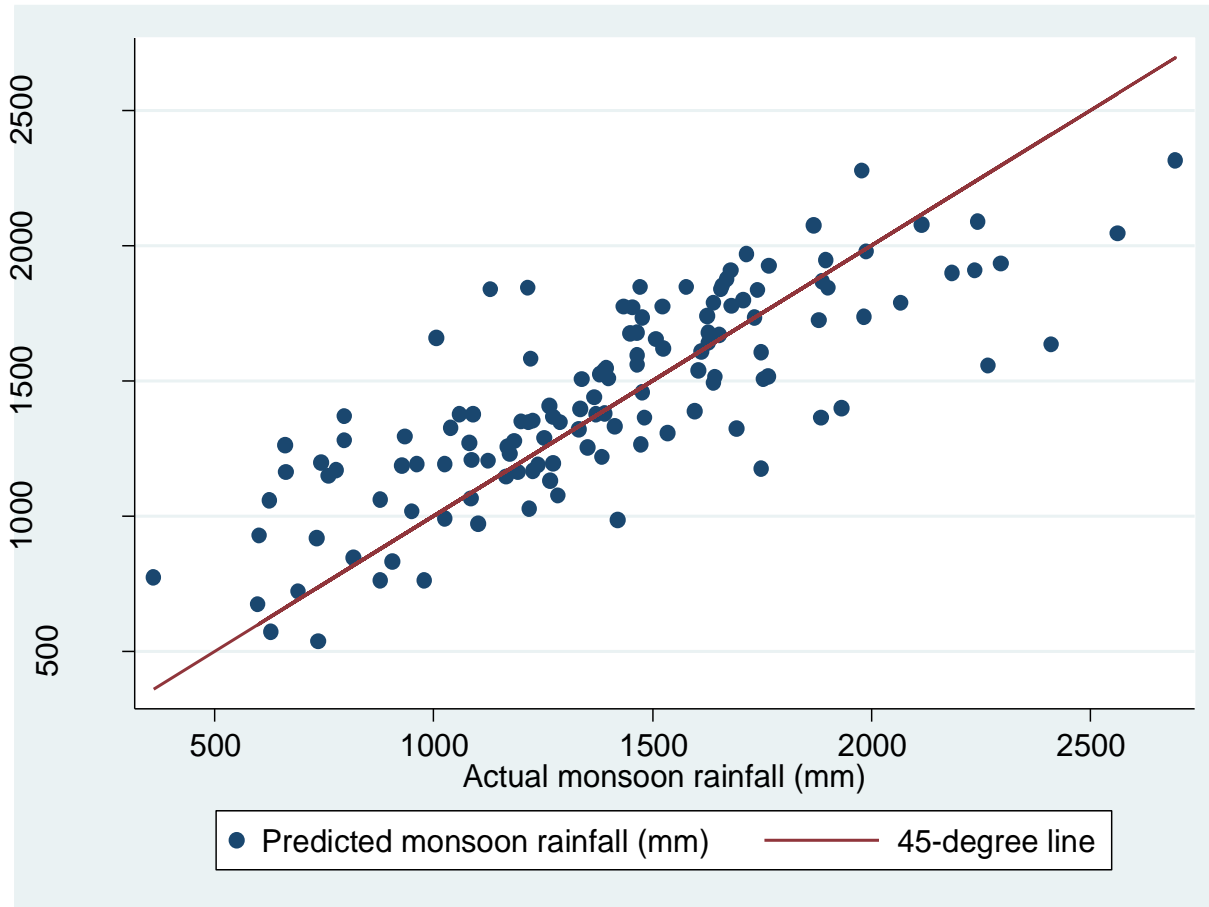
# Imputing Rainfall Shocks



$$\bar{W}_{sm} = \alpha + \beta_1 Lat_{sm} + \beta_2 Long_{sm} + \beta_3 Lat_{sm} * Long_{sm} + \beta_4 Alt_{sm} + \beta_5 Lat_{sm} * Alt_{sm} + \beta_6 Long_{sm} * Alt_{sm} + \mu$$

