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# Monsoon Babies

## Rainfall Shocks and Child Nutrition in Nepal

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## Abstract

Do household consumption-smoothing strategies in poor countries entail significant long-run costs in terms of reduced human capital? This paper exploits the timing of monsoon rainfall shocks and the seasonal nature of agriculture to isolate income effects on early childhood anthropometric outcomes in rural Nepal and to provide evidence on the persistence of these effects into later childhood. Findings suggest that a 10 percent increase in rainfall from historic norms during the most recently completed monsoon leads to a 0.15 standard deviation increase in weight-for-age for children ages 0–36 months. This total impact consists of a negative "disease environment effect" of no more than 0.02 standard deviations and a positive "income effect" as high as 0.17 standard deviations. Consistent with this interpretation, excess monsoon rainfall also enhances child stature, but only if the monsoon rainfall shock is experienced in the *second* year of life. Moreover, this effect on child height is transitory, dissipating completely by age five.

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# Monsoon Babies:
# Rainfall Shocks and Child Nutrition in Nepal

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## 1. Introduction

Recognition that households in poor countries, especially those in rural areas, face considerable uninsured income risk has led to increasing policy emphasis on expanding social safety nets as well as encouraging crop or weather insurance. One important rationale for these policies is that lack of insurance, even if it does not manifest itself directly in terms of high consumption volatility, can have harmful indirect effects (Chetty and Looney, 2006). In particular, uninsured households may engage in costly ex-post consumption-smoothing strategies, such as liquidating productive assets or drawing down investments in response to bad shocks. Of chief concern is protecting investments in the human capital of children.

Evidence from Jacoby and Skoufias (1997) that parents in rural India withdraw children from school in response to negative income shocks induced by poor rainfall indicates a significant downside to self-insurance, one borne largely by the subsequent generation.[2] Yet, without follow-up information on the eventual schooling (or labor market) *outcomes* of these children it is difficult to evaluate the long-run cost of this particular consumption-smoothing mechanism. More recently, Maccini and Yang (2009) find that rural Indonesian girls exposed to excess rainfall in their first year of life (though not in their second or subsequent years) grew up to become taller and better educated than their otherwise identical peers. While suggestive, this evidence linking uninsured *income* volatility and eventual human capital is indirect.

This paper looks to strengthen the linkage by considering the impact of rainfall shocks on child anthropometrics (weight and height) in rural Nepal. Our analysis shares features of both of the abovementioned papers. Like Maccini and Yang (2009), we exploit the fact that height is a cumulative measure of past health/nutrition shocks and should therefore reflect income variability experienced earlier in life. In our case, however, we examine height-for-age of children no more than five years of age, rather than of adults. The biomedical literature suggests that stature in adulthood is largely predetermined by age three (e.g., Martorell et al., 1994). A large body of evidence from developing countries

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[2] Jensen (2000) provides similar evidence for child health investments in Africa. Alderman et al. (2006), Foster (1995), and Hoddinott and Kinsey (2001) also examine the child health effects of different types of weather shocks.

also shows a causal link between malnutrition, as proxied by height, and success in school (see Glewwe and Miguel, 2008, for a review) and in the labor market (Strauss and Thomas, 1998). In short, child height-for-age is a good indicator of adult human capital.[3] But what sets our approach apart is that we analyze a long-term measure of nutritional status (height-for-age) in combination with a short-term measure (weight-for-age) for the same sample of children.

Like school attendance in Jacoby and Skoufias (1997), a child's weight-for-age should be sensitive to the *current* economic conditions of the household (see also Foster, 1995). This insight along with a key observation about the timing of rainfall shocks allows us to extract compelling evidence of an income effect from anthropometric data. Given its hilly terrain that makes large-scale irrigation facilities infeasible, Nepali agriculture is highly dependent on rainfall, roughly 80% of which falls in the summer monsoon. All the major staples (paddy, maize, and millet) are cultivated during this season. This stark seasonality of agricultural production means that the realization of a shock to income in our setting takes place with a lag relative to the realization of rainfall; that is, income is only obtained once crops have been harvested and, possibly, sold. The influence of rainfall on *disease environment*, by contrast, is largely contemporaneous. Excessive rainfall in poor countries is linked to higher incidence of diarrheal disease and, indirectly, to an increase in vector-borne diseases. Episodes of acute illness induced by high rainfall can lower a child's capacity to take in and retain essential nutrients from food. Thus, weight changes observed around the time of a monsoon rainfall shock but before the associated harvest should mainly reflect the change in disease environment whereas weight changes observed post-harvest should reflect the combined effects of income and the *lagged* effects of the disease environment that prevailed during the most recent monsoon.[4]

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[3] Among others, Rose (1999), Kudamatsu et al (2011) and Baird et al. (2011) look at the impact of shocks on child *mortality* in developing countries. Given that vastly more children survive into adulthood than die, however, a greater focus on survivors' human capital seems warranted.

[4] Our analysis also addresses the question of whether households prioritize boys' welfare over that of girls during times of economic hardship (see Dreze and Sen, 1989, for an early review of this literature in the South Asian context). Among many studies, Behrman (1988) and Behrman and Deolalikar (1990) show biases in favor of boys in nutrient allocation among Indian households during lean times. In India again, Rose (1999) shows that the gender bias in infant mortality, which normally favors boys, narrows when districts experience higher rainfall. In rural Pakistan, Alderman and Gertler (1997) find that the demand for girls' medical care is more income- and price-elastic than the demand for boys' medical care.

Using three rounds of Demographic and Health Surveys (DHS) conducted in Nepal over the last decade linked to data on precipitation from an expansive network of rainfall stations, we find that a 10% increase in rainfall from historic norms during the most recently completed monsoon season is associated with a 0.15 standard deviation increase in weight-for-age across all children ages 0-36 months. However, a similar rainfall shock during the *current* monsoon leads to a 0.02 standard deviation *reduction* in weight-for-age. We can thus infer that the total impact of the past monsoon rainfall consists of a negative "disease environment effect" of no more than 0.02 standard deviations and a positive "income effect" of no less than 0.15 standard deviations, but as high as 0.17 standard deviations.

Our evidence also indicates that excess monsoon rainfall experienced in the *second* year of life (though not in the first year, as found by Maccini and Yang, 2009) has a significantly positive impact on both male and female stature (not just on female stature as in Maccini and Yang). This timing pattern suggests heightened vulnerability immediately following the transition to the family diet. Importantly, however, these nutritional shocks appear to be largely transitory. By the time a child reaches age five, the negative height impact of drought experienced at age two completely dissipates.

The rest of the paper is organized as follows. Section 2 lays out the conceptual framework. Section 3 describes the anthropometric and rainfall data. Sections 4 and 5 present the empirical specification and estimation results, respectively. The final section recaps and discusses implications for policy.

## 2. Conceptual Framework

A standard human capital production function specifies a child's nutritional status at the end of period $t$ ($H_t$) as a function $f$ of her nutritional status at the end of the previous period ($H_{t-1}$), all of the relevant nutritional and health inputs she received during period $t$ ($I_t$), and her period $t$ disease exposure ($E_t$). Thus,

$$H_t = f(H_{t-1}, I_t, E_t), \tag{1}$$

where lagged nutritional status captures the entire history of inputs and disease prior to period *t* as well as the child's genetic endowments. Parental investment in child nutritional status consist principally in allocating caloric intake and other dimensions of food consumption, as well as in responding to illness induced by the disease environment, for instance by administering oral rehydration therapy during spells of diarrhea.

