Birth Year Environment and Adult Life Outcomes for Females:

Evidence from Nepal

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Abstract

A growing body of literature has shown that environment shocks around birth can impact long-run human capital outcomes. Is that true in the case of Nepal too? This project investigates the impact of rainfall and temperature shock around the time of birth on height and education of Nepali women born between 1962 and 1991. The project links historical rainfall and temperature data for the women's birth-year and location with current outcomes from the 2006, 2011 and the 2016 Demographic and Health Survey (DHS). The project finds that on average, one-degree Celsius increase in average birthyear temperature leads to women being 1.06 cm shorter. In the Terai region of the country, a 10% increase in rainfall in the year after birth leads to increased schooling by 0.136 years. However, in the mountain region, increased rainfall around birth year leads to reduced education. The project also provides suggestive evidence of the potential channels through which these effects take place.

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1. Introduction

An increasing number of research works have investigated how early life environmental or nutritional shocks, either during early childhood or in utero, affect the outcomes such as health, educational attainment, and cognitive development among others. While most of these works focus on investigating the link between the shocks and outcomes for child, a small portion focuses on the long run impact of these shocks. In general, the link between natural environment and livelihood is particularly stronger in developing countries. From agricultural production to illness and mortality, environment shocks can project many risks in these areas. The effects of some shocks might be synchronous, but some can generate effects that might last several years down the line. Because the dependency on environment cannot be reduced drastically, it is imperative to identify the shocks that lead to long run impacts, understand the mechanism underlying the persistence and then to look at it from the lens of a policy maker to help mitigate the effects.

This project focuses on environmental shocks at the beginning of life and investigates how sensitive long-run human capital in the form of health and education is to the natural conditions around the time of conception. More precisely, the project examines the effect of weather shocks around the time of birth on adult height and education outcomes for Nepali women born between 1962 and 1991. Women's data comes from the Demographic and Health Survey (DHS). Their birth month and year is given, and their location of birth is inferred by selecting for non-migrants from the sample. The project uses rainfall and temperature data from University of East Anglia Climatic Research Unit.

In developing countries like Nepal, where more than half of the population is involved in agriculture, variation in rainfall and temperature leads to variation in agricultural output and incomes will vary accordingly. This can lead to deficient level of nutrition for a child during the most sensitive years and these deficiencies can lead to permanently reduced body size in adulthood (Barker 1998). Similarly, research works have also shown that better nutrition in-utero and early life impact educational attainment positively (Nandi et. al 2018). Therefore, this project uses height and education as outcome measures to test whether such strong impacts can be seen in the case of this project.

When examining the relationship for the whole country, this project finds that temperature in the birth-year impacts the height of females in the long run. On average, a one-degree Celsius increase in average birthyear temperature leads to a reduced height by 1.06 cm. However, there is no evidence of significant impact of birthyear rainfall. Rainfall and temperature, in years adjacent to the birthyear, also have an imprecise impact. The project also finds no significant difference in the impact of birthyear environment on long run height and education. When the three geographic regions of the country (The Terai, The Hilly and The Mountain) are looked at separately, the project finds differing impacts. In the Terai region, more rainfall in the year after birth leads to higher education. It is most likely that because this region is very fertile for agriculture. More rainfall means more agricultural output and higher realized income thereby improving health via better nutrition and investment. However, in the Mountain region, where agricultural activities are very low, higher than average rainfall leads to reduction in years of education. The project provides suggestive evidence on the factors in play.

Section 2 reviews relevant literature, section 3 provides a conceptual theory, section 4 describes the data used, section 5 gives a context on rainfall, temperature, agriculture and disease environment in Nepal, section 6 discusses the empirical model, section 7 discusses the results and section 8 concludes the paper.

2. Literature Review

The study of early-life environmental shocks on later life outcomes has been expanding over the years with most studies finding a strong relationship. Initial studies in this area focused on more extreme or unusual early-life conditions as natural experiments. Some examples include (Almond 2006), who used the 1918 influenza pandemic as a natural experiment for testing the fetal origins hypothesis and found that the pandemic that arrived unexpectedly in the fall of 1918 had sharp long-term effects. Using data from the 1960-80 decennial U.S census, he finds that cohorts in-utero during the pandemic displayed reduced educational attainment, increased rates of physical disability, lower income, lower socio-economic status, and higher transfer payments compared with other birth cohorts. Chen and Zhou (2007) using data from the great famine of 1959-1961, and using a difference-in-differences method, find that the famine caused serious health and economic consequences for the survivors. also find the impact to be more severe for those in early childhood. On average, they find that in absence of the famine, individuals of the 1959 birth cohort would have otherwise grown 3.03 cm taller in adulthood. Their finding shows how crucial this period is in determining the long-term health and well-being of human beings.

