The Effect of Climate Change on Fertility in West Africa

Isabel McLoughlin & Alexander Weinreb

Department of Sociology and Population Research Center, University of Texas at Austin

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Abstract: This study combines 22 rounds of Demographic and Health Survey data for 11 countries in West Africa with remotely sensed rainfall and temperature data georeferenced to the interview location. This combination allows for testing how fertility is influenced by climate change for the immediate surrounding area in the years leading up to a recent birth or pregnancy at time of interview. We test a number of measures of rainfall and temperature to determine which measures matter more for influencing fertility and how the effects vary for different environmental and household characteristics. We find that in times of increasing mean rainfall there is a positive effect on fertility but when variation is increasing there is a negative effect on fertility. We also find that dependence on agriculture and percent of land in cultivation increases the odds of a birth or pregnancy, though this effect varies significantly by parity.

Keywords: Climate Change, Fertility, West Africa

Introduction

The interaction between environment and fertility is one of the oldest areas of research in demography. Anchored in Malthus' distinction between the arithmetic versus geometric growth of resources and population, questions about the nature of this relationship have been regularly raised, revisited and reframed over the last 70 years (Ruttan 1993; Pebley 1998; McNeil 2006).[1] The most recent iteration of this literature focuses on the effects of climate change (Hunter and Menken 2015; Grace 2017).

We summarize this literature in the next section. Here, we simply point to the general absence of a unified set of findings across the climate-change/fertility literature. It arises not only from the "distressingly complex" (McNeil 2006:183) relationship between population and environment in general, and not only from behavioral variation in fertility across and within societies, but also from a number of generalization and identification issues. This is broadly recognized. Systematic reviews of the climate change-fertility literature have noted the frequent spatial and temporal limitations, attempts to identify effects at an aggregate level, focus on developed countries, selective subsamples, and tendencies to remain within restrictive disciplinary paradigms (Pebley 1998; De Sherbinin, VanWey, McSweeney et al 2008; Grace 2017).[2]

These methodological issues provide the entry point for the present study. Merging a time-series of remotely sensed environmental data with nationally representative household data from Demographic and Health Surveys (DHS), we examine the effects of changes in rainfall and temperature on individual women's fertility in 11 West African countries—Benin, Burkina Faso, Cote D'Ivoire, Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, Togo—conducted in the 2001-2014 period. Together, these cover the full range of ecological zones in the region, while representing 93 percent of West Africa's population.[3] By carefully matching the timing of births in the year prior to the interview or current pregnancy status at time of interview to local environmental conditions around and preceding the period of conception, we are able to identify the specific spatial and temporal context within which individual fertility behavior takes place. This allows us to directly test hypotheses related to the fertility effects of changes in overall levels of rainfall and temperature, and in the variance of rainfall and temperature. We also test the sensitivity of these effects to other factors such as child parity, household dependence on agriculture, and various household characteristics, distinguishing the

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[1] Ruttan (1993) describes three phases since World War II: classic Malthusian questions about whether economic growth and food production can be sustained in the face of population increase reemerged in the 1940s-50s; new questions about how much the environment can absorb the pollution produced by modern technology were added in the 1960s-70s; doomsday concerns about the demographic consequences of ozone depletion, acid rain, and global warming were added in the 1980s-90s. More recently, researchers have focused on how climate change modifies the ecology of microorganisms (Pebley 1998). Fertility figures prominently in much of the literature, if not directly, then at least as a motive for research.

[2] Grace (2017) summarizes her review thus: "most existing studies are limited in important ways because they focus primarily on families from rich countries or use aggregated climate or health data that may obscure variation between households and relationships at the individual-level. Similarly, existing research also often fails to distinguish between within-location variation and between-location variation in conditions or outcomes."

[3] The only West African countries not represented in our sample are Niger, Mauritania, Guinea Bissau and The Gambia. As of 2011, the median year of data collection, the total population of these four countries was about 22.5 million, relative to the 290.5 million represented in the 11 sampled countries (US Census Bureau International Data Base).

"microdemographic dynamics of rural smallholders" (de Sherbenin et al 2008: 39) from those of other rural residents, and from their counterparts in urban areas.

Overall, our results show that positive changes in mean rainfall relative to a historical baseline positively influences subsequent fertility, but increasing variation in amounts of rainfall, also relative to a historical baseline, negatively predicts subsequent fertility. We also identify notable interactions between these climate effects and parity and dependence on agriculture.

We argue that these results have more general implications for understanding fertility dynamics in West Africa, which remains one of the highest fertility areas in the world.

Background

i. Climate-change/fertility

In her review of the scholarly literature linking climate change to fertility, especially in high fertility environments, Grace (2017) identifies three discrete mechanisms. First, climate change affects time use, the intensity of physical labor, patterns of spousal separation, which can influence both the frequency of sex, the likelihood of conception, and the infant's birth-weight, a strong predictor of child health and survival that affects subsequent fertility decisions. Second, climate change can affect nutrition and food security, which in turn impacts women's health, their ability to breastfeed, and under certain circumstances, fecundability. Third, climate change affects household income, access to resources in general, and relations among households, all of which can influence demand for children.

In terms of quantity of research, this third mechanism has attracted the most attention.[4] Its core idea is that environmental factors moderate the risk environment within which people develop and act on fertility preferences, especially in rural areas, and most especially in rain-fed agricultural areas. Climate-induced economic effects therefore lead to a number of adaptive responses at the household level that can affect fertility. These are often framed as part of a multiphasic response strategy (Davis 1963) or rural livelihoods strategy (Ellis 1998).

Both older and more contemporary empirical research point to positive and negative fertility effects of climate change. A starting point is research in societies with little access to modern contraception or ideas of family limitation. Here, long-term family size ideals and fertility behavior are treated—explicitly or implicitly—as if they are in sync with environmental factors and the underlying population-resource balance. Examples include the variability in natural fertility regimes (Leridon 1977; Howell 1979), the different fertility regimes associated with drought and flood-prone areas in South Asia (Cain 1981), the five-child ideal in a high-Andes community in Peru (Collins 1983), and frequent association between farm size and family size, sometimes referred to as the "land-labor-demand hypothesis" (Schutjer and Stokes 1984). Subsequent environmental change can modify fertility behavior in ways that match the values emerging from that particular population-resource balance, though this effect appears to be somewhat influenced by a given population's stage of fertility transition. For example, fertility tends to be lower where a long-term drought undermines children's labor contributions in rain-fed agricultural areas (Cain 1981), where agricultural extensification reaches