Within this framework, there are two main channels through which excess rainfall can influence child nutritional status. The first is through the alteration of the disease environment net of any parental responses to child illness. In particular, flooding is associated with higher contemporaneous incidence of diarrheal disease, most seriously typhoid and cholera (Confalonieri et al., 2007; WHO, 2002). Standing water also indirectly leads to an increase in vector-borne diseases, such as malaria and dengue, through the expansion in the number and range of vector habitats. Such illnesses lower the capacity to take in and retain essential nutrients from food. Insofar as parents cannot entirely prevent or perfectly ameliorate these effects of child illness, excess rainfall shocks will have a negative impact on nutritional status through the disease channel.

The second main channel is through food consumption or real income. In a rural economy based largely on rainfed agriculture, household income is of course highly dependent on rainfall realizations. Moreover, credit constraints limit households' ability to smooth consumption over time, rendering health more vulnerable to economic shocks (Behrman and Deolalikar, 1988 and 1990, Foster, 1995). Finally, insofar as households are spatially dispersed and transport infrastructure is weak, markets in food staples may not be well integrated. Localized rainfall shocks may, consequently, influence food prices. When seasonal rains are plentiful, yields will be high, food supplies robust and prices low. Such general equilibrium effects reinforce the positive association between rainfall and household purchasing power or *real* income. Given the seasonal nature of agricultural production and limited borrowing opportunities, the effect from income to consumption, and thereby to child nutrition, is likely to take place with some delay; higher rainfall during the current cropping season can increase consumption only after harvesting.

A natural question to ask is whether it is possible to distinguish these disease environment and income channels empirically. Consider a child observed (weighed) during the *current* monsoon season. Excess rainfall around this time (a current monsoon rainfall shock in our parlance) captures the disease environment effect, which, according to the discussion above, is likely to reduce the child's weight. At this point in the agricultural calendar, however, the household cannot yet avail itself of the increased purchasing power induced by the higher than normal rainfall; this windfall is realized only after the harvest, which has yet to take place. Hence, the income effect of a contemporaneous rainfall shock on the child's weight is essentially zero.[5]

In contrast, excess rainfall during the *last* completed monsoon season is likely to operate through both the income *and* disease environment channels. High past monsoon rainfall has a negative impact on previous period nutritional status through $E_{t-1}$, which is then carried through to the current period by $H_{t-1}$ in equation (1). Moreover, plentiful rainfall during the last monsoon results in a better harvest, increasing $I_t$.[6] In sum, the reduced form impact of excess rainfall in the last monsoon on child weight consists of two opposing effects: a (negative) lagged disease environment effect and a (positive) income effect; the reduced form impact is thus a *lower bound* on the income effect of rainfall shocks on child weight. Indeed, in principle, *the reduced form effect of excess rainfall in the last monsoon can be negative.*

## 3. Data

*Anthropometrics*

Child and household-level data are drawn from three rounds of the nationally representative Demographic and Health Surveys conducted in Nepal in 2001, 2006 and 2011. The DHS samples were selected using a stratified, two-stage cluster design. The 2001 round consists of 8602 households in 257 clusters of which 84% are rural; 2006 and 2011 rounds are larger with, respectively, 9036 households in 260 clusters (68% rural) and 10,826 households in 289 clusters (71% rural).

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[5] Excess precipitation could have a *contemporaneous* effect on household income via changes in the local agricultural labor market. In particular, if the rainfall shock is realized prior to planting *and* there is significant scope to increase area planted or the use of inputs that require a lot of labor to apply, then wages paid to hired farm workers may rise. We suspect, however, that such effects are of second order importance at best in the context of rural Nepal.

[6] To reiterate, it is not necessary to be a food producer in order to reap the benefits of higher yields if food markets are not perfectly integrated. In addition, rural households engaged in non-farm activities may experience an increase in demand, and hence income, when local agriculture is doing well.

Given our focus, we restrict attention to children age 0-35 months born and residing in rural areas for our analysis of weight-for-age. For height-for-age on the other hand, we make use of the expanded sample of children 0-59 months as it allows us to assess the persistence of impact of rainfall shocks experienced in the early years over a longer period of time. Height (or length) and weight are standardized based on WHO (2006) to create height-for-age (HAZ) and weight-for-age (WAZ) z-scores.[7] After eliminating biologically implausible z-score values, we are left with 6,941 children pooled across DHS rounds for the analysis of weight-for-age and 11,491 for height-for-age. Tables 1 and 2 present summary z-scores for the sample children broken down by gender, age group and the three survey years. The averages can be compared with the international reference group which has an expected mean z-score of zero. Z-scores below -2 indicate severe growth retardation or "stunting" in the case of HAZ and acute malnutrition or underweight in the case of WAZ.

Average WAZ for children in our sample is -1.70 with an underweight prevalence of 49%. Underweight prevalence among boys is slightly higher than for girls and most serious for children older than 0-11 months of age. The latter fact is consistent with the weight-loss children typically experience once they have transitioned from breast milk to the family diet. Comparing across the three survey years, there appears to have been a steady improvement, with underweight prevalence decreasing from 41% in 2001 to 31% in 2011.

Summary statistics for height-for-age exhibit similar patterns but are somewhat worse relative to the reference population. Average HAZ is -2.23 with a corresponding stunting prevalence of around 58%. Stunting rates are fairly similar for boys and girls, but starkly higher for children 12-59 months-old compared to infants, which again corresponds to the point of full transition to the family diet.[8] Finally, between 2001 and 2011, the rate of stunting fell from 62% to 48%.

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[7] Another commonly used anthropometric indicator is weight-for-height, a measure of how "lean" a child is for her height. Weight-for-height, like weight-for-age, is considered a short-run indicator of nutritional status, especially useful when age cannot be determined precisely. Results of our empirical analyses replacing weight-for-age by weight-for-height are very similar (available upon request).

[8] The median duration of exclusive breastfeeding in Nepal is 4.2 months, whereas roughly 70% of children between the ages of 6 months and 9 months combine breast milk with complementary food. Global standards of infant and child feeding practices recommend that children who have fully transitioned to the family diet be fed a minimum of four food groups and be fed a minimum number of times per day. Only 25% of the children less than 23 months of age in our 2011 sample met that requirement.

### *Rainfall*

Monthly precipitation data for a network of 171 rainfall stations and their respective geo-coordinates were obtained from the Department of Hydrology and Meteorology in Nepal. Since each of the DHS sample clusters is geo-coded as well, we are able to match each child to a precise time series of monthly precipitation. The location of rainfall stations and DHS clusters are shown in Figure 1. Geographic coverage of the rainfall stations is fairly expansive and well-balanced throughout Nepal. Though there are fewer stations in the northern, mountainous, parts of the country, these are also areas with sparser population.

A key task is to match precipitation records from the weather stations to each of the DHS clusters. The usual practice in the literature is to match each locality – a cluster or the geographic center of an administrative unit – to the geographically closest weather station (Yang and Choi, 2007; Maccini and Yang, 2009; and Menon, 2009). However, this approach may give rise to inaccuracies if there is high prevalence of missing records in the data, stations have been affected by site relocation, or if cluster and station differ considerably in terms of topographic characteristics (e.g., elevation). Instead, therefore, we predict climate or weather based on a station's observable characteristics (latitude, longitude, elevation, and interactions among these variables) and impute values for each of the DHS clusters based on their corresponding characteristics (Nordhaus et al., 1994, use a similar procedure).

We calculate normal rainfall for every month using the average precipitation in that month over the 26 year period 1972-97. Month-to-month precipitation patterns are broadly similar across the four major regions and topographic zones of Nepal as seen in Figure 2.