# How well does the imputation work?

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# The Short Run Model (weight-for-height)

- ▶  $WHZ_{ijt} = \alpha + \beta RP_{ijt} + \gamma RC_{ijt} + \delta' X_{ijt} + \varphi_r + \mu_t + \varepsilon_{ijt}$
- $RC_{ijt}$  deviation from normal rainfall (%) since beginning of monsoon season until date of interview for cluster  $j$  in year  $t$  (current period shock).
  - $RP_{ijt}$  is deviation from normal rainfall (%) during previous year's monsoon for cluster  $j$  (past shock or the most recent completed monsoon shock).
  - $X_{ijt}$  child and household characteristics.
  - $\varphi_r$  region dummy.
  - $\mu_t$  year dummy.

## Key parameters of interest:

$\gamma$  (Disease environment effect): Expected to be unambiguously negative

$\beta$  (Real income + disease environment effect): Sign is a priori unclear because it is a combination of two countervailing effects

$$\beta \leq \text{True Income Effect of Shock} \leq (\beta - \gamma)$$

# Main Result

|  | (1)                        | (2)                 | (3)                 | (4)                 | (5)                 |
|--|----------------------------|---------------------|---------------------|---------------------|---------------------|
| VARIABLES  | Weight-for-height z-scores |                     |                     |                     |                     |
| Shock in current period monsoon rain (RC)            | -0.000<br>(0.001)          | -0.001<br>(0.001)   | -0.001*<br>(0.001)  | -0.002*<br>(0.001)  | -0.002*<br>(0.001)  |
| Shock in the most recent completed monsoon rain (RP) | 0.015***<br>(0.003)        | 0.014***<br>(0.003) | 0.012***<br>(0.003) | 0.012***<br>(0.003) | 0.013***<br>(0.003) |
| Normal monsoon rainfall (mm)                         | -0.000<br>(0.000)          | -0.001*<br>(0.000)  | -0.000<br>(0.000)   | -0.000<br>(0.000)   | -0.000<br>(0.000)   |
| Interviewed during the monsoon (= 1)                 | -0.179***<br>(0.052)       | -0.063<br>(0.055)   | -0.050<br>(0.049)   | -0.049<br>(0.049)   | -0.055<br>(0.049)   |
| Drinking water source far? (DWS)                     |                            |                     |                     | 0.006<br>(0.025)    | -0.005<br>(0.027)   |
| Health post difficult to access? (HPA)               |                            |                     |                     | -0.005<br>(0.024)   | 0.002<br>(0.025)    |
| DWS x RC   |                            |                     |                     |                     | 0.000<br>(0.001)    |
| DWS x RP   |                            |                     |                     |                     | -0.003<br>(0.002)   |
| HPA x RC   |                            |                     |                     |                     | 0.000<br>(0.001)    |
| HPA x RP   |                            |                     |                     |                     | 0.001<br>(0.002)    |
| Year of survey dummies                               | Yes                        | Yes                 | Yes                 | Yes                 | Yes                 |
| Region dummies                                       | Yes                        | Yes                 | Yes                 | Yes                 | Yes                 |
| Child characteristics                                | No                         | Yes                 | Yes                 | Yes                 | Yes                 |
| Mother's characteristics                             | No                         | No                  | Yes                 | Yes                 | Yes                 |
| Observations   | 11,338                     | 11,338              | 11,338              | 11,338              | 11,338              |
| R-squared  | 0.063                      | 0.116               | 0.187               | 0.187               | 0.187               |