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[4] It is also arguably the most important of the three, since it includes the first and second mechanisms. Briefly, the effects of climate change on household income trigger changes in time-use and, contingent on success in smoothing household income and consumption, affect food security.

the limits of arable land (Collins 1983; Shreffler and Dodoo 2009), where landholders have secure title to the land—the "land-security hypothesis" (Carr, Pann and Bilsborrow 2006)—where farmers adopt labor-saving farming devices (Bhandari and Ghimire 2013), or among the wealthy rural households in an otherwise poor rural area (Sasson and Weinreb 2017). On the other hand, fertility tends to be higher where child labor can still be put to use in spite of climate change (Cain 1981). This is referred to as the "vicious circle model" (VCM): poverty generates fertility which in turn places even greater pressure on the family and on the environment (Dasgupta 1993; Lutz and and Scherbov 2000; Filmer and Pritchett 2002). There are signs of VCM among poor rural residents in areas with low and declining levels of natural capital (Sasson and Weinreb 2017), and in areas with rising child morbidity, a product of shifting patterns of infectious disease associated with climate change (Aksan 2014).

The overall message that emerges from this literature is that there are no unified set of findings across the climate-change/fertility literature, but it is difficult to evaluate how much of this lack of unity can be ascribed to methodological issues and how much to actual behavioral differences across societies.

ii. Fertility in West Africa

Fertility in West Africa is high. In the 11 countries in our sample, national-level Period TFRs estimated from DHS collected in the 2001-2014 era fell in the 4.0 – 6.8 range (DHS StatCompiler), though the variable quality of DHS data means that at least some of those—Benin, Burkina Faso, Guinea, Mali, and Nigeria—appear to be underestimated by at least 10 percent (Gerland, Biddlecom, and Kantorová 2017).

These high national levels of fertility are, as Bongaarts (2017) describes, exceptional. They reflect the fact that, relative to other populations in the world, fertility transition in East, Central and West Africa began later, has been slower paced, and has given countries in those regions a higher level of fertility at any given level of development. Of course this is not a new realization. A long series of papers written during the golden years of fertility research in Africa identified a number of exceptional cultural and institutional barriers to fertility decline in Africa in general, and West Africa in particular (Caldwell and Caldwell 1987; Caldwell, Orubuloye, and Caldwell 1992; van de Walle 1992).

A more recent series of Africa-focused studies has highlighted some cracks in this high fertility edifice. Women and men of reproductive age in contemporary West Africa are a lot more exposed to ideas about family limitation than their counterparts were in the 1980s, and have access to more types of contraception (Smith 2004). As a result, fertility levels in some subpopulations—especially in regions around capital cities—are much lower than national averages. Contrast, for example, Ouagadougou's TFR of 3.4 to Burkina Faso's national average of 6.0 (2010); Monrovia's 3.2 to Liberia's 4.7 (2013); Greater Accra's 2.8 to Ghana's 4.2 (2014).

These capital city versus national differences, alongside differences across countries, point to considerable variability across West Africa in how tensions between, on one hand, modern sensibilities and aspirations and, on the other hand, traditional reproductive expectations rooted in older institutions and social relations, can affect fertility. As these tensions play out, fertility often falls, or at least changes its tempo (Smith 2001; Johnson-Hanks 2006; Trinitapoli and Yeatman 2011, 2018).

The pivotal conceptual idea in much of this new wave of Africa-focused fertility research is "uncertainty:" the moral uncertainty involved in using contraception, avoiding childbirth, and becoming modern (Watkins . . .; Johnson-Hanks 2006); and uncertainties about length of life in high HIV settings (Trinitapoli and Yeatman 2011). The hypothesized effects of climate-change on fertility work much more directly through this final type. Approximately 61% of people in sub-Saharan Africa (SSA) rely on agriculture for subsistence and livelihood (NEPAD 2013). Small-scale agriculture—typically rain-fed—is therefore the main source of food and a major source of employment. This makes household income in SSA much more susceptible to climate-change than is the case in other regions. Reduced or mistimed rainfall, or anomalous weather patterns that generate sharp spikes in temperature at sensitive stages of plant growth, can imperil yields and therefore threaten household survival. The threat is amplified by the absence of strong public safety nets.

iii. Trends in climate change

This three-way combination of high fertility, heavy reliance on small-scale agriculture, and absence of public welfare or social insurance scheme, is what makes the climate-change/fertility question so important in SSA in general, and West Africa in particular. West Africa is a varied climatic region with a precipitation regime that is characterized by decreasing rainfall and wet season length over the last few decades. Drought is recurrent and overall there has been a drying trend since 1900, though there is some evidence of increases in rainfall from the 1990s into the early 2000s (Herrman, Anyamba and Tucker 2005). Coupled with the longterm reduction in rain, West Africa has also experienced increased temperatures over the last 50 years[5], in line with increases seen globally (USGS). The combination of less rain and hotter temperatures are felt acutely by those dependent on agriculture in the region.

Consistent with the expectations of the rural livelihoods strategy, these changes in climate are affecting other behaviors. Not only has West Africa experienced rapid urbanization over the last 40 years (Menashe-XXXX and Stecklov 2017)—which has likely reduced the percentage of people who directly rely on agricultural production, though not the number (given high rates of population growth)—but rural-out migration appears to be higher in periods with greater loss of rainfall and rise in temperature, relative to a historical mean (Weinreb, Stecklov and Aslihan 2018).[6] In addition, the documented increases in NDVI in certain areas of West Africa since the 1980s, notwithstanding the general drop in rainfall and rise in temperature, points to some level of agricultural adaptation—more likely a change in farming technique or crop substitution than extensification—that may in turn signal some measure of household adaptation to climate change.

iv. Summary

Beyond the general question of how, if at all, people are changing their fertility behavior in response to climate change, three sets of specific questions arise from this review.

First, what type of climate change matters more: a change in mean rainfall or mean temperature; a change in anomalous values of rainfall and temperature; some interaction between any of these?

Second, to what extent are the effects of climate change on fertility moderated by other environmental factors like soil quality, general patterns of land use, average farm size?

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[5] The effect of temperature increase is difficult to assess due to variability in season and type of climate across the region (USGS).

[6] Whether this affects fertility depends on the age, gender, marital status of the migrants, and the frequency of home visits.

Third, are the effects of climate change on fertility moderated by other household characteristics, like wealth, dependence on agriculture, or parity?