## 4. Empirical Specification

*Rainfall shock variables*

Let $R_{jtm}$ be the amount of precipitation in cluster *j* in month *m* of year *t*, and denote by $\bar{R}_{jm}$ corresponding historical monthly averages.[9] Now, since the monsoon season (June-September) consists of *m* = 6, 7, 8, and 9, the rainfall shock in *the last completed* monsoon, in terms of log deviations, is

$$\Delta_{jt-1} = \log(\textstyle\sum_{k=6}^{9} R_{jt-1m}) - \log(\textstyle\sum_{k=6}^{9} \bar{R}_{jm}) \tag{2}$$

The *current* monsoon rainfall shock is slightly more complicated because it depends upon the month $M_{ijt}$ in which child *i* was interviewed and weighed. Thus, define

$$\tilde{\Delta}_{ijt} = \begin{cases} \log(\sum_{k=6}^{M_{ijt}} R_{jtm}) - \log(\sum_{k=6}^{M_{ijt}} \bar{R}_{jm}) & if\ M_{ijt} = 6,7,8, or\ 9 \\ 0 & otherwise \end{cases} \tag{3}$$

where the additional *i* subscript reminds us that $\tilde{\Delta}_{ijt}$ can vary across children in the same survey round and cluster.

*Weight-for-age*

The basic regression for weight-for-age is then

$$WAZ_{ijt} = \alpha + \beta\Delta_{jt-1} + \gamma\tilde{\Delta}_{ijt} + \delta' X_{ijt} + \varphi_r + \mu_t + \varepsilon_{ijt}\ , \tag{4}$$

where $WAZ_{ijt}$ is the weight-for-age z-score of child *i* in cluster *j* in survey round *t*. Controls consist of normal monsoon rainfall in the cluster ($\sum_{k=6}^{9} \bar{R}_{jm}$) along with gender, age, year of birth, month of birth, birth order of the child, fixed effects ($\varphi_r$) for the 15 regions and fixed effects ($\mu_t$) for the three survey rounds. An augmented set of controls includes characteristics of the mother (age, education level, occupation) and her partner (education level and occupation), and the ethnicity of the household head.

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[9] More precisely, each of these variables is the exponential of the log rainfall prediction using DHS cluster-level explanatory variables and coefficients from the regression of the corresponding log rainfall variable on the same set of explanatory variables (see section 3) at the weather station-level.

Identification of $\beta$ and $\gamma$ is secured through the considerable cross-sectional and temporal variation in cluster-level rainfall deviations, which should be uncorrelated with any unobserved determinants of child nutritional status ($\varepsilon_{ijt}$). It should be noted with regard to $\gamma$ (impact of current monsoon rainfall), that roughly a quarter of household interviews were carried out during the four monsoon months of June-September; i.e., somewhat less than the expected one-third if interviews were uniformly distributed across the year. The reason for this appears to be that survey work was suspended in the three most mountainous regions during the monsoon. In any case, to account for this we also include a dummy for whether the child was interviewed during the monsoon in all of our specifications.

Recall from our discussion in Section 2 that $\gamma$ captures the disease environment effect, which we expect to be negative, whereas $\beta$ captures the income effect plus any residual of the disease environment effect from the last monsoon. If there is no weight recovery from past illness, or "catch-up" growth, then the residual disease environment effect should equal $\gamma$, the disease environment effect from the current monsoon; if there is complete catch-up, then the residual effect should be zero. In general, the residual effect is $\lambda\gamma$, where $\lambda \in [0,1]$ is a parameter reflecting the persistence of illness shocks on body weight. It follows, then, that the income effect is equal to $\beta - \lambda\gamma$, and since $\gamma < 0$, we see that *the income effect of a rainfall shock is bounded from below by* $\beta$ *and from above by* $\beta - \gamma$.

### *Height-for-age: A cohort analysis*

There are two key differences between our analyses of weight-for-age and height-for-age. First, since height-for-age is a cumulative measure nutritional status, and as such unresponsive to current conditions, contemporaneous rainfall shocks are irrelevant. We, therefore, only consider rainfall shocks from prior completed monsoons (i.e., we exclude $\tilde{\Delta}_{ijt}$). Second, children of different ages will have experienced different numbers of completed monsoons. For this reason, we divide our sample of children age 0-59 months into five *cohorts* defined by the number of past monsoons they have lived through. Cohort 1 (the oldest) is comprised of those children who have experienced five completed monsoons since birth, cohort 2 are those with four completed monsoons, and so on. Cohort 5, the youngest, has experienced only one monsoon.

Now, let $\Delta_{jkc}$ be the excess monsoon rainfall (as defined in equation 2) experienced by children of cohort *c* in their *kth* year of life in DHS cluster *j* (Appendix A lays out the details of cohort construction and the associated rainfall variables). Our regression for the height-for-age z-score of child *i* in cluster *j* and survey round *t* is

$$HAZ_{ijt} = \alpha + \sum_{k=1}^{3} \sum_{c=1}^{5-k+1} \beta_{-k}^{c} \Delta_{jkc} + \delta' X_{ijt} + \varphi_r + \mu_t + \varepsilon_{ijt}, \tag{5}$$

with the parameters $\delta$, $\varphi_r$, and $\mu_t$ having the same interpretation as in equation (4). In keeping with our weight-for-age results, we focus on shocks experienced in the first three years of life. This implies twelve $\beta_{-k}^{c}$ parameters to be estimated: five for monsoon rainfall shocks in the first year of life, relevant to cohorts 1 through 5; four for shocks in the second year of life (cohorts 1-4); and three for shocks in the third year of life (cohorts 1-3).

Identification of multiple past-monsoon rainfall effects for a given cohort is facilitated by the lack of correlation in cluster-level rainfall deviations across calendar years. We have no particular priors on the sign or magnitude of the $\beta_{-k}^{c}$, however. Even if we find large disease environment or income effects on weight-for-age, there is still the possibility for growth recovery during these formative early years of life resulting in no discernible impact on height-for-age. Conversely, a positive (or negative) estimate of $\beta_{-k}^{c}$ without a corresponding positive (negative) estimate of $\beta$ in equation (4) would be inconsistent with the framework laid out in Section 2. For instance, it would be surprising if past monsoon rainfall had no effect at all on short-run nutritional status (weight-for-age), yet a substantial effect on longer run status (height-for-age).

## 5. Results

### *Weight-for-age results*

Table 3 reports the OLS estimates for weight-for-age, based on the sample discussed in Section 3 and the specification developed in Section 4. The first column includes the current and past rainfall shocks as explanatory variables along with the normal monsoon rainfall in the cluster, a dummy for whether the child was interviewed during the monsoon and region and survey year fixed effects. The second column adds child-level characteristics, and the third column adds characteristics of the mother, her partner, and household. We take this last set of estimates as the basis for distinguishing impacts of excess rainfall through the income and disease environment channels.

Returning to equation (4), the implied estimate of $\beta$ is thus 0.15 and that of $\gamma$ is -0.02. The former magnitude, for example, implies that a 10% deviation in the past monsoon rainfall from its historic norm leads to a 0.15 standard deviation change in weight-for-age.[10] Disease environment effects induced by excessive current monsoon rainfall, captured by $\gamma$, are relatively small in magnitude, but statistically significant and negative, as the epidemiology suggests. Based on our discussion in Section 4, we infer that the income effect of past monsoon rainfall on weight-for-age lies between 0.15 (if there is complete catch-up from illness induced weight-loss) and 0.17 (zero catch-up growth). Fortunately, this is a fairly narrow window.