Similarly, (Alderman, et al. 2006), using civil war and drought shocks to identify the differences, examine the impact of preschool malnutrition on subsequent human capital formation in rural Zimbabwe. Using a maternal fixed-effects instrumental variables estimator with a long-term panel data set, they find that improvements in height-for-age in preschoolers are associated with increased height as a young adult and number of grades of schooling completed. According to their finding, had the median preschool child in the sample had a height of a median child in a developed country, by adolescence, she would be 3.4 cm taller, had completed an additional 0.85 years of schooling and would have commenced school six months earlier. While these works establish a causal relation between the shocks and later life outcomes, a lingering concern is the external validity and generalization of these results.

More recent works, however, have shown that natural shocks during early life that are more frequent and less extreme can also have a persistent impact on adult life outcomes. Wilde, et al. (2017), explore whether increases in ambient temperature at the time of conception, while in utero, or after birth, affect health and educational outcomes as adults. Using census and Demographic and Health Survey data from sub-Saharan Africa, they show that individuals conceived during high temperatures have higher educational attainment and literacy. In addition, they also find evidence of temperature effects at other times in utero, especially during the first trimester. Similarly, Almond and Mazumder (2011) investigate the impact of maternal fasting during the Islamic holy month of Ramadan on fetal health. In the short term, they find that prenatal exposure leads to lower birth weight. In the long term, they find that Muslims in Uganda and Iraq are 20 percent more likely to be disabled as adults if early pregnancy overlapped with Ramadan with larger impacts for mental/learning disabilities. This project aims to contribute to this growing body of research and establish that more general variations that occur frequently also hold this relation using a representative sample of a national population over a period.

Maccini and Yang (2009) using historical rainfall data for individuals birth-year and location and linking them with current adult life outcomes in Indonesia, find that higher early life rainfall leads to improved health, schooling, and socioeconomic status for women. They find that

20% higher rainfall during the birth year of an Indonesian women leads to an increase of 0.54 cm in height and 0.22 years of schooling. This impact of 20% higher rainfall also sees an increase in asset index that is significant at 5% level. They, however, do not find any statistically significant impact on men. This implies, consistent with previous works that investment in females (women and children) is more income elastic and that a negative income shock due to less rainfall leading to less crops would mean that investment in females would be lower. They explain that the mechanism through which increased rainfall has a positive impact is that increasing rainfall means increased production of crops and increase income ultimately leading to more nutrition and investment in infant girls leading to better outcomes later.

While works like Maccini and Yang (2009) and other similar works investigating the impact of early life rainfall on human capital outcome seem to mostly find a positive relationship with increasing rainfall resulting in better outcome, works involving the investigation of relation between temperature with human capital outcomes are mixed. Wilde et al (2017) as mentioned above, found that increase in ambient temperature during the time of conception results in increased educational attainment but no significant impact on health. However, Randell et. al (2020), found negative relationship between weather conditions and child nutrition in Ethiopia. Using data from four rounds of the Ethiopia Demographic and Health Survey and linking it to high resolution climate data to measure exposure to rainfall and temperature in-utero and early life, found that higher temperatures in-utero particularly during first and third trimester, and more rainfall during the third trimester, are positively associated with severe stunting. They find potential evidence for a few pathways underlying this relationship including heat stress, infectious disease transmission and women’s time use during pregnancy.

This project makes two contributions to the expanding literature that focuses on estimating the impact of birthyear natural environment on human capital outcome. First, this will be the first project to conduct such analysis in the context of Nepal. Second, using Nepal's distinct geographical regions, this project will seek to find the differentiated impact of temperature and rainfall shocks in those regions. This is relevant because the importance of topography and altitude aren't commonly factored into works linking environment to human outcomes.