Data

To answer these questions for the West Africa region as a whole we combine two main types of data. Individual-level data on fertility and all other individual and household characteristics are from Demographic and Health Surveys (DHS). These are nationally representative surveys of women aged 15-49 that are typically fielded every four to five years, based on a multistage cluster sample. Table 1 details the 23 discrete rounds used in this analysis. They were collected in 11 West African countries in the 2001-2014 period. In six countries, we use data from two discrete DHS rounds. In three countries—Ghana, Mali and Nigeria—we use data from three rounds. And in the final two—Cote d'Ivoire and Togo—we only use one round.

Table 1 about here

Table 1 confirms relatively high levels of fertility in these countries. TFR fluctuates from 4.0 to 6.8 across the survey years, with an average of 5.3. Across the nine countries with at least two rounds of data, fertility fell, from an average TFR of 5.5 in the earliest wave to 5.2 in the latest. This relatively slow reduction—approximately 0.05-0.1 children per year, implying a 60 year process to reduce TFR from 7.0 to 3.0—is consistent with Bongaarts' (2017) account of a late and slow transition. In fact, in two of the nine countries with at least two rounds of data, TFR marginally increased. In one of them, Burkina Faso, that increase appears to be driven by a 0.6 child increase in TFR in the region that includes the capital city, Ougadougou.

Table 1 also shows that there is considerable within-country variability in TFR, with a 3.3 child difference between the lowest and highest TFR regions. Interestingly, the average value of the lowest and highest TFR hardly changed between the earliest and latest round, an indication that the drop in national TFR is driven by reductions among non-extreme regions.

Table 2 about here

The indicator of fertility—and the dependent variable in all analyses—is a dichotomous variable comprising two DHS questions. It is coded "1" where women report either having given birth in the last year or being currently pregnant, and "0" otherwise. Approximately 29% of respondents have given birth in the last year or are currently pregnant; 18.8% had given birth in the last year and 10.2% were pregnant at time of interview. Table 2 presents descriptive statistics for the sample.

To identify the effects of climate-change on this indicator of fertility, we merge DHS data with a second type of data: remotely sensed data on rainfall and temperature. The rainfall data are from the Climate Hazard Group InfraRed Precipitation with Station (CHIRPS) dataset, made available by the USGS Earth Resources Observation and Science Center and UC Santa Barbara Climate Hazards Group. This includes continuous rainfall data for each month from 1982 to the present. The dataset is a raster grid, made up of cells with a spatial resolution of .05 degrees (about 50km grid in West Africa), with rainfall measured in millimeters (Funk et al. 2015). The temperature data are from the Climatic Research Unit (CRU) at the University of East Anglia's CRUTS4.01 which is a dataset of monthly high resolution climate variation, at a 0.5 degree spatial resolution. We use diurnal temperature, which is the measure of variation between a high and low temperature that occurs during the same day, with units in degrees Celsius (University of East Anglia Climatic Research Unit; Harris, and Jones, 2017).

We merged these with the DHS data at the level of the sample cluster. This generated a dataset of 244,887 individuals in 7,559 discrete clusters. Figure 1 maps the cluster locations across the 11 countries used in this study.[7]

Figure 1 about here

Environmental and fertility data are also carefully merged in terms of time. Figure 2 describes the basic model. Time t, month 0 is the month of DHS interview. Combining respondent's reports of being currently pregnant or having given birth in the last year allows us to define a window of time during which a given woman became pregnant: it occurred no earlier than 21 months before the interview.

Figure 2 about here

All environmental data are defined in relation to the end of that window. Specifically, we generated two types of baseline measures of rainfall and diurnal temperature for each cluster for 1982 to 1997[8]: a mean and coefficient of variation (CoV)[9]. We calculated lagged 3-year averages of each of these for both rainfall and temperature over the period 22-57 months before the interview, and estimated the ratio of these measures to their respective 1982-1997 baseline. For example, if a woman was interviewed in August 2003, we identified the effect of changes in mean rainfall over a three-year window prior to her pregnancy by looking at mean rainfall November 1999 to October 2001, relative to rainfall January 1982 to December 1997. We followed a similar procedure looking at the effects of a change in CoV.

The change in mean rainfall or temperature is intended to tap into a shift in total value of that climatological dimension. The change in CoV focuses on changes in the frequency of anomalous weather patterns—i.e., spikes and dips—in both rainfall and temperature, each of which can damage agricultural yields over and above any change in the mean. Looking at the effect of either on fertility is equivalent to asking whether, net of an array of individual and household characteristics, the probability of a given woman having become pregnant was affected by a change in either mean rainfall or temperature, or anomalous patterns, relative to a longer historical norm for that area. In our analysis, the change in mean and the anomalous patterns are operationalized into quintiles. This division allows for nuanced understanding of what type/direction of change is influencing fertility – i.e. negative change, or initial positive change versus increasing positive change. Table 2, identifies the value ranges of the mean rainfall and CoV of rainfall (both relative to baseline) that fall within the quintile ranges.

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[7] To protect respondent anonymity, DHS randomly displaces urban clusters by up to 2 kilometers and rural clusters by up to 5 kilometers (up to 10 kilometer displacement in 1 percent of cases) (Burgert et al 2013). To account for this displacement in our identification of local rainfall and temperature patterns, a buffer of 20 kilometer (radius) was created around each point. This "cluster zone" is the actual area used to estimate all our remote-sensed measures. Although this seems like a wide geographic area, we think it identifies environmental conditions close enough to the village or neighborhood to be meaningful.

[8] The CHIRPS data availability begins in 1982.

[9] The coefficient of variation (CoV) is a standardized measure of dispersion.

Table 3 about here

Climate change involves interactions between rainfall and temperature. To identify whether these affect fertility, we specified four main types of interactions between these measures. Table 3 outlines our approach, organizing the interactions by climatic element and type of measure. Interaction 1 multiplies the change in mean of rainfall by the change in mean temperature, Interaction 2 the change in mean rainfall by the change in CoV of temperature, Interaction 3 the reverse, and Interaction 4 the CoVs of rainfall and temperature.

Table 4 about here

To capture other environmental conditions that may influence the relationship between rainfall/ temperature and fertility, other types of remotely-sensed data were estimated at the cluster level: land cover/ land use, soil quality and vegetation indices. The first two are from the Food and Agriculture Organization (FAO) Harmonized World Soil Database v 1.2. We include two land-cover controls. The percent of cluster land covered by grassland, shrubland, woodland and forestland are combined together to account for the use of land for grazing, foraging and collecting firewood and other resources. The percent of the DHS cluster area that is cultivated—net of a household-level control for urban and cluster-level measure of the percent of land that is grass, shrub, wood, or forest—allows us to directly test the land-labor-demand hypothesis (Schutjer and Stokes 1984).