The last two columns of Table 3 report experiments with controls for proximity to a drinking water source and health posts and the interaction of these variables with current and past monsoon rainfall shocks.[11] Of course, endogenous placement of such facilities may render the estimates of the direct effects of these covariates spurious. Our interest, however, is in the interaction terms; i.e., whether better access to drinking water sources and health facilities mitigates the disease environment effect. Evidently, none of these interactions are significant.

Next we probe heterogeneity of impact across gender and age of children. Evidence from south Asia (see fn. 4) suggests that girls are particularly disadvantaged in intra-household reallocations as households respond to economic distress. As for age, while it is generally agreed that the first three years of life are critical for a child's long term human development, less clear is the particular age "window" of greatest vulnerability to transitory shocks.

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[10] Reported coefficients have been scaled up by a factor of 100 to conform to this interpretation.

[11] Rainfall has direct bearing on the availability of potable water in rural Nepal. Access to piped water is limited and households often rely on community taps, wells and sometimes even river water for drinking purposes. Among several basic health services, one of the most important delivered by health posts in rural Nepal is oral rehydration therapy for diarrheal disease.

The results in Table 4 suggest that disease environment effects (the current monsoon rainfall shock) are more salient for boys in the first two years of life. This apparent disadvantage of boys, however, could just as well reflect the interaction of biological and environmental factors than any differences in behavioral responses to child illness on the part of parents. At any rate, based on the coefficients on last completed monsoon rainfall deviations, we do not find much evidence of "discrimination" against girls; the point estimates across columns 2 and 3 are statistically indistinguishable. Indeed, once we net out the larger disease environment effects for boys – using our arguments from Section 4 – the pure *income effects* are extremely close for boys and girls.

*Robustness*

As support for our argument that excess rainfall in the current or ongoing monsoon is associated with the disease environment, we examine the determinants of diarrhea episodes in our sample children. DHS surveys record the incidence of diarrhea in the two weeks preceding the day of the interview; 20% of children in our sample reported a bout of diarrhea. Results in Table 5 indicate a significant positive relationship between excess rainfall and contemporaneous diarrhea among children. Insofar as diarrheal morbidity inhibits nutrient uptake and thereby decreases body weight in the short-run, we take this evidence as corroboration that the current monsoon rainfall shock operates through a disease environment channel.

Turning next to the rainfall shock in the last completed monsoon, we perform two robustness checks. First, if our interpretation is correct, then we should see that the implied income effect is much smaller, if not nonexistent, for children residing in urban areas (see also Maccini and Yang, 2009). After all, urban households' purchasing power is likely to be much less sensitive to the vagaries of the harvest than that of rural households. Indeed, the results reported in Table 6 suggest as much. Using the coefficients in the last column, we can bound the income effect of monsoon rainfall shocks for urban children at no greater than -0.014, which is actually negative but statistically indistinct from zero. This finding bolsters our argument that much of the positive rainfall effect on the body weight of rural children is mediated through fluctuations in agricultural income. Second, we perform a "placebo" test of whether a *future* completed monsoon rainfall shock – that is, excess rainfall in the monsoon that begins only after the date of interview – has any effect on weight-for-age. Unless correlations between rainfall shocks and child nutritional status are entirely spurious, future shocks should be irrelevant and the results reported in Table 7 show that indeed they are.

*Height-for-age results*

Results for height-for-age, our longer-term measure of nutritional status, appear in Table 8. To reiterate, cohorts are defined according to how many past monsoons were experienced. The impact of excess monsoon rainfall in the first year of life is statistically indistinguishable from zero for all five cohorts. Recall that the identical shock had a significant effect on body weight for children 0-11 months. Arguably, for cohort 5, the youngest, not enough time has elapsed following the shock (and associated harvest) to observe an impact on body length. For the older cohorts, however, the finding that shocks affecting body weight in the first of year of life have no lasting impact on stature suggest that, at these very young ages, catch-up growth is possible. Further support for the catch-up hypothesis emerges in the effects of monsoon rainfall shocks experienced in the second year of life: For children in cohorts 3 and 4, excess rainfall in their second monsoon is associated with a significant increase in stature, while the effects of the identical shocks for cohorts 1 and 2 (i.e., children age 4-5) are statistically indistinguishable from zero.[12]

These findings stand in stark contrast to the evidence from Indonesian adults presented by Maccini and Yang (2009). First, although the effect-size implied by our point estimate of 0.13 standard deviations (for cohort 4) for a 10% excess rainfall is roughly twice as large as that of Maccini and Yang (based on the standard deviation of adult heights in their sample), the impact disappears by age five. Second, whereas in Maccini and Yang's study, the shock experienced in the *first* year of life was most salient for the stature of adult women, our results highlight shocks in the second year of a child's life (for both girls *and* boys). The average child in the sample was 17 months old at the close of their second monsoon season. Thus, we place the critical age window closer to the end of the child's transition to

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[12] Here, as with weight-for-age, there is no significant difference between boys and girls in the cohort-specific effects of rainfall shocks. Joint F-tests for shock × cohort × female are insignificant for all cohorts taken together or for each individually (results of unrestricted specification available upon request).

the family diet, a time when caloric intake is likely to be more sensitive to fluctuations in household purchasing power relative to the breastfeeding period; it is a pattern consistent as well with the timing of growth-faltering that we observe on average in the sample.

To home in on the dissipation effect, we now drop cohort 5 (the youngest) from the estimation sample and eliminate all shock × cohort interactions from the regression. Instead, we count the number of months elapsed for each child since their *second* monsoon ended and interact this variable with excess rainfall in that monsoon. The average number of months elapsed since the event in question is 43, 31, 19, and 7, for cohorts 1 through 4 respectively.

In the first column of Table 9, we see that the (positive) impact of 10% higher monsoon rainfall in the second year of life on child stature falls by 0.003 standard deviations for every month removed from that monsoon (the time pattern is not significantly different for girls; col. 2). Thus, according to this linear-in-months specification, by 37 months out, the shock impact goes to zero. A quadratic specification (col. 3) leads to essentially the same conclusion. In other words, three years after the fact, a deficit in the first post-weaning monsoon leaves no detectable trace on child nutritional status.

## 6. Conclusions

We have made considerable progress in understanding the long-run costs of uninsured income risk in poor countries. Exploiting the seasonal nature of agriculture in Nepal and the fact that body weight (as opposed to length) is sensitive to current economic conditions, our empirical analysis has uncovered compelling evidence of income effects on child nutritional status. Although we do find that excessive rainfall reduces the weight of young children by altering the disease environment, the income channel working in the opposite direction (i.e., wet years leading to good harvests) dominates in terms of magnitudes. Our evidence also indicates that rainfall shocks experienced early in life contribute to child growth-faltering, but that the damage is transitory, with no discernible scars by age five. Similar findings from sub-Saharan Africa (Rabassa et al., 2012) suggest that catch-up growth may be sufficient to restore a child to his or her development trajectory after such temporary perturbations.[13]

Child malnutrition is a complex development challenge, to be sure, calling for coordinated policy response on several fronts, ranging from improving the intake of essential nutrients, expanding basic health care facilities, water quality, and sanitation. Our evidence, however, does not support an emphasis on income insurance as a means to protect this form of human capital accumulation. While providing access to insurance may be valuable for a host of other reasons, enhancing long-run nutritional status is not likely to be one of them.

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[13] Whether there might be long-term impacts of early childhood income shocks on such forms of human capital as cognitive skills is an interesting topic for future research.