3. Theory

Michael Grossman (1972) constructed a model with a central proposition that health can be viewed as a durable capital stock that produces an output of healthy time. Now, common as health production function, it typically considers that individuals inherit an initial stock of health that depreciates with age and can be increased by investment. Formally, in line with the work of Maccini and Yang (2009), the model considers an individual's health in period t to be a function of initial endowment H_0 and history of health inputs $N_1, \ldots, N_t$. Similarly, demographic variables X (such as gender and age), community infrastructures $(C_0, C_1, \ldots, C_t)$ and the disease environment $(D_0, D_1, \ldots, D_t)$ also help to shape the health production function.

$$H_t = h\,\{H_0, X, (N_1, \ldots, N_t), (C_0, C_1, \ldots, C_t), (D_0, D_1, \ldots, D_t)\}$$

Further, the initial health endowment is also comprised of few components. It is shaped by genetic characteristics at conception (G) and further determined by environmental conditions in early life, infrastructure, and disease environment. Research works, linking the impact of environment through initial health endowment, have shown a lasting and sometimes irreversible effect on human capital outcomes. This phenomenon, which comes from epidemiology is called “Fetal Origins Hypothesis”. Epidemiologist David Barker (1995) is the earliest proponent of this theory.

Apart from the birth year, environmental conditions in certain sensitive periods of life can also have long-run, irreversible impacts. The idea is called “Critical Period Programming”. This project also extends the research from birth year to a year prior to birth and a year after birth as the critical period. This should help make the results more distinct. If the year before birth is significant, it would point towards environmental conditions affecting mothers’ health having an impact on the long run outcome while the year after birth being significant would suggest that the conditions during infancy period is more crucial.

Based on this framework, this project postulates that environmental conditions affect nutritional status of a newborn through two channels. The first channel would be through increased income, consumption and food security arising from deviation in agricultural output and the second channel would be through the disease environment. Favorable temperature and rainfall lead to better human capital outcomes through the first channel. This would be consistent with the findings of Maccini and Yang (2009). However, the combination of high temperature can lead to heat stress and in combination with rainfall causes vector borne diseases both of which are considered harmful for the development of fetus and newborn as suggested by Beaudrap et al (2016) who, using clinical data from Uganda find that children born to mothers who had Malaria in Pregnancy (MiP), are on average, 2.71 cm shorter than those born to mothers who didn’t suffer from Malaria in Pregnancy.

4. Data

4.1 USAID DHS Data

The Demographic and Health Survey (DHS) data comes from a survey that is funded by the United States Agency for International Development (USAID) and conducted every 5 years. This project makes use of data for women from the 2006, 2011 and the 2016 survey. The sample consists of 12,481 women born between 1962 and 1991. Among them, 7609 women were born in the rural area while 4872 women were born in urban area. I have restricted the sample to females over 25 years of age to account for the fact that they could still be in school or college continuing their studies and that their body could be growing too. Figure 1 in the appendix shows the map of Nepal with the location of the survey clusters and the 75 districts.

Table 1 reports the summary statistics for the variables of interest. The mean height of the females in this sample is 151.3 cm which is roughly equal to 4 feet 10 inches. Mean years of education is 2.80 years with a standard deviation of approximately 4 years. The mean age in the sample is 34.3 years with a minimum age of 25 and a maximum of 49.

4.2 Rainfall and Temperature data

The rainfall and temperature data for the project comes from the Climatic Research Unit of University of East Anglia. Average monthly rainfall and temperature has been included from 1961 to 2020.The weather is measured for every half degree geographic co-ordinate and these co-ordinate values are also included with the data. Since the surveys in DHS are geo-referenced, the weather data is then coded to each DHS cluster. The log value of annual rainfall is calculated as the natural log value of annual rainfall for the year of birth and the birth location. The temperature is calculated as the average annual temperature for each birthyear and the birth location.

Table 1 reports the summary statistics for the rainfall and temperature variables of interest. The average value of the natural log of annual birthyear rainfall is 7.39. Similarly, the standard deviation is 0.30 with a minimum of 5.54 and maximum value of 8.18. Also, the annual average temperature during the birth year of the females is 19.48 $°C$ with a standard deviation of 4.75 $°C$. The standard deviation reflects the heterogeneity in geographical distribution in the country. Section 5 provides further highlights about this scenario.

5. Temperature, Rainfall, Agricultural Output and Disease in Nepal

Nepal has a unique geographical distribution. The average distance from the south of the country to the north is about 193 km (120 miles). However, within this distance the elevation ranges from 60 meters to 8848 meters above sea level. There are three distinct geographic regions namely: Terai, Hilly, and Mountain. The Terai is the southernmost region of the country. Covering 17% of the total land area, this region is mostly flat and fertile and therefore is the hub of agriculture. The Hilly region lies between the Terai and the Mountain region. This region covers 66% of the total land area and also has mostly arable land. The Mountain region is the northernmost region of the country. It covers 16% of the total land area of the country. This region is the coldest and the least inhabited region of the country. Since, soil temperature is a major factor for the germination of seeds, the agricultural production is very low with most areas in this region unsuitable for agriculture.