Second, to test whether the effects of climate change on fertility are moderated by the inherent quality of agricultural land, we include a cluster-level control for soil quality. This is a composite measure averaged within the cluster which accounts for nutrient availability and retention, rooting conditions, oxygen availability, excess salts, toxicity and workability. For ease of interpretation, this measure is divided into quintiles and the codes reversed, so that higher numbers represent lower soil quality, which should be more susceptible to climate change.

A final environmental measure is the normalized difference vegetation index (NDVI). Although this should be correlated with prior rainfall and temperature patterns, any effect above rainfall and temperature should tap local agricultural change, like a shift toward more drought-resistant crops, or more irrigation (Hermann, Anyamba and Tucker 2005). Those would moderate the effects of undesirable types of climate change on economic uncertainty. The NDVI data come from the Vegetation Phenology and Vegetation Index Products from Multiple Long Term Satellite Data Records from NASA and University of Arizona. The yearly cumulative vegetation index was used because of the large geographic spread and large time span of the data. Using seasonal measures would not be compatible with our range of data as different locations within our study region may have their high season at different points of time. NDVI measures range from 0 – 1.0, with higher numbers representing better vegetation health.

We also employ a standard array of individual and household control variables typically used in analyses of fertility: Age, including a quadratic term to capture non-linearities; marital status; education; parity; rural versus urban residence; whether the respondent or her partner works in agriculture; and wealth. For the last of these, we use an asset-based additive index of household wealth comprising six items—household ownership of a radio, a television, a refrigerator, a bicycle, a motorcycle, or a car—measured both in absolute terms and relative to the cluster average.

We directly test whether the effects of climate change on fertility are moderated by direct dependence on agriculture, captured by employment in agriculture by either respondent or partner and by percent of land in cultivation, and parity using interaction terms. In the future we will also test whether the effects of climate change on fertility are moderated by household wealth; absolute and relative to the cluster.

Analysis [Not complete]

The initial set of analyses herein begin to answer our three questions for one climatological element, rainfall. First, we address whether fertility is more influenced by prior changes in mean rainfall or changes in anomalous values of rainfall. We then address our second question, adding environmental control factors to see if the effects of climate change on fertility are moderated by soil quality, land cover/land use, cultivated land per cluster, and vegetation index. Finally, we begin to answer our third question: is the effect of climate change moderated by household characteristics like parity and dependence on agriculture. All models include an indicator of the DHS phase period which accounts for the decreasing TFR over time, we expect later periods to show a negative effect on fertility,

To answer these questions we fit logistic regression models for the sample of 244,877 individuals in 7,559 clusters using robust standard errors to account for non-independence of observations in the cluster sample, in addition to issues arising from spatial proximity.

Model 1 (Table 5) includes demographic controls and the quintiles of change in mean rainfall (using the first quintile as a reference) as predictors of the fertility outcome, giving birth in the last year or pregnant at time of interview. Next, in Model 2, the environmental controls are included and measures of baseline rain and temperature; mean and CoV for each element. In the third model, we also include change in CoV of rainfall quintiles. Model 4 add in the change in mean rainfall (relative to baseline) measure as a final moderator. Taken together this set of models will show what effects mean rainfall has on fertility and show how, if at all, that differs from change in rainfall variation. In addition the results will show how environmental controls moderate these effects. In Table 6, the results of three interaction models are shown which test of the effect of dependence on agriculture and parity and effect of changing rainfall on fertility.

Future work will continue with the progression of models but will 1) test how temperature effects fertility: using change in mean or change in anomalous values, 2) test the interaction of change in rainfall and change in temperature, using the interactions outlined in Table 4, and 3) examine to what extent to environmental and household characteristics moderate the effect of temperature and the effect of both rainfall and temperature on fertility.

Results [Initial]

i. Main Models

Table 5 displays the results for the first set of analysis. In Model 1, we begin with demographic controls. Most of these have the expected association with fertility. Within this aged 15-49 sample, the likelihood of fertility increases with age, though the quadratic term points to a reduction at older ages. Being married increases the odds of having a child in the last year or being pregnant, compared to being single. Living in a rural area has a moderate but significant positive effect associated with almost 1.16 OR increase in the likelihood of the fertility outcome. Working in agriculture has a slightly negative effect, though this does not meet the conventional standards for significance. The effects by parity level show a positive, monotonic effect. This pattern of effects is expected as families with higher parity levels are likely to have more children. Effects by the two wealth measures show significant and countervailing effects. A one-unit increase in household wealth is associated with a 0.936 OR decrease in the likelihood of pregnancy or giving birth in the last year. However, as household wealth increases relative to others in the cluster, the odds of fertility increase by 1.037 OR. Finally, the dummy variables for DHS phase, in reference to the earliest phases, 2001 – 2005, points to an ongoing secular reduction in fertility, with an OR of 0.899 by 2010 – 2014. [10]

Model 1 tests the effect of the change in mean rainfall as quintiles (relative to the first quintile which represents changes in rainfall from -32,396 to -1705 millimeters of rain, (see Table 4 for more details on the range of values in each quintile)). The second through fifth quintiles all have positive and significant effects on fertility. As the change in mean rainfall becomes more positive there is an increasing, up to a point, effect on fertility; the range of associated effects is between 1.107 and 1.173 OR. In the fifth quintile the effect is slightly lower than for the fourth quintile.

With the addition of environmental controls we focus on detecting moderation effects on the key independent variable; mean rainfall relative to baseline by quintile. Results of Model 2 show that there is a slight moderation of effects, such that the range of effects on fertility associated with increasing mean rainfall are now between 1.097 to 1.154 OR. While small in magnitude the changes do point to the importance of other environmental factors in determining the effect of climate change on fertility. The environmental controls' own effects on fertility show a notable pattern. As percent of land in cultivation per cluster increases there is a slight positive effect on fertility. Indicating some support for the "land-labor-demand hypothesis" (Schutjer and Stokes 1984). With increasing soil quality and NDVI increase, which represents better growth potential and vegetation growth, there is a significant negative effect on the odds of recent birth or current pregnancy of about 0.967 and 0.223 OR, respectively. The baseline measures of rainfall and temperature also have effects of note. An increase in average rainfall during the baseline period (1982 – 1997) has neither a positive nor negative effect on fertility but increasing variation in rainfall during that period has a strong negative effect on fertility, an OR of 0.252. Increase in average temperature during this time is associated with a very small reduction in odds whereas increase in variation of temperature has a very strong positive effect, though it does not reach standards for significance.