# Age Heterogeneity of Impact

| VARIABLES   | (1)                        | (2)      | (3)      |
|---|----------------------------|----------|----------|
|   | Weight-for-height z-scores |          |          |
|   | All children               | Boys     | Girls    |
| Shock in current period monsoon rain (RC)                 | -0.002*                    | -0.001   | -0.002*  |
|   | (0.001)                    | (0.001)  | (0.001)  |
| 0-11 months x Shock in the most recent completed monsoon  | 0.013**                    | 0.015**  | 0.011    |
|   | (0.005)                    | (0.007)  | (0.007)  |
| 12-23 months x Shock in the most recent completed monsoon | 0.015***                   | 0.013*** | 0.019*** |
|   | (0.004)                    | (0.005)  | (0.005)  |
| 24-35 months x Shock in the most recent completed monsoon | 0.010***                   | 0.008*   | 0.011**  |
|   | (0.004)                    | (0.005)  | (0.005)  |
| 35-47 months x Shock in the most recent completed monsoon | 0.014***                   | 0.017*** | 0.013*** |
|   | (0.004)                    | (0.006)  | (0.005)  |
| 48-59 months x Shock in the most recent completed monsoon | 0.009***                   | 0.012**  | 0.007    |
|   | (0.003)                    | (0.005)  | (0.005)  |
| Female  | 0.030                      |          |          |
|   | (0.020)                    |          |          |
| Normal monsoon rainfall (mm)                              | -0.000                     | -0.001   | -0.000   |
|   | (0.000)                    | (0.001)  | (0.001)  |
| Interviewed during the monsoon (= 1)                      | -0.078                     | -0.038   | -0.113** |
|   | (0.049)                    | (0.069)  | (0.056)  |
| Year of survey dummies                                    | Yes                        | Yes      | Yes      |
| Region dummies  | Yes                        | Yes      | Yes      |
| Child characteristics                                     | Yes                        | Yes      | Yes      |
| Mother's characteristics                                  | Yes                        | Yes      | Yes      |
| Observations  | 11,338                     | 5,685    | 5,653    |
| R-squared   | 0.200                      | 0.260    | 0.259    |

# Current Rainfall Shock and Morbidity

| VARIABLES                                | (1)   | (2)                    | (3)                | (4)                  |
|--|---|------------------------|--------------------|----------------------|
|  | Dependent variable: Diarrhea (=1 if reported in the last two weeks) |                        |                    |                      |
| Shock in the current period monsoon (RC) | 0.0010**<br>(0.0005)  | 0.0011**<br>(0.0005)   | 0.001**<br>(0.000) | 0.001**<br>(0.000)   |
| Female x RC                              |   |                        | 0.000<br>(0.000)   | 0.0002<br>(0.0004)   |
| Female                                   | -0.0327***<br>(0.0117)  | -0.0344***<br>(0.0119) | -0.031*<br>(0.017) | -0.0306*<br>(0.0167) |
| Drinking water source far? (DWS)         |   |                        | 0.001<br>(0.017)   | 0.0073<br>(0.0243)   |
| Health post difficult to access? (HPA)   |   |                        | 0.022<br>(0.014)   | 0.0345<br>(0.0277)   |
| DWS x RC                                 |   |                        |                    | 0.0004<br>(0.0007)   |
| HPA x RC                                 |   |                        |                    | 0.0003<br>(0.0008)   |
| Normal monsoon rainfall (mm)             | 0.0001<br>(0.0003)  | 0.0001<br>(0.0003)     | 0.000<br>(0.000)   | 0.0001<br>(0.0004)   |
| Year of survey dummies                   | Yes   | Yes                    | Yes                | Yes                  |
| Region dummies                           | Yes   | Yes                    | Yes                | Yes                  |
| Child characteristics                    | Yes   | Yes                    | Yes                | Yes                  |
| Mother's characteristics                 | No  | Yes                    | Yes                | Yes                  |
| Observations                             | 3,146   | 3,146                  | 3,146              | 3,146                |
| R-squared                                | 0.110   | 0.139                  | 0.140              | 0.140                |