Rainfall is the other important aspect of weather variation in Nepal. There is a distinct monsoon season (June to September) and 70%-90% of the total rainfall happens during this window. (Janak Lal Nayava, 2004). Most of the agricultural activities also take place during the monsoon season with some activity during the month of May and harvesting during the month of October. The production of rice, which is the staple food also occurs during this period. Using this information, this project assigns the respondents to two distinct seasons of birth depending on their birth month. Those born between the second month in the Nepali Calender (May/June in the English Calender) through the sixth month in the Nepali Calender (Sep/Oct in the English Calender), are assigned as born in rainy season and the rest are assigned as dry season.

The other important part of the impact of natural environment in Nepal is the disease environment. The southern (Terai) region of Nepal, where temperature is higher compared to the other two regions, vector borne diseases are common. Our cohort covers women born between 1961-1991 and during this period, especially the 60's and 70's, Visceral Leishmaniasis (kala-azar) and Malaria were widely prevalent to the extent that the government had to run nationwide programs like spraying of dichloro-diphenyl-trichloroethane (DDT). These programs made the region more sanitized and habitable. This also resulted in migration from other regions of the country to this region due to the potential of higher agricultural production. While this region is less plagued recently, cases of these diseases continue to pose a challenge. Recently, these diseases are also found to be prevalent in areas of higher altitude (Nepal Health Research Council, 2019) where people also suffer from other environment related problems like diarrhea and cholera. Shrestha et al (2017) using daily data of climate sensitive variables from 16 stations spanning the three geographic regions and hospitalization rates for 5 years (2009-2014) and accounting for lagged effects show that 1% increase in average temperature leads to 3.08% increase in water borne and 10.14% increase in hospitalizations due to vector borne diseases.

6. Empirical model

Assuming that environmental shocks are exogenous, the project attempts to focus on the relationship between those shocks in early life and outcomes as adults. The first step here is to isolate the deviation of an individual's outcome from the mean outcome in their cluster and birth-cohort. To achieve that, the project uses two fixed effects.

The following linear relationship is estimated for an adult women's outcome Y_{icst} for a woman (i) born in cluster (c) in season (s) and in time (t):

$$Y_{icst} = \beta_1 P_{ct} + \beta_2 T_{ct} + \alpha_{cs} + \delta_{st} + u_{icst}$$

The coefficients of interest are β_1 and β_2. β_1 is the impact of birth year rainfall P_{ct} on adult outcomes. Similarly, β_2 is the impact of birth year temperature T_{ct} on adult outcomes. α_{cs} is a fixed effect for an individual born in cluster c and season s (e.g: born in cluster Z during rainy season, born in cluster Z during dry season). Similarly, δ_{st} is the fixed effect for season and year of birth (e.g: born in 1990 during rainy season, born in 1990 during dry season). u_{icst} is the mean zero error term.

The model also encounters the risk of broad spatial correlation. Since, data only from the closest station has been matched to birth location, it is a possibility that weather in other stations nearby are correlated. Hence, to account for this, the model uses clustered standard errors for every grid of weather data measurement.

7. Results

As can be seen from Table 2, rainfall in the birth year has a positive impact on the height and years of education of females in the long run. 10% more rainfall in the year of birth leads to women being 0.0345 cm taller, on average. Similarly, it also leads to women, on average, having 0.0076 years of more schooling. While the results are consistent with other works investigating similar relation, these findings are not statistically significant and have a high standard error suggesting that the actual impact on individuals varies widely and cannot be specified with precision.

Temperature in the birth year has a mixed impact on the adult life outcome of the females. From Table 2, a one-degree Celsius increase in average temperature in the birth year, on average leads to women being 1.06 cm shorter and is statistically significant at 5% level. This result is like the finding from Randell et. al (2020) and is likely due to the disease channel playing a prominent role. Since Nepal suffers from vector borne diseases that are triggered by higher temperatures, these diseases if suffered during pregnancy can lead to children being born with stunted height at birth and having impaired growth. Similarly, a one-degree Celsius increase in average birthyear temperature also leads to women, on average, having 0.422 more years of schooling. However, this result, as with the impact of rainfall, is not statistically significant at the conventional levels and therefore the impact is imprecise.