Model 3 introduces CoV for rainfall by quintiles, relative to baseline CoV, to the model. In reference to the first quintile (CoV of .759 to .811) (see Table 3 for value ranges per quintile), as CoV increases the effect on fertility becomes increasingly negative, from OR of 0.900 to 0.711. Increasing variation in rainfall has a negative effect on the odds of recent birth or current pregnancy status. Accounting for the variation increases the positive effect of mean rainfall. Thus reducing the depression effect of the environmental controls, evident in the previous model. The effects for mean rainfall quintiles is now between ORs of 1.105 and 1.167, following the same pattern as in previous models, the last quintile has a slightly less positive effect on the odds of recent birth or pregnancy. These two measures of recent rainfall show a striking countervailing effect.

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[10] The only variable with an unexpected association with fertility is education. Having any education, compared to no education, is associated with higher likelihood of being pregnant or having given birth.

The inclusion of the CoV of rainfall has partial mediating effects on the environmental controls. Baseline CoV for rainfall has a stronger negative effect at OR of 0.003 but NDVI's effect is less negative, at OR of 0.304. The effects of other variables stay much the same.

The last model in Table 5, Model 4, includes the raw change in mean rainfall relative to baseline (not in quintiles). The effect is not significant and has a neutral effect on the odds. It does, however, attenuate some of the effect of change in mean by quintiles and change in CoV by quintiles. Mean rainfall's effect is reduces in all quintiles such that the range is now between ORs of 1.076 and 1.118 and the fifth quintile's effect is no longer significant. The effect of CoV is less negative for the second and third quintiles but more negative for the fourth and fifth quintiles.

Overall, and in answer to our questions, we find that the effect on fertility is particular to the measure of climate. Mean and variation in rainfall, relative to the baseline, have countervailing effects on recent birth or current pregnancy such that increasing rain positively predicts fertility while increasing variation negatively predicts fertility. We also find that environmental controls do moderate the effect of climate change on fertility, though the magnitude is quite small. We next turn our attention to testing the effects of household characteristics on changing rainfall's effect on fertility.

ii. Interactions

We next test the interaction of change in mean rainfall (by quintile) and dependence on agriculture, operationalized by employment in agriculture by respondent or her partner. In the previous set of models (Table 5) work in agriculture was not significant and had a very small negative effect. In Model 1 of Table 6 there is more pronounced negative effect that reaches significance. The interaction, of work in agriculture and quintile of mean rainfall has an associated positive effect for each quintile (relative to the first quintile). In times of increasing change in mean rainfall, those who are engaged in agriculture have a higher likelihood of recent birth/current pregnancy. This effect varies in strength and significance; at the highest level of mean rain, relative to baseline, the effect is the least positive (1.069 OR) and is not significant but the second and third quintile are significant and increase in effect (1.156 and 1.171 OR, respectively), while the fourth quintile's effect is slightly smaller in comparison (1.111 OR). The main effect of mean rainfall is not significant at any level and all effects are between 1.017 and 1.075 OR. Variation of rainfall continues to exhibit an increasingly negative effect, which is significant at all levels.

We also test dependence on agriculture by interacting percent cultivated land per cluster with mean rainfall by quintile, see Model 2, Table 6. This interaction attenuates the strength and significance of the main effect of mean rainfall and the main effect of cultivated land. The interaction is significant for certain levels of change in rain; at the third and fourth quintile there is a significant positive effect on fertility with OR of about 1.004 for both.

Model 3 in Table 6A shows the results of the interaction between quintiles of mean rainfall and parity level. For each quintile level (referenced to the first quintile) there is an interaction with a different parity level. The main effect of mean rainfall is not significant and the main effect of parity level is slightly depressed for all levels but still large and positive. For each level of increasing rainfall and parity that has an effect that reaches significance, the increase in odds of fertility ranges between OR of 1.193 and 1.446. Overall, with increasing mean rain there is a positive effect on fertility for households with parity at or above 2. At the highest increase in mean, quintile 5, only parity level 2 is significant and positive. Within each level of mean rainfall the effect by parity has a fluctuating pattern. For the second through fourth quintiles the effect increases with parity levels but in the fifth quintile the effect decreases by parity.

In sum, we find evidence that while rainfall increases are encouraging of fertility, the effect varies by parity of the household, and is positive in trend. Dependence on agriculture and increasing rainfall, while controlling for increasing variation in rainfall, shows a positive effect on fertility. In addition we see a small positive effect for increasing mean rainfall (also while controlling for variation in rain) and amount of land in cultivation in the surrounding area. Together, these results begin to answer our third question and lend support to the ideas that children are vital agricultural workers who are in demand in times of increasing rainfall and increasing variation in rainfall. This supports the land-labor demand hypothesis and indicates that fertility may be a strategy to mitigate against uncertainty.

Discussion and Planned Future Work

These results point to the potential of this study. For changing rainfall alone we find that 1) increasing rain relative to baseline rain, in the three years preceding a recent birth or pregnancy increases the likelihood of a recent birth or being pregnant at the time of interview 2) if there is also increasing variation in the rainfall, relative to baseline rain variation, in the three years preceding the fertility outcome, there is a negative effect on the odds of recent birth or pregnancy, which attenuates the positive effect of more rain. We also find these effects to be moderated by environmental controls. Dependence on agriculture has a positive effect on fertility when the mean of rainfall is increasing relative to the baseline, and while accounting for increasing variation, but otherwise has a negative effect. We also see that the effect varies by parity, households with more children experience different effects of increasing rain, such that as rain increases, but not to the highest levels, there is an increasingly positive effect on the fertility outcome.

Our next steps include extending this analysis to change in mean temperature and change in temperature variation, relative to baseline measures, and then interacting these measures of rainfall and temperature to determine to which measures fertility is sensitive and how do environmental and household characteristics moderate the effects.

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Figure 1. DHS Clusters.