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## Table 1: Descriptive statistics for weight-for-age z-scores

| | | | Gender | | | Age in months |
|---|---|---|---|---|---|---|
| | | All children | Boys | Girls | 0-11 | 12-23 |
| 2001 | Mean | -1.77 | -1.79 | -1.75 | -1.44 | -1.95 |
| | St. Dev. | 1.17 | 1.19 | 1.15 | 1.25 | 1.13 |
| | Underweight (%) | 0.41 | 0.43 | 0.39 | 0.31 | 0.47 |
| | Obs | 3399 | 1655 | 1744 | 1143 | 1166 |
| 2006 | Mean | -1.73 | -1.74 | -1.71 | -1.33 | -1.91 |
| | St. Dev. | 1.17 | 1.19 | 1.15 | 1.31 | 1.07 |
| | Underweight (%) | 0.39 | 0.39 | 0.39 | 0.28 | 0.45 |
| | Obs | 2421 | 1215 | 1206 | 750 | 811 |
| 2011 | Mean | -1.45 | -1.55 | -1.34 | -1.22 | -1.49 |
| | St. Dev. | 1.19 | 1.21 | 1.15 | 1.31 | 1.11 |
| | Underweight (%) | 0.31 | 0.35 | 0.26 | 0.25 | 0.31 |
| | Obs | 1121 | 563 | 558 | 371 | 359 |
| Total | Mean | -1.70 | -1.73 | -1.67 | -1.37 | -1.87 |
| | St. Dev. | 1.18 | 1.19 | 1.16 | 1.28 | 1.12 |
| | Underweight (%) | 0.49 | 0.49 | 0.48 | 0.29 | 0.44 |
| | Obs | 6941 | 3433 | 3508 | 2264 | 2336 |

Note: Based on children aged 0-35. Underweight refers to children whose weight-for-age z-scores were below 2 standard deviation of the international reference group of children the same age.

## Table 2: Descriptive statistics for height-for-age z-scores

| | | | Gender | | Age in months | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | All children | Boys | Girls | 0-11 | 12-23 | 24-35 | 36-47 | 48-59 |
| 2001 | Mean | -2.35 | -2.36 | -2.34 | -1.35 | -2.24 | -2.58 | -2.59 | -2.43 |
| | St. Dev. | 1.29 | 1.28 | 1.29 | 1.31 | 1.29 | 1.23 | 1.24 | 1.16 |
| | Stunted | 0.62 | 0.62 | 0.62 | 0.29 | 0.57 | 0.69 | 0.71 | 0.66 |
| | Obs | 4966 | 2459 | 2507 | 473 | 1159 | 1083 | 1135 | 1116 |
| 2006 | Mean | -2.19 | -2.17 | -2.22 | -1.18 | -2.08 | -2.32 | -2.38 | -2.29 |
| | St. Dev. | 1.24 | 1.23 | 1.26 | 1.23 | 1.29 | 1.23 | 1.15 | 1.14 |
| | Stunted | 0.58 | 0.57 | 0.58 | 0.25 | 0.53 | 0.62 | 0.65 | 0.61 |
| | Obs | 3477 | 1748 | 1729 | 233 | 811 | 858 | 778 | 797 |
| 2011 | Mean | -1.94 | -1.99 | -1.88 | -1.02 | -1.67 | -2.18 | -2.23 | -2.05 |
| | St. Dev. | 1.34 | 1.36 | 1.32 | 1.52 | 1.38 | 1.28 | 1.18 | 1.20 |
| | Stunted | 0.48 | 0.50 | 0.46 | 0.19 | 0.41 | 0.56 | 0.57 | 0.51 |
| | Obs | 1666 | 859 | 807 | 168 | 355 | 389 | 400 | 354 |
| Total | Mean | -2.23 | -2.23 | -2.23 | -1.24 | -2.10 | -2.41 | -2.45 | -2.32 |
| | St. Dev. | 1.29 | 1.28 | 1.30 | 1.34 | 1.32 | 1.25 | 1.21 | 1.17 |
| | Stunted | 0.58 | 0.58 | 0.58 | 0.26 | 0.53 | 0.64 | 0.67 | 0.62 |
| | Obs | 10109 | 5066 | 5043 | 874 | 2325 | 2330 | 2313 | 2267 |

Note: Based on children aged 0-59. Stunted refers to children whose weight-for-height z-scores were below 2 standard deviation of the international reference group of children the same age.

## Table 3: Impact of rainfall shocks on weight-for-age z-scores

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| VARIABLES | Weight-for-age z-scores | | | | |
| Shock in current period monsoon rain (RC) | -0.001 | -0.003* | -0.002** | -0.002** | -0.003*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Shock in the most recent completed monsoon rain (RP) | 0.023*** | 0.022*** | 0.015*** | 0.015*** | 0.016*** |
| | (0.006) | (0.007) | (0.005) | (0.005) | (0.005) |
| Normal monsoon rainfall (mm) | 0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Interviewed during the monsoon ( = 1) | -0.170*** | 0.110 | 0.159** | 0.158** | 0.154** |
| | (0.048) | (0.074) | (0.054) | (0.053) | (0.054) |
| Drinking water source far? (DWS) | | | | -0.077** | -0.077* |
| | | | | (0.035) | (0.039) |
| Health post difficult to access? (HPA) | | | | -0.029 | -0.020 |
| | | | | (0.029) | (0.041) |
| DWS x RC | | | | | 0.001 |
| | | | | | (0.002) |
| DWS x RP | | | | | -0.003 |
| | | | | | (0.003) |
| HPA x RC | | | | | 0.001 |
| | | | | | (0.002) |
| HPA x RP | | | | | 0.001 |
| | | | | | (0.003) |
| Year of survey effects | Yes | Yes | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes | Yes | Yes |
| Child characteristics | No | Yes | Yes | Yes | Yes |
| Mother's characteristics | No | No | Yes | Yes | Yes |
| Observations | 6,853 | 6,853 | 6,853 | 6,853 | 6,853 |
| R-squared | 0.013 | 0.106 | 0.250 | 0.251 | 0.251 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). Current period monsoon shock and the most recent completed monsoon shock variables represent the log deviation of the current period monsoon and the most recent completed monsoon from the historic norm for each DHS cluster. DWS is an indicator for whether the nearest drinking water source is at least a 5 minute walk from the dwelling; HPA is an indicator for whether the household reports getting to the nearest health post is difficult due to distance. Normal monsoon rainfall is the average monsoon rainfall for the cluster for the period 1972-1996. Region fixed effects are a combination of three topographic zones (mountains, hills and terai) and five regions (eastern, central, western, mid-western and far-western). Child characteristics include age in months, birth order, month of birth, year of birth, year of birth interacted with month of birth and gender. Mother's characteristics are education level, occupation, partner's education, and his occupation, as well as ethnicity of household head.