Apart from the birth year, extending the results to adjacent years to birth as critical periods, the effect of average annual temperature becomes statistically insignificant at traditional levels. This result is most likely because birthyear temperature is insignificant independently and the initial significance was largely due to its correlation with temperature of adjacent years. Figure 2 in the appendix shows the difference in variation in average temperature in more detail. As can be seen, when the birthyear temperature is regressed with the fixed effects, there is more variation in the residuals but when the temperature of the adjacent years is added, some of the variation is lost, and the distribution is narrower. This loss in variance is most likely a determining factor of the results being insignificant when extended to critical period.

To better gauge the relationship between natural environment and human capital outcome, this project looked at the degree of differentiated impact across rural and urban areas. In general, impact of environment is expected to be higher in rural areas due to higher dependency on agriculture, low standard of living and less medical facilities. However, contrary to the expectation, there is no difference in outcomes among these two areas. The results reported in Table 4 show that the results are insignificant at traditional levels and therefore imprecise. Before 1991, the health system in Nepal was primarily government owned and there were only 16 private hospitals nationwide (Adhikari et. al. 2021). Hence, one plausible reason for similar outcomes could be the lack of substantively better health infrastructures in urban areas during the period of analysis. Also, at the end of 1991, the last birth cohort that this project covers, around 82% of the population in Nepal was involved in agriculture (The World Bank). This suggests that it is likely for the urban population to also be involved in agriculture in directly or via dependency on the agricultural output.

Delving deeper, this project also tested if temperature and rainfall, in adjacent years of birth have an impact on height and education in rural areas. Interestingly, temperature in the year after birth has a positive impact on education that is significant at the 1% level. As reported in Table 5, a one-degree Celsius increase in average annual temperature, in the year after birth increases schooling by 0.836 years, on average. Most of the rural areas experience cold temperatures as they lie in Hilly and Himalayan region. An increase in temperature likely results in higher agricultural production due to the soil temperature being more favorable for growth. This would then lead to better nutrition which aids cognitive development of an infant thereby aiding educational attainment in the long run.

To determine how birth year natural environment impacts the human capital outcome in various geographical areas, this project looked at the disparate relationship among Terai, Hilly and Mountain region. Starting with the Terai region in Table 6, deviation in rainfall in the year after birth had a positive impact on education of the females. On average, a 10% increase in annual rainfall, in the year after birth, increases schooling by 0.136 years. Increasing rainfall leads to increased agricultural output thereby increasing the realized income and higher nutrition. Hence, this shows that nutrition as infant is crucial in educational attainment in the long run. This result also aligns with Maccini and Yang (2009). The other thing to note is that rainfall in the year after birth is not significant. This indicates that rainfall shocks affecting the mother's health does not impact the infant's educational attainment in the long run.

The effects of environment in the critical period are mostly insignificant in the Hilly region. Here, rainfall in all three years of analysis; year before birth, birthyear and year after birth doesn't have significant impact on the height and education of females. Similarly, temperature in all three years of critical period used also has imprecise and insignificant impact on education. Temperature in the year after birth does impact height negatively. As reported in Table 7, on average, a one-degree Celsius increase in average annual temperature, leads to women being 1.65 cm shorter. However, the result is significant at only 10% level.

In the Mountain region, the effect of environment on height of the females is insignificant for all three years of analysis. Because this region is very cold, people in this region are not at risk of suffering from diseases triggered by higher temperatures. Rainfall, however, has a pronounced effect on education of females in this region. All three years of analysis have a significant impact with the birth year significant at 1% level while the year before and after birth are significant at the 5% level. Higher rainfall in this region, on average, reduces the education of females. This result contrasts with Maccini and Yang (2009). However, the socio-economic features of this region might help explain this relationship. In this region, agricultural activities are scarce due to the very cold weather. Some areas in this region are above the vegetation line too. People in this region rely on tourism for a major part of their income. Mountain tourism pays people in this region between 150 and 250 million Nepali rupees every year (Sayas D Joshi, 2022). For activities that are favorable for mountain tourism, higher rainfall is a hinderance as it poses risks that can even be fatal. Hence, lower tourism means there is going to be lower income overall. This leads to lower nutrition and lower investment in education which likely explains the result. Even with less agriculture, higher temperature in general in this region leads to higher production through favorable soil temperature.