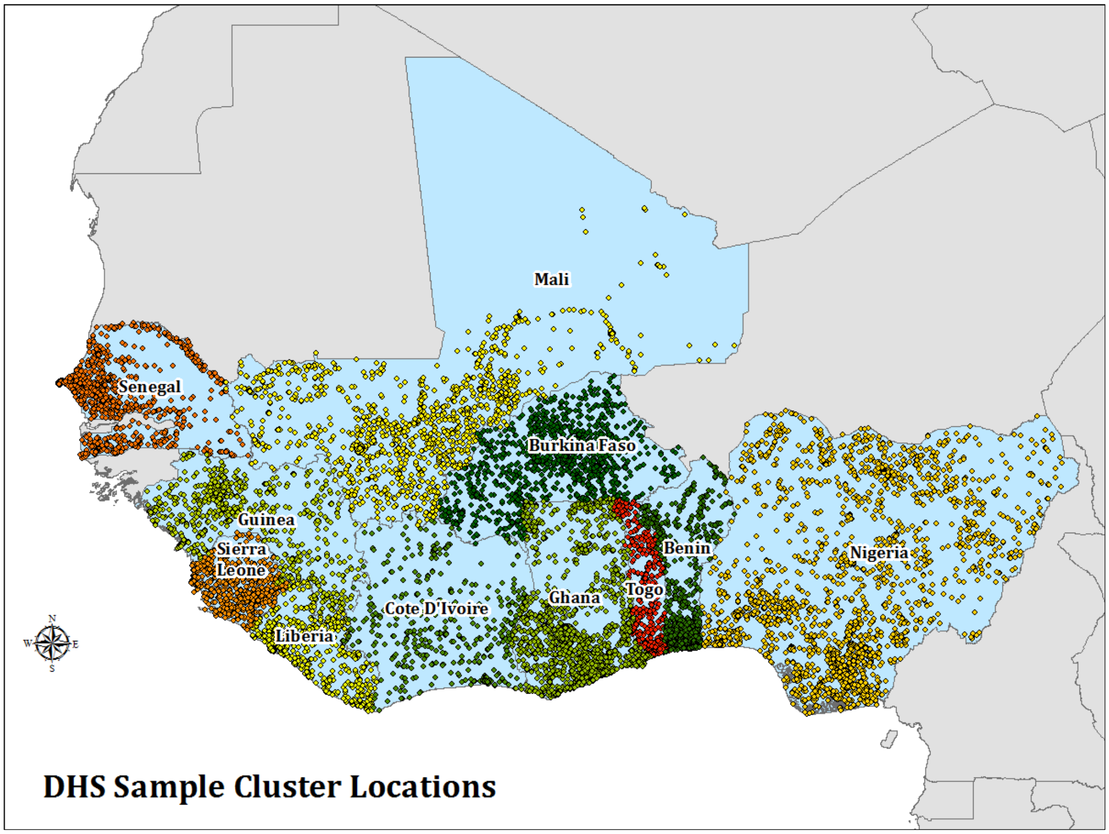
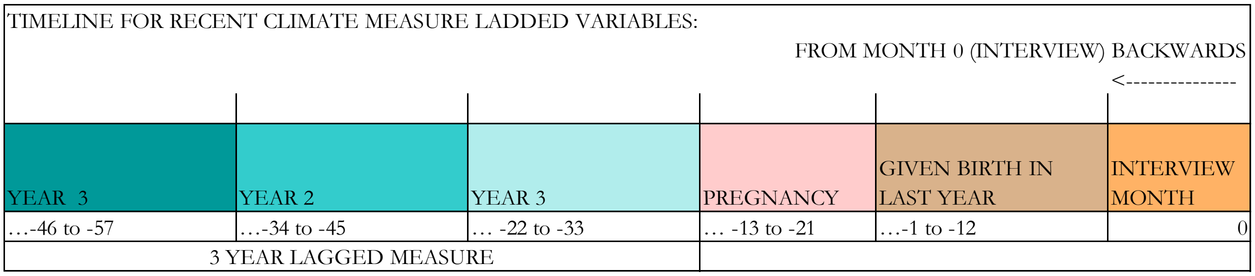


Figure 2. Timeline for Construction of Lagged Variables.



TIMELINE FOR RECENT CLIMATE MEASURE LADDED VARIABLES:

FROM MONTH 0 (INTERVIEW) BACKWARDS

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YEAR 3	YEAR 2	YEAR 3	PREGNANCY	GIVEN BIRTH IN LAST YEAR	INTERVIEW MONTH
…-46 to -57	…-34 to -45	… -22 to -33	… -13 to -21	…-1 to -12	0
3 YEAR LAGGED MEASURE					

Table 1. Sample size and TFR, by country and DHS Year

				TFR Range by Region			
Country	**DHS Year**	**Sample Size**	**TFR**	**Low**		**High**	
Benin	2001	5,612	5.6	Littoral (Cotonou)	3.4	Atacora/Donga	6.9
Benin	2012	14,844	4.9	Littoral (Cotonou)	3.6	Alibori / Atacora	5.8
Burkina Faso	2003	10,410	5.9	Ouagadougou	2.8	Nord	7.5
Burkina Faso	2010	13,838	6.0	Ouagadougou	3.4	Sahel	7.5
Cote d'Ivoire	2012	8,884	5.0	Abidjan	3.1	Nord-Ouest	6.8
Ghana	2003	4,243	4.4	Greater Accra	2.9	Northern	7.0
Ghana	2008	2,846	4.0	Greater Accra	2.5	Northern	6.8
Ghana	2014	4,674	4.2	Greater Accra	2.8	Northern	6.6
Guinea	2005	644	5.7	Conakry	4.1	Kankan	7.3
Guinea	2012	7,088	5.1	Conakry	3.6	Kankan	6.9
Liberia	2007	5,134	5.2	Monrovia	3.4	South Eastern A	6.9
Liberia	2013	7,081	4.7	Monrovia	3.2	River Cess	7.2
Mali	2001	11,504	6.8	Bamako	4.9	Sikasso	7.6
Mali	2006	12,719	6.6	Kidal	4.7	Sikasso	7.4
Mali	2012	9,267	6.1	Bamako	5.1	Sikasso	6.6
Nigeria	2003	6,142	5.7	South East	4.1	North East	7.0
Nigeria	2008	27,383	5.7	South West	4.5	North West	7.3
Nigeria	2013	31,268	5.5	Rivers	3.8	Zamfara	8.4
Senegal	2005	990	5.3	Dakar	3.7	Fatick	6.8
Senegal	2010	11,406	5.0	Dakar	3.7	Sédhiou	6.9
Sierra Leone	2008	12,884	5.1	Western	3.4	Northern	5.8
Sierra Leone	2013	29,528	4.9	Western Urban	3.1	Pujehun	6.3
Togo	2013	6,498	4.8	Lomé	3.5	Savanes	6.0
Mean (unweighted) **earliest** round			5.52		3.63		6.98
Mean (unweighted) **latest** round			5.16		3.59		6.91