## Table 4: Impact of rainfall shocks on weight-for-age by gender and age group

| VARIABLES | (1) | (2) | (3) |
|---|---|---|---|
| | Weight-for-age z-scores | | |
| | All children | Boys | Girls |
| 0-11 months x Shock in the current period monsoon | -0.006** | -0.010** | -0.002 |
| | (0.002) | (0.004) | (0.002) |
| 12-23 months x Shock in the current period monsoon | -0.001 | -0.004* | 0.001 |
| | (0.002) | (0.002) | (0.003) |
| 24-35 x Shock in the most recent completed monsoon | -0.000 | -0.000 | -0.001 |
| | (0.002) | (0.003) | (0.003) |
| 0-11 months x Shock in the most recent completed monsoon | 0.019*** | 0.017** | 0.021** |
| | (0.006) | (0.007) | (0.008) |
| 12-23 months x Shock in the most recent completed monsoon | 0.012** | 0.010* | 0.016* |
| | (0.005) | (0.005) | (0.009) |
| 24-35 x Past rainfall shock | 0.012** | 0.010* | 0.017** |
| | (0.004) | (0.005) | (0.007) |
| Female | 0.074*** | | |
| | (0.022) | | |
| Normal monsoon rainfall (mm) | 0.000 | -0.000 | 0.000 |
| | (0.000) | (0.001) | (0.001) |
| Interviewed during the monsoon ( = 1) | 0.160*** | 0.156* | 0.162*** |
| | (0.051) | (0.080) | (0.050) |
| Year of survey effects | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes |
| Child characteristics | Yes | Yes | Yes |
| Mother's characteristics | Yes | Yes | Yes |
| Observations | 6,853 | 3,383 | 3,470 |
| R-squared | 0.264 | 0.338 | 0.346 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). Current period monsoon shock and the most recent completed monsoon shock variables represent the log deviation of the current period monsoon and the most recent completed monsoon from the historic norm for each DHS cluster. DWS is an indicator for whether the nearest drinking water source is at least a 5 minute walk from the dwelling; HPA is an indicator for whether the household reports getting to the nearest health post is difficult due to distance. For other variables, see notes to Table 3.

## Table 5: Impact of rainfall shocks on incidence of diarrhea

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | Dependent variable: Diarrhea ( =1 if reported in the last two weeks) | | | |
| Shock in the current period monsoon (RC) | 0.0014** | 0.0016** | 0.0015* | 0.0015* |
| | (0.0006) | (0.0006) | (0.0007) | (0.0007) |
| Female x RC | | | 0.0003 | 0.0004 |
| | | | (0.0006) | (0.0006) |
| Female | -0.0436** | -0.0434** | -0.0342 | -0.0330 |
| | (0.0147) | (0.0178) | (0.0291) | (0.0255) |
| Drinking water source far? (DWS) | | | -0.0012 | -0.0064 |
| | | | (0.0268) | (0.0301) |
| Health post difficult to access? (HPA) | | | 0.0108 | 0.0331 |
| | | | (0.0157) | (0.0365) |
| DWS x RC | | | | -0.0005 |
| | | | | (0.0009) |
| HPA x RC | | | | 0.0008 |
| | | | | (0.0010) |
| Normal monsoon rainfall (mm) | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| Year of survey effects | Yes | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes | Yes |
| Child characteristics | Yes | Yes | Yes | Yes |
| Mother's characteristics | No | Yes | Yes | Yes |
| Observations | 1,908 | 1,908 | 1,908 | 1,908 |
| R-squared | 0.086 | 0.132 | 0.132 | 0.155 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). See notes to Table 3.

## Table 6: Impact of rainfall shocks on weight-for-age z-scores for urban children

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | Weight-for-age z-scores | | |
| Shock in current period monsoon rain (RC) | 0.000 | -0.004 | 0.000 |
| | (0.004) | (0.003) | (0.004) |
| Shock in the most recent completed monsoon rain (RP) | -0.003 | -0.005 | -0.014 |
| | (0.009) | (0.006) | (0.012) |
| Normal monsoon rainfall (mm) | -0.001 | -0.002*** | -0.001 |
| | (0.001) | (0.001) | (0.001) |
| Year of survey effects | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes |
| Child characteristics | No | Yes | Yes |
| Mother's characteristics | No | No | Yes |
| Observations | 1,257 | 1,257 | 1,257 |
| R-squared | 0.006 | 0.141 | 0.446 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). See notes to Table 3.

## Table 7: ‘Placebo test’ for future rainfall shocks on weight-for-height z-scores

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | | Weight-for-age z-scores | |
| Shock in current period monsoon rain (RC) | -0.001 | -0.003* | -0.002*** |
| | (0.001) | (0.001) | (0.001) |
| Shock in the "future" monsoon rain (t+1) (RF) | -0.001 | 0.001 | 0.000 |
| | (0.002) | (0.002) | (0.002) |
| Normal monsoon rainfall (mm) | -0.002 | -0.002* | -0.001 |
| | (0.001) | (0.001) | (0.001) |
| Year of survey effects | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes |
| Child characteristics | Yes | Yes | No |
| Mother's characteristics | No | Yes | No |
| Observations | 5,820 | 5,820 | 5,820 |
| R-squared | 0.006 | 0.106 | 0.261 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). See notes to Table 3.

## Table 8: Impact of past rainfall shocks on height-for-age

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | | Height-for-age | |
| Rainfall shock in first year of life (%)[R1] x Cohort 1 | -0.014 | -0.014 | -0.010 |
| | (0.010) | (0.009) | (0.009) |
| R1 x Cohort 2 | 0.005 | 0.002 | 0.002 |
| | (0.005) | (0.005) | (0.004) |
| R1 x Cohort 3 | 0.000 | -0.001 | -0.001 |
| | (0.006) | (0.006) | (0.005) |
| R1 x Cohort 4 | -0.007*** | 0.002 | -0.002 |
| | (0.002) | (0.003) | (0.003) |
| R1 x Cohort 5 (youngest) | 0.001 | -0.001 | -0.002 |
| | (0.004) | (0.009) | (0.009) |
| Rainfall shock in the second year of life (%)[R2] x Cohort 1 | 0.004 | 0.006 | 0.004 |
| | (0.004) | (0.005) | (0.005) |
| R2 x Cohort 2 | -0.001 | -0.005 | -0.006 |
| | (0.007) | (0.008) | (0.008) |
| R2 x Cohort 3 | -0.004 | 0.009** | 0.008* |
| | (0.002) | (0.004) | (0.004) |
| R2 x Cohort 4 | 0.012** | 0.012** | 0.013** |
| | (0.005) | (0.005) | (0.004) |
| Rainfall shock in the third year of life (%)[R3] x Cohort 1 | 0.009 | 0.005 | 0.004 |
| | (0.011) | (0.012) | (0.012) |
| R3 x Cohort 2 | -0.005 | 0.003 | 0.000 |
| | (0.003) | (0.004) | (0.005) |
| R3 x Cohort 3 | -0.002 | -0.003 | -0.004 |
| | (0.003) | (0.006) | (0.005) |
| Year of survey effects | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes |
| Child characteristics | No | Yes | Yes |
| Mother's characteristics | No | No | Yes |
| Observations | 10,102 | 10,102 | 10,102 |
| R-squared | 0.064 | 0.125 | 0.146 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10). R1 is the monsoon rainfall shock experienced by the child in the first year of life, R2 is the monsoon shock experienced in the second year of life and R3 the monsoon shock experienced in the third year of life. Monsoon shocks for each child are computed as the log deviation from the normal rainfall in the cluster in which he/she resides. Cohort 1 corresponds to the oldest children in the sample while Cohort 5 is comprised of the youngest ones. See notes to Table 3.

## Table 9: Impact of rainfall shock experienced in the second year of life

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | | Height-for-age | |
| Rainfall shock in the second year of life (%) [R2] | 0.011*** | 0.011*** | 0.016*** |
| | (0.00216) | (0.00254) | (0.00400) |
| R2 x No. of months since the shock | -0.00030*** | -0.00021*** | -0.00069 |
| | (0.00008) | (0.00007) | (0.00041) |
| R2 x No. of months since the shock x Female | | -0.00010 | |
| | | (0.00018) | |
| R2 x Female | | 0.00114 | |
| | | (0.00371) | |
| R2 x (No. of months since the shock)$^2$ | | | 0.0000082 |
| | | | (0.0000078) |
| Year of survey effects | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes |
| Child characteristics | Yes | Yes | Yes |
| Mother's characteristics | Yes | Yes | Yes |
| Observations | 7,767 | 7,767 | 7,767 |
| R-squared | 0.084 | 0.082 | 0.084 |

*Notes*: Robust standard errors clustered by region in parentheses (*** p<0.01, ** p<0.05, * p<0.10. See notes to Table 8.