8. Conclusion

This project finds that long-run human capital outcomes of female in Nepal is susceptible to environment shocks in the critical period around birth-year. By investigating the impact of rainfall and temperature shocks around the time of birth on height and education, for women born between 1962 and 1991, this project finds that the depending on the geography and socio-economic activity, the impacts are felt differently. In Terai region, an area rich in agricultural activity, 10% more rainfall, on average, in the year after birth, lead to 0.136 years of more education. However, in the Mountain region, where temperature and dependency on agriculture is low, increased rainfall in the birth-year and years around birth, resulted in less education for females. Similarly, when analyzed for the whole country, a one-degree Celsius increase in average birthyear temperature resulted in reduced height for the females by 1.06 cm. However, when the critical periods around birth were added, the result became insignificant suggesting that the temperature in birth-year is significant because it correlated to temperature in the adjacent years. In addition, the impact of environmental shocks in the birth year is felt similarly in both urban and rural areas with no significant heterogeneity.

The results from this project have some important policy implications. The findings show that infant girls in a developing economy like Nepal are vulnerable to fluctuations in the natural environment. When trying to plan programs that target this groups' well-being, the long run benefits should be factored as well. Control of the disease environment through better sanitation, better health facilities in the rural areas and policies pertaining to food security should be of utmost concern to improve the human capital of females in the long run. On top of that, high focus should remain on channels for consumption smoothing. Policies that provide food security to families and especially expectant mothers and infants who are most vulnerable to environment shocks should be utmost concern. Similarly, the government should evaluate if there are regions that cannot be developed and connected with better infrastructures. If that is the case, they should investigate spatial relocation programs for people from those regions to places that have more economic opportunities. This could be especially effective for people living in extreme areas of the mountain region that are also not viable for tourism.

Tables

Table 1: Summary Statistics

Variable	Mean	SD	Min	Max
Age	34.52	6.51	25.00	49.00
Height	151.29	5.61	105.00	187.00
Education	2.80	3.98	0.00	14.00
Log of total rainfall	7.39	0.30	5.54	8.18
Average temperature	19.48	4.75	-3.22	25.72

Number of Observations: 12,481

Notes: Sample is females born between 1962 and 1991 in Nepal. Age is based on reported year and month of birth. Height is measured in centimeters and measured in number of schooling years completed. Rainfall is measured in mm/year unit at the cluster (geo-referenced location from the DHS survey) level and the log value is presented in the table. Temperature is measured in $°C$ at the cluster (geo-referenced location from the DHS survey) level and annual average value is presented in the table.

Table 2: Effect of birthyear rainfall and temperature on adult outcomes

	(1) (Height in cm.)	(2) (Years of Education)
Log annual rainfall in birthyear	0.345	0.076
	(0.627)	(0.367)
Average annual temperature in birthyear	-1.058**	0.422
	(0.469)	(0.267)
Observations	12,446	12,446
R-squared	0.197	0.483

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 3: Effect of rainfall and temperature in years around birth

VARIABLES	(1) (Height in cm.)	(2) (Years of Education)
Rainfall Year -1	-0.359	0.339
	(0.627)	(0.382)
Rainfall Year 0	0.447	0.105
	(0.643)	(0.370)
Rainfall Year 1	0.784	0.372
	(0.627)	(0.378)
Temperature Year -1	-0.786	0.120
	(0.498)	(0.300)
Temperature Year 0	-0.335	0.286
	(0.574)	(0.297)
Temperature Year 1	-0.783	0.165
	(0.560)	(0.303)
Observations	12,446	12,446
R-squared	0.198	0.483

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 4: Effect of rainfall and temperature in Rural area

VARIABLES	(1) (Height in cm.)	(2) (Years of Education)
Log annual rainfall in birthyear	0.848	0.064
	(0.863)	(0.536)
Average annual temperature in birthyear	-1.095**	0.639*
	(0.525)	(0.326)
Rural * Rainfall	-0.785	0.023
	(0.892)	(0.529)
Rural * Temperature	0.073	-0.345
	(0.373)	(0.251)
Observations	12,446	12,446
R-squared	0.198	0.483

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. There are 7622 observations for women from rural area and 4859 from urban areas. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 5: Effect of rainfall and temperature in years around birth in Rural area

VARIABLES	(1) (Height in cm.)	(2) (Years of Education)
Rainfall Year -1	-0.891	0.587
	(0.807)	(0.440)
Rainfall Year 0	0.584	-0.568
	(0.797)	(0.412)
Rainfall Year 1	0.759	-0.641
	(0.728)	(0.431)
Temperature Year -1	-0.615	0.470
	(0.619)	(0.325)
Temperature Year 0	0.286	0.343
	(0.719)	(0.327)
Temperature Year 1	-1.192*	0.836***
	(0.697)	(0.320)
Observations	7,609	7,609
R-squared	0.195	0.411