Table 2. Descriptive Statistics

	Variable	**Mean**	**Standard Deviation**
Outcome	Birth in Last Year or Currently Pregnant	0.29	
Demographic Controls	Age	28.68	9.49
	Marital Status		
	Single	0.23	
	Widowed/Separated/Divorced	0.05	
	Married	0.72	
	Educational Attainment		
	No Education	0.56	
	< Secondary Education	0.18	
	>= Secondary Education	0.27	
	Rural	0.64	
	Either Resp/Partner works in Agriculture	0.37	
	Parity Level		
	Parity 0	0.27	
	Parity 1	0.15	
	Parity 2	0.14	
	Parity 3	0.13	
	Parity 4	0.11	
	Parity 5	0.09	
	Parity 6+	0.13	
	Household Wealth		
	Assets	1.76	1.34
	Assets Relative to Cluster	3.04E-06	1.05
Environmental Controls	Baseline Mean: Rain 1982 - 1997	57231.01	33556.14
	Baseline Mean: Diurnal Temperature 1982 - 1997	138.20	38.40
	Baseline CoV: Rain 1982 - 1997	0.09	0.02
	Baseline CoV: Diurnal Temperature 1982 - 1997	0.02	0.01
	Percent Cultivated Land Per Cluster	28.64	17.01
	Percent Grass/Shrub/Wood/Forestland Per Cluster	62.49	19.17
	Soil Quality Per Cluster	2.15	0.98
	Mean NDVI Per Cluster	0.18	0.06
	Change in Mean Rainfall Relative to Baseline	1039.68	6376.91

Table 3. Values of Change in Mean Rainfall and Change in CoV of Rainfall by Quintile

Mean	**Variable**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
1st Mean Rainfall Quintile	Change in Mean Rain Relative to Baseline	49,110	-8806.539	6219.856	-32396.71	-1705.559
2nd Mean Rainfall Quintile		49,132	45.03213	824.8867	-1704.977	1183.49
3rd Mean Rainfall Quintile		49,121	1931.138	441.5924	1183.57	2715.646
4th Mean Rainfall Quintile		49,074	3967.274	804.7808	2717.662	5481.691
5th Mean Rainfall Quintile		49,099	8071.454	2436.213	5482.332	19904.23
CoV	**Variable**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
1st CoV Rainfall Quintile	Change in CoV of Rain Relative to Baseline	49,116	0.7972	0.0104	0.7590	0.8111
2nd CoV Rainfall Quintile		49,128	0.8194	0.0039	0.8111	0.8266
3rd CoV Rainfall Quintile		49,108	0.8346	0.0045	0.8266	0.8416
4th CoV Rainfall Quintile		49,087	0.8480	0.0034	0.8416	0.8534
5th CoV Rainfall Quintile		49,097	0.8581	0.0034	0.8534	0.8682

Table 4. Climate Change Interaction Analysis.
(Analysis and Results Forthcoming)

Climate Change Measures (Interactions)		Diurnal Temperature	
	Measure	*Change in Mean*	*Change in CoV*
Rainfall	*Change in Mean*	1	2
	Change in CoV	3	4

Table 5. Logistic Regression with Robust Standard Errors.

		Model 1			Model 2			Model 3			Model 4		
		OR	**SE**		**OR**	**SE**		**OR**	**SE**		**OR**	**SE**	
Demographic Controls	Age	1.1185	(0.0070)	***	1.1193	(0.0070)	***	1.1202	(0.0070)	***	1.1205	(0.0070)	***
	Age squared	.9962	(0.0001)	***	.9962	(0.0001)	***	.9962	(0.0001)	***	.9962	(0.0001)	***
Marital Status	Widowed/Separated/Divorced	1.7302	(0.0806)	***	1.7311	(0.0809)	***	1.7301	(0.0807)	***	1.7293	(0.0807)	***
	Married	6.3548	(0.2120)	***	6.3352	(0.2129)	***	6.3272	(0.2123)	***	6.3261	(0.2123)	***
Educational Attainment	< Secondary Education	1.0787	(0.0167)	***	1.0732	(0.0171)	***	1.0758	(0.0173)	***	1.0751	(0.0172)	***
	>= Secondary Education	1.0991	(0.0191)	***	1.0881	(0.0199)	***	1.0901	(0.0201)	***	1.0888	(0.0201)	***
	Rural	1.1589	(0.0187)	***	1.1305	(0.0187)	***	1.1307	(0.0187)	***	1.1301	(0.0187)	***
	Either Resp/Partner works in Agriculture	.9954	(0.0137)		.9817	(0.0138)		.9825	(0.0138)		.9833	(0.0138)	
Parity Level	Parity 1	3.7964	(0.1025)	***	3.8101	(0.1031)	***	3.8004	(0.1027)	***	3.8006	(0.1027)	***
	Parity 2	3.8835	(0.1146)	***	3.8973	(0.1152)	***	3.8843	(0.1147)	***	3.8836	(0.1147)	***
	Parity 3	4.7788	(0.1504)	***	4.7866	(0.1507)	***	4.7685	(0.1500)	***	4.7654	(0.1499)	***
	Parity 4	5.4879	(0.1849)	***	5.4895	(0.1851)	***	5.4664	(0.1842)	***	5.4618	(0.1840)	***
	Parity 5	6.7751	(0.2454)	***	6.7627	(0.2451)	***	6.7317	(0.2437)	***	6.7238	(0.2435)	***
	Parity 6+	10.4950	(0.3790)	***	10.4563	(0.3781)	***	10.4059	(0.3757)	***	10.3908	(0.3754)	***
Household Wealth	Assets	.9357	(0.0088)	***	.9255	(0.0094)	***	.9206	(0.0097)	***	.9203	(0.0097)	***
	Assets Relative to Cluster	1.0368	(0.0110)	***	1.0479	(0.0118)	***	1.0534	(0.0123)	***	1.0539	(0.0123)	***
	DHS Phase 2006-2009	.9800	(0.0192)		.9757	(0.0194)		.9770	(0.0194)		.9793	(0.0195)	
	DHS Phase 2010-2014	.8988	(0.0152)	***	.9061	(0.0163)	***	.9075	(0.0162)	***	.9049	(0.0162)	***
Mean Rainfall Quintiles	2nd Mean Rainfall Quintile	1.1071	(0.0266)	***	1.0966	(0.0298)	***	1.1047	(0.0302)	***	1.0761	(0.0352)	*
	3rd Mean Rainfall Quintile	1.1460	(0.0269)	***	1.1273	(0.0308)	***	1.1365	(0.0314)	***	1.0987	(0.0396)	**
	4th Mean Rainfall Quintile	1.1734	(0.0279)	***	1.1542	(0.0309)	***	1.1666	(0.0316)	***	1.1176	(0.0450)	**
	5th Mean Rainfall Quintile	1.1365	(0.0276)	***	1.1222	(0.0310)	***	1.1319	(0.0319)	***	1.0679	(0.0525)	
Environmental Controls	Baseline Mean: Rain 1982 - 1997				1.000	(0.0000)	***	1.000	(0.0000)	***	1.000	(0.0000)	***
	Baseline Mean: Diurnal Temperature 1982 - 1997				.9993	(0.0002)	**	.9993	(0.0002)	**	.9993	(0.0002)	**
	Baseline CoV: Rain 1982 - 1997				.2521	(0.1490)	*	.0031	(0.0033)	***	.0042	(0.0045)	***
	Baseline CoV: Diurnal Temperature 1982 - 1997				4.4912	(5.9430)		5.0263	(6.8760)		4.9272	(6.7433)	
	Percent Cultivated Land Per Cluster				1.0025	(0.0007)	***	1.0021	(0.0007)	**	1.0020	(0.0007)	**
	Percent Grass/Shrub/Wood/Forestland Per Cluster				1.0011	(0.0006)		1.0007	(0.0006)		1.0006	(0.0006)	
	Soil Quality Per Cluster				.9667	(0.0076)	***	.9624	(0.0076)	***	.9611	(0.0077)	***
	Mean NDVI Per Cluster				.2232	(0.0632)	***	.3037	(0.0887)	***	.3535	(0.1061)	***
	Change in Mean Rainfall Relative to Baseline										1.000	(0.0000)	
CoV Rainfall Quintiles	2nd CoV Rainfall Quintile							.9001	(0.0265)	***	.9013	(0.0266)	***
	3rd CoV Rainfall Quintile							.7959	(0.0353)	***	.7970	(0.0353)	***
	4th CoV Rainfall Quintile							.7443	(0.0446)	***	.7353	(0.0440)	***
	5th CoV Rainfall Quintile							.7109	(0.0493)	***	.7002	(0.0487)	***
	Constant	.0264	(0.0023)	***	.0368	(0.0054)	***	.0652	(0.0124)	***	.0642	(0.0122)	***
	Observations	244,887			244,887			244,887			244,887		