**Figure 1: Location of DHS clusters and rainfall stations**

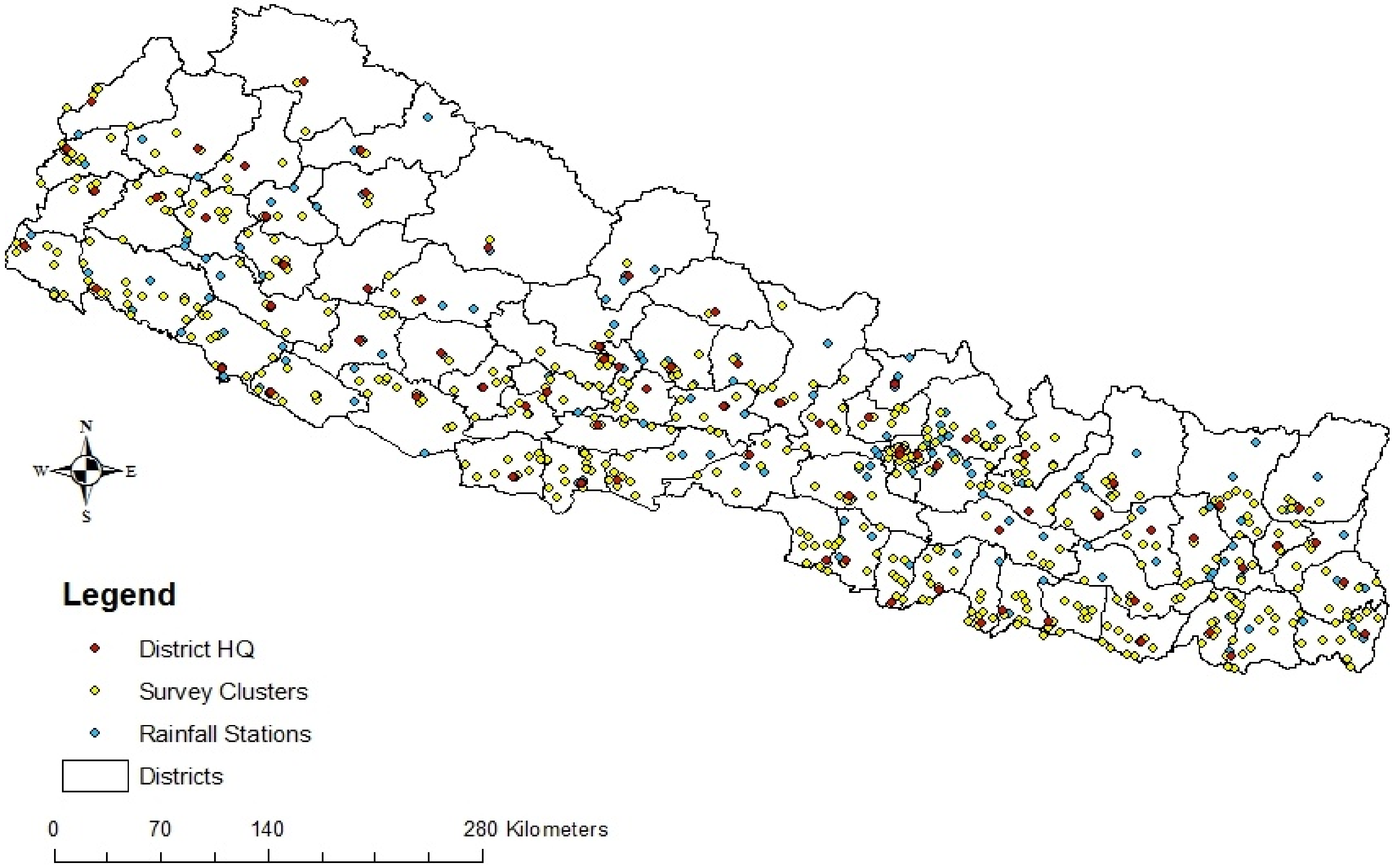
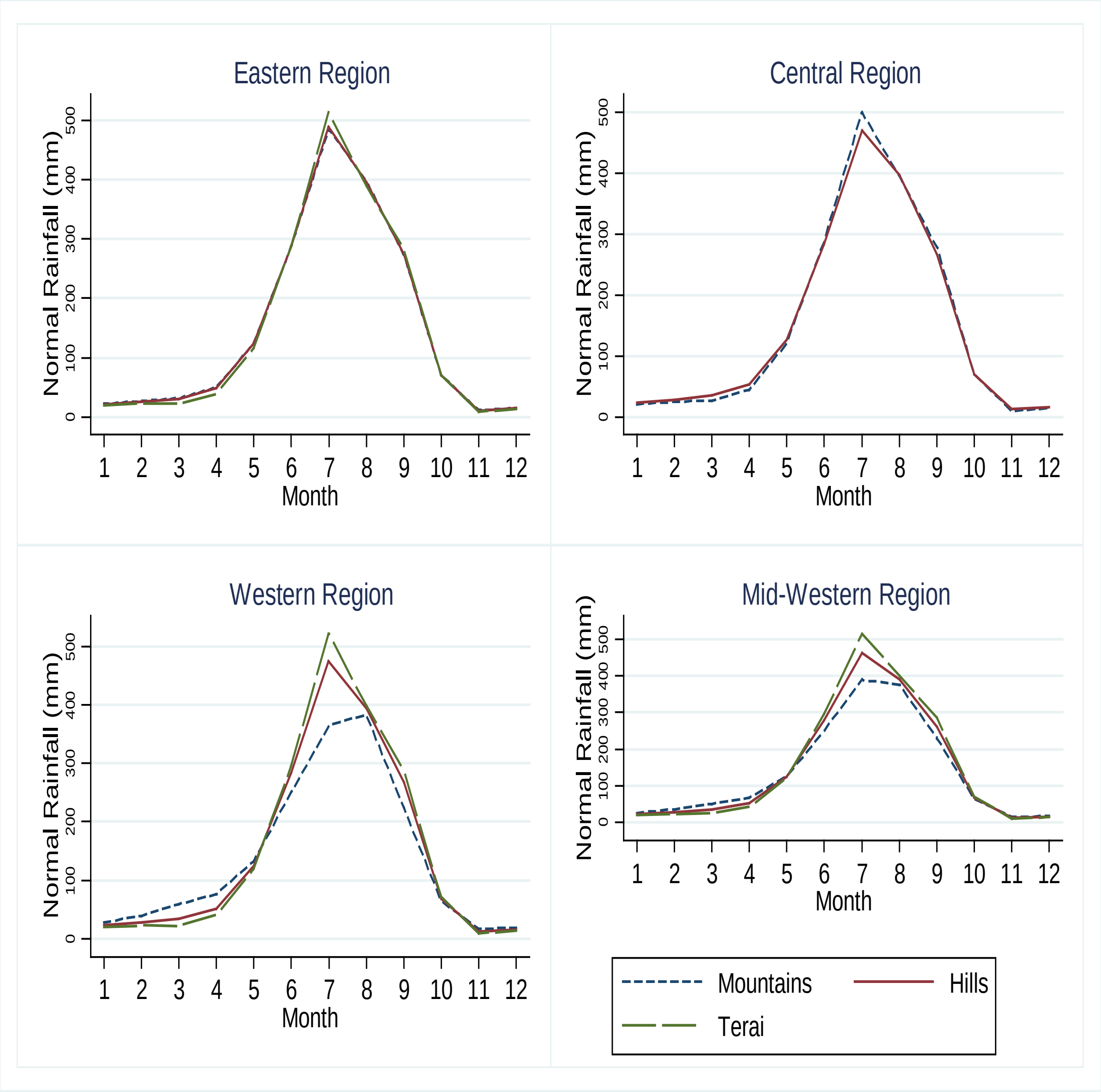
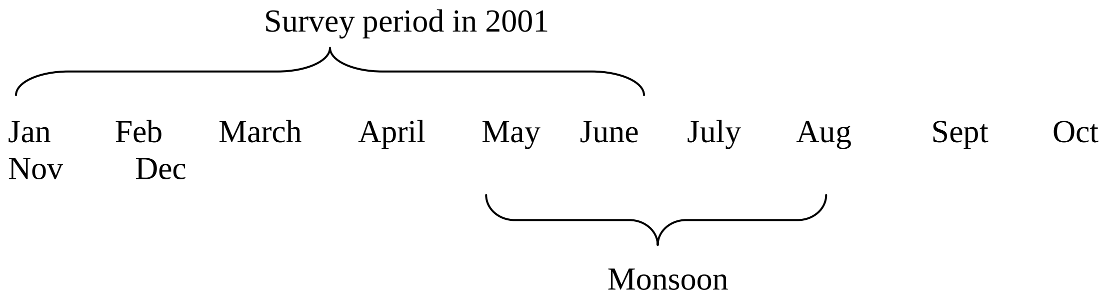