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. There are 5776 observations for women from the Terai region. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 6: Effect of rainfall and temperature in years around birth in the Terai region

	(1)	(2)
VARIABLES	(Height in cm.)	(Years of Education)
Rainfall Year -1	-0.495	0.420
	(0.867)	(0.598)
Rainfall Year 0	-0.709	0.729
	(1.005)	(0.553)
Rainfall Year 1	1.380	1.366**
	(0.928)	(0.557)
Temperature Year -1	-1.444*	-0.425
	(0.749)	(0.529)
Temperature Year 0	-0.135	0.338
	(0.843)	(0.496)
Temperature Year 1	-0.155	-0.516
	(0.863)	(0.465)
Observations	5,776	5,776
R-squared	0.194	0.475

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. There are 5776 observations for women from the Terai region. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 7; Effect of rainfall and temperature in years around birth in the Hilly region

VARIABLES	(1) (Height in cm.)	(2) (Years of Education)
Rainfall Year -1	-0.965	0.828
	(1.081)	(0.617)
Rainfall Year 0	1.469	-0.073
	(1.134)	(0.632)
Rainfall Year 1	0.470	0.266
	(1.156)	(0.652)
Temperature Year -1	-0.634	0.374
	(0.848)	(0.421)
Temperature Year 0	-0.831	0.437
	(0.927)	(0.491)
Temperature Year 1	-1.650*	0.702
	(0.888)	(0.490)
Observations	5,099	5,099
R-squared	0.211	0.509

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. There are 5099 observations for women from the Hilly region. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

Table 8: Effect of rainfall and temperature in years around birth in the Mountain region

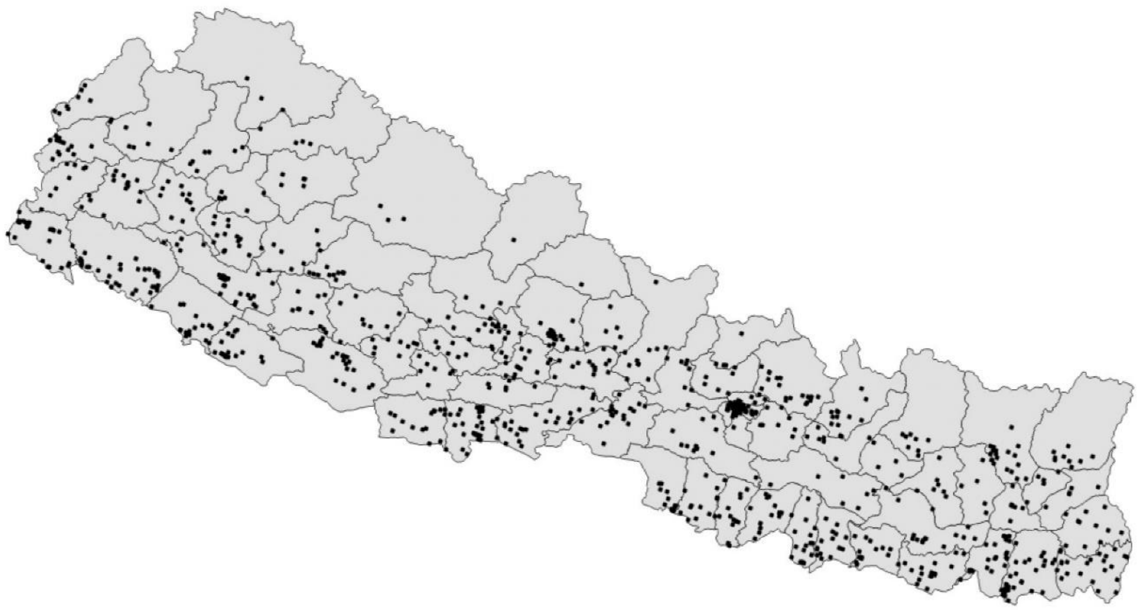
VARIABLES	(1) (Height in cm.)	(2) (Years of Education)
Rainfall Year -1	0.124	-1.909**
	(2.090)	(0.954)
Rainfall Year 0	0.656	-2.535***
	(1.545)	(0.895)
Rainfall Year 1	-0.988	-1.754**
	(1.583)	(0.814)
Temperature Year -1	-0.016	1.309**
	(1.190)	(0.635)
Temperature Year 0	1.344	0.851
	(1.651)	(0.542)
Temperature Year 1	-0.199	0.495
	(1.481)	(0.812)
Observations	1,568	1,568
R-squared	0.229	0.435

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

Note: Sample includes females born between 1962 and 1991 in Nepal that were surveyed by DHS in 2006, 20211 and 2016. There are 1568 observations for women from the Mountain region. The two columns of coefficients are from separate regressions of the dependent variables (height measured in cm and education measured in years completed) on birthyear rainfall (log of annual rainfall measured in mm/year) and temperature (average annual value in $°C$). Regression includes Cluster-Season FE and Season-Year FE. Standard errors have been clustered by the geo-referenced cluster of birth from the Survey.