# Robustness Check #1 – Urban Children

| VARIABLES  | (1)                        | (2)                | (3)               |
|--|----------------------------|--------------------|-------------------|
|  | Weight-for-height z-scores |                    |                   |
| Shock in current period monsoon rain (RC)            | 0.000<br>(0.002)           | -0.000<br>(0.002)  | -0.002<br>(0.002) |
| Shock in the most recent completed monsoon rain (RP) | 0.007<br>(0.009)           | 0.001<br>(0.008)   | -0.003<br>(0.009) |
| Normal monsoon rainfall (mm)                         | -0.001<br>(0.001)          | -0.001*<br>(0.001) | 0.000<br>(0.001)  |
| Year of survey dummies                               | Yes                        | Yes                | Yes               |
| Region dummies                                       | Yes                        | Yes                | Yes               |
| Child characteristics                                | No                         | Yes                | Yes               |
| Mother's characteristics                             | No                         | No                 | Yes               |
| Observations   | 2,180                      | 2,180              | 2,180             |
| R-squared  | 0.065                      | 0.124              | 0.328             |

# Robustness Check #2 – Future Shocks

| VARIABLES   | (1)                        | (2)                  | (3)                 |
|---|----------------------------|----------------------|---------------------|
|   | Weight-for-height z-scores |                      |                     |
| Shock in current period monsoon rain (RC)         | -0.000<br>(0.001)          | -0.001*<br>(0.001)   | -0.001*<br>(0.001)  |
| Shock in the "future" monsoon rain ( $t+1$ ) (RF) | -0.002<br>(0.001)          | -0.001<br>(0.001)    | -0.001<br>(0.001)   |
| Normal monsoon rainfall (mm)                      | -0.001**<br>(0.001)        | -0.002***<br>(0.001) | -0.001**<br>(0.000) |
| Year of survey dummies                            | Yes                        | Yes                  | Yes                 |
| Region dummies                                    | Yes                        | Yes                  | Yes                 |
| Child characteristics                             | No                         | Yes                  | Yes                 |
| Mother's characteristics                          | No                         | No                   | Yes                 |
| Observations                                      | 9,666                      | 9,666                | 9,666               |
| R-squared   | 0.047                      | 0.125                | 0.232               |



# Robustness Check #3 – Other Illnesses

| VARIABLES                                     | (1)                              | (2)      | (3)     | (1)                                 | (2)      | (3)     |
|---|----------------------------------|----------|---------|-------------------------------------|----------|---------|
|   | Any fever in the last two weeks? |          |         | Any coughing in the last two weeks? |          |         |
| Shock in the current period monsoon rain (RC) | 0.0006*                          | 0.0004   | 0.001   | 0.0004                              | 0.0002   | 0.000   |
|   | (0.0003)                         | (0.0004) | (0.000) | (0.0004)                            | (0.0004) | (0.000) |
| RC x Female                                   |                                  |          | -0.000  |                                     |          | -0.000  |
|   |                                  |          | (0.000) |                                     |          | (0.000) |
| Female  | -0.0103                          | -0.0111  | -0.012  | -0.0122                             | -0.0111  | -0.010  |
|   | (0.0145)                         | (0.0145) | (0.015) | (0.0143)                            | (0.0139) | (0.014) |
| Drinking water source far? (DWS)              |                                  |          | -0.012  |                                     |          | -0.027  |
|   |                                  |          | (0.018) |                                     |          | (0.020) |
| Health post difficult to access? (HPA)        |                                  |          | 0.025   |                                     |          | 0.007   |
|   |                                  |          | (0.018) |                                     |          | (0.017) |
| Year of survey effects                        | Yes                              | Yes      | Yes     | Yes                                 | Yes      | Yes     |
| Region fixed effects                          | Yes                              | Yes      | Yes     | Yes                                 | Yes      | Yes     |
| Child characteristics                         | Yes                              | Yes      | Yes     | Yes                                 | Yes      | Yes     |
| Mother's characteristics                      | No                               | Yes      | Yes     | No                                  | Yes      | Yes     |
| Observations                                  | 3,135                            | 3,135    | 3,135   | 3,136                               | 3,136    | 3,136   |
| R-squared                                     | 0.121                            | 0.156    | 0.157   | 0.118                               | 0.156    | 0.157   |
| Robust standard errors in parentheses         |                                  |          |         |                                     |          |         |