**Figure 2: Normal rainfall in mountains, hills and the *terai*, across four regions of Nepal**



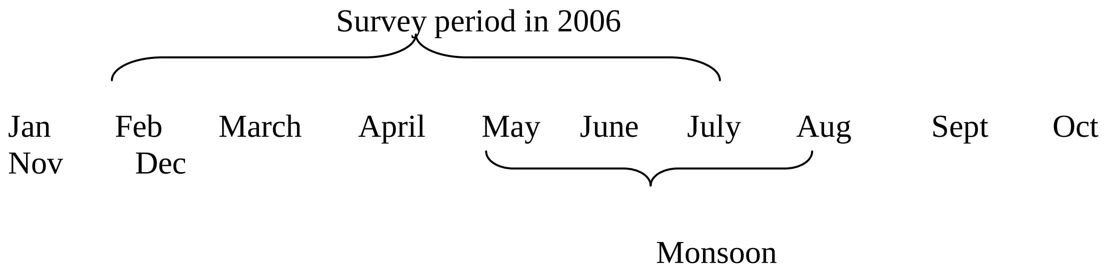
# APPENDIX A
## Construction of cohorts and rainfall variables for height-for-age analysis

### DHS 2001



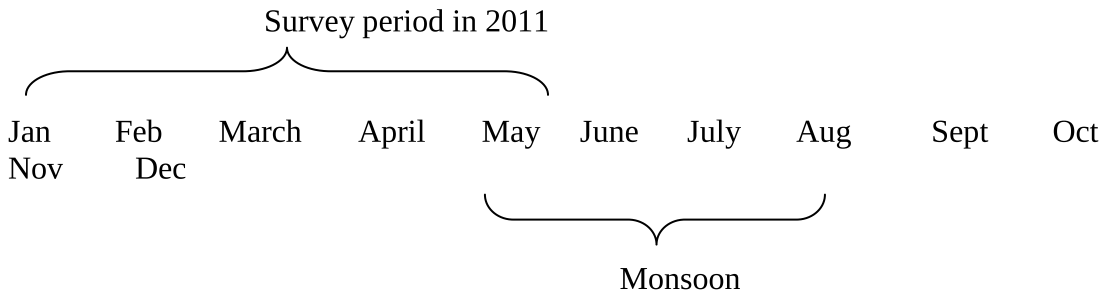
| Cohort | Year of Birth | Month of Birth | Rainfall shock experienced in the…. | | | | |
|---|---|---|---|---|---|---|---|
| | | | ..1st year | ..2nd year | ..3rd year | ..4th year | ..5th year |
| 5 | 2000 | Jan. – Sep. | Rain 2000 | | | | |
| 5 | 1999 | Sept. – Dec. | Rain 2000 | | | | |
| 4 | 1999 | Jan. – Sep. | Rain 1999 | Rain 2000 | | | |
| 4 | 1998 | Sept. – Dec. | Rain 1999 | Rain 2000 | | | |
| 3 | 1998 | Jan. – Sep. | Rain 1998 | Rain 1999 | Rain 2000 | | |
| 3 | 1997 | Sept. – Dec. | Rain 1998 | Rain 1999 | Rain 2000 | | |
| 2 | 1997 | Jan. – Sep. | Rain 1997 | Rain 1998 | Rain 1999 | Rain 2000 | |
| 2 | 1996 | Sept. – Dec. | Rain 1997 | Rain 1998 | Rain 1999 | Rain 2000 | |
| 1 | 1996 | Jan. – Sep. | Rain 1996 | Rain 1997 | Rain 1998 | Rain 1999 | Rain 2000 |

## DHS 2006



| Cohort | Year of Birth | Month of Birth | Rainfall shock experienced in the…. | | | | |
|---|---|---|---|---|---|---|---|
| | | | ..1st year | ..2nd year | ..3rd year | ..4th year | ..5th year |
| 5 | 2005 | Jan. – Sep. | Rain 2005 | | | | |
| 5 | 2004 | Sept. – Dec. | Rain 2005 | | | | |
| 4 | 2004 | Jan. – Sep. | Rain 2004 | Rain 2005 | | | |
| 4 | 2003 | Sept. – Dec. | Rain 2004 | Rain 2005 | | | |
| 3 | 2003 | Jan. – Sep. | Rain 2003 | Rain 2004 | Rain 2005 | | |
| 3 | 2002 | Sept. – Dec. | Rain 2003 | Rain 2004 | Rain 2005 | | |
| 2 | 2002 | Jan. – Sep. | Rain 2002 | Rain 2003 | Rain 2004 | Rain 2005 | |
| 2 | 2001 | Sept. – Dec. | Rain 2002 | Rain 2003 | Rain 2004 | Rain 2005 | |
| 1 | 2001 | Jan. – Sep. | Rain 2001 | Rain 2002 | Rain 2003 | Rain 2004 | Rain 2005 |

## DHS 2011



| Cohort | Year of Birth | Month of Birth | Rainfall shock experienced in the…. | | | | |
|---|---|---|---|---|---|---|---|
| | | | ..1st year | ..2nd year | ..3rd year | ..4th year | ..5th year |
| 5 | 2010 | Jan. – Sep. | Rain 2010 | | | | |
| 5 | 2009 | Sept. – Dec. | Rain 2010 | | | | |
| 4 | 2009 | Jan. – Sep. | Rain 2009 | Rain 2010 | | | |
| 4 | 2008 | Sept. – Dec. | Rain 2009 | Rain 2010 | | | |
| 3 | 2008 | Jan. – Sep. | Rain 2008 | Rain 2009 | Rain 2010 | | |
| 3 | 2007 | Sept. – Dec. | Rain 2008 | Rain 2009 | Rain 2010 | | |
| 2 | 2007 | Jan. – Sep. | Rain 2007 | Rain 2008 | Rain 2009 | Rain 2010 | |
| 2 | 2006 | Sept. – Dec. | Rain 2007 | Rain 2008 | Rain 2009 | Rain 2010 | |
| 1 | 2006 | Jan. – Sep. | Rain 2006 | Rain 2007 | Rain 2008 | Rain 2009 | Rain 2010 |