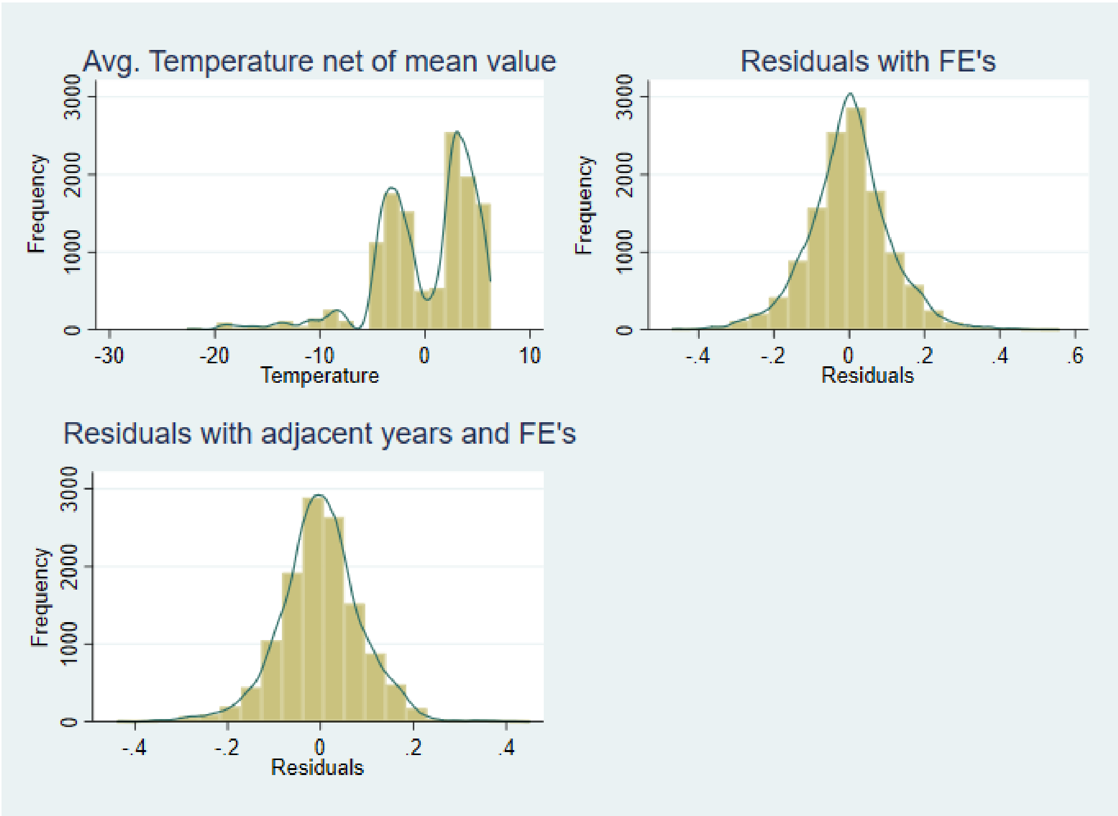
Figures

Figure 1: Map of Nepal with location of the DHS clusters and 75 districts



Note: The figure shows the map of Nepal divided into 75 administrative areas called districts. Within the map, the dots are location of the DHS survey called clusters. Clusters from all 3 years of survey used, 2006, 2011 and 2016 is shown.

Figure 2: Absorption in variation of the distribution of average temperature residuals



Note: Graph 1, in the top left corner above, shows the distribution of annual average birthyear temperature around the mean value of the annual average birthyear temperature. Graph 2, in the top right corner above, shows the distribution of variation of residuals when average birthyear temperature is regressed with the Cluster-Season FE and Season-Year FE. Graph 3, in the left bottom corner above, shows the distribution of variation of residuals when average birthyear temperature is regressed on birthyear temperature in the year prior to birth and the year after birth in addition to the Cluster-Season FE and Season-Year FE.

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