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

# Height-for-Age Results

| VARIABLES   | (1)               | (2)               | (3)                |
|---|-------------------|-------------------|--------------------|
|   | Height-for-age    |                   |                    |
| Rainfall shock in first year of life (%) [R1] x Cohort 1      | 0.006<br>(0.005)  | -0.013<br>(0.008) | -0.009<br>(0.008)  |
| R1 x Cohort 2   | 0.005*<br>(0.003) | 0.003<br>(0.004)  | 0.003<br>(0.004)   |
| R1 x Cohort 3   | -0.000<br>(0.005) | -0.003<br>(0.007) | -0.003<br>(0.007)  |
| R1 x Cohort 4   | 0.001<br>(0.004)  | 0.001<br>(0.004)  | -0.003<br>(0.004)  |
| R1 x Cohort 5 (youngest)                                      | 0.002<br>(0.003)  | -0.003<br>(0.008) | -0.003<br>(0.008)  |
| Rainfall shock in the second year of life (%) [R2] x Cohort 1 | 0.004<br>(0.004)  | 0.005<br>(0.006)  | 0.003<br>(0.006)   |
| R2 x Cohort 2   | -0.002<br>(0.006) | -0.006<br>(0.007) | -0.007<br>(0.007)  |
| R2 x Cohort 3   | 0.005*<br>(0.003) | 0.006*<br>(0.003) | 0.005*<br>(0.003)  |
| R2 x Cohort 4   | -0.001<br>(0.002) | 0.013*<br>(0.007) | 0.014**<br>(0.007) |
| Rainfall shock in the third year of life (%) [R3] x Cohort 1  | 0.007<br>(0.009)  | 0.003<br>(0.012)  | 0.002<br>(0.012)   |
| R3 x Cohort 2   | -0.005<br>(0.005) | 0.001<br>(0.005)  | -0.001<br>(0.005)  |
| R3 x Cohort 3   | -0.002<br>(0.002) | -0.000<br>(0.009) | -0.001<br>(0.009)  |

# Catch up growth?

|  | (1)            | (2)         | (3)       |
|--|----------------|-------------|-----------|
| VARIABLES  | Height-for-age |             |           |
| Rainfall shock in the second year of life (%) [R2] | 0.00913*       | 0.00969*    | 0.01534*  |
|  | (0.00530)      | (0.00538)   | (0.00877) |
| R2 x No. of months since the shock                 | -0.00023***    | -0.00019*** | -0.00071  |
|  | (0.00007)      | (0.00006)   | (0.00070) |
| R2 x No. of months since the shock x Female        |                | -0.00007    |           |
|  |                | (0.00015)   |           |
| R2 x Female  |                | 0.00098     |           |
|  |                | (0.00335)   |           |
| R2 x (No. of months since the shock) <sup>2</sup>  |                |             | 0.00001   |
|  |                |             | (0.00001) |
| Year of survey dummies                             | Yes            | Yes         | Yes       |
| Region dummies                                     | Yes            | Yes         | Yes       |
| Child characteristics                              | Yes            | Yes         | Yes       |
| Mother's characteristics                           | Yes            | Yes         | Yes       |
| Observations                                       | 7,767          | 7,767       | 7,767     |
| R-squared  | 0.112          | 0.110       | 0.112     |

- The positive effect on child height of a 10% excess rainfall in the second year of life falls by 0.002 standard deviations for every month removed from the monsoon.
- This implies that by 39 months, the shock impact goes to 0.

# Implications for Policy

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Our evidence suggests that:

- (1) Income fluctuations induced by rainfall shocks have significant effects on human capital investment;
- (2) Though large and significant in the short run, these effects are not persistent over time.

From the point of view of policy:

- (1) It is unclear if long run impact of shocks on children's human capital can be used to justify investments in ex ante income insurance schemes (e.g. rainfall insurance)
- (2) We have examined one component of the stock of long run human capital: stature. But a natural question that arises is whether these shocks can also affect cognitive abilities in the long run.
- (3) Climate change – non-linearity of impact?