Table 6. Interaction with Agricultural Variables

		Model 1			Model 2		
		OR	SE		OR	SE	
Demographic Controls	Age	1.1206	(0.0070)	***	1.1206	(0.0070)	***
	Age squared	.9962	(0.0001)	***	.9962	(0.0001)	***
Marital Status	Widowed/Separated/Divorced	1.7388	(0.0810)	***	1.7282	(0.0806)	***
	Married	6.3632	(0.2126)	***	6.3258	(0.2121)	***
Educational Attainment	< Secondary Education	1.0741	(0.0172)	***	1.0728	(0.0172)	***
	>= Secondary Education	1.0843	(0.0201)	***	1.0870	(0.0201)	***
	Rural	1.1312	(0.0187)	***	1.1310	(0.0188)	***
	Either Resp/Partner works in Agriculture	.8898	(0.0333)	**	.9820	(0.0138)	
Parity Level	Parity 1	3.7925	(0.1023)	***	3.8028	(0.1028)	***
	Parity 2	3.8754	(0.1142)	***	3.8827	(0.1147)	***
	Parity 3	4.7569	(0.1494)	***	4.7649	(0.1500)	***
	Parity 4	5.4514	(0.1834)	***	5.4613	(0.1840)	***
	Parity 5	6.7134	(0.2428)	***	6.7207	(0.2434)	***
	Parity 6+	10.3719	(0.3741)	***	10.3724	(0.3749)	***
Household Wealth	Assets	.9202	(0.0097)	***	.9227	(0.0098)	***
	Assets Relative to Cluster	1.0541	(0.0123)	***	1.0512	(0.0123)	***
	DHS Phase 2006-2009	.9880	(0.0198)		.9703	(0.0194)	
	DHS Phase 2010-2014	.9083	(0.0162)	***	.8988	(0.0162)	***
Mean Rainfall Quintiles	2nd Mean Rainfall Quintile	1.0167	(0.0369)		1.0045	(0.0560)	
	3rd Mean Rainfall Quintile	1.0305	(0.0408)		.9957	(0.0570)	
	4th Mean Rainfall Quintile	1.0754	(0.0461)		.9980	(0.0602)	
	5th Mean Rainfall Quintile	1.0445	(0.0531)		1.0520	(0.0725)	
CoV Rainfall Quintiles	2nd CoV Rainfall Quintile	.9003	(0.0266)	***	.9028	(0.0266)	***
	3rd CoV Rainfall Quintile	.8050	(0.0358)	***	.8175	(0.0365)	***
	4th CoV Rainfall Quintile	.7448	(0.0447)	***	.7659	(0.0465)	***
	5th CoV Rainfall Quintile	.7105	(0.0496)	***	.7248	(0.0509)	***
Environmental Controls	Baseline Mean: Rain 1982 - 1997	1.000	(0.0000)	***	1.000	(0.0000)	***
	Baseline Mean: Diurnal Temperature 1982 - 1997	.9993	(0.0002)	***	.9994	(0.0002)	**
	Baseline CoV: Rain 1982 - 1997	.0054	(0.0058)	***	.0055	(0.0061)	***
	Baseline CoV: Diurnal Temperature 1982 - 1997	4.7058	(6.4544)		3.4107	(4.6460)	
	Percent Cultivated Land Per Cluster	1.0022	(0.0007)	**	.9994	(0.0015)	
	Percent Grass/Shrub/Wood/Forestland Per Cluster	1.0007	(0.0006)		1.0009	(0.0006)	
	Soil Quality Per Cluster	.9607	(0.0077)	***	.9604	(0.0076)	***
	Mean NDVI Per Cluster	.3496	(0.1051)	***	.3400	(0.1017)	***
	Change in Mean Rainfall Relative to Baseline	1.000	(0.0000)		1.000	(0.0000)	
Dependence on Agriculture	2nd Mean Rainfall Quintile * Either Work in Ag	1.1562	(0.0522)	**			
	3rd Mean Rainfall Quintile * Either Work in Ag	1.1705	(0.0521)	***			
	4th Mean Rainfall Quintile * Either Work in Ag	1.1106	(0.0491)	*			
	5th Mean Rainfall Quintile * Either Work in Ag	1.0689	(0.0480)				
	2nd Mean Rainfall Quintile * % Cultivated Land				1.0028	(0.0018)	
	3rd Mean Rainfall Quintile * % Cultivated Land				1.0038	(0.0017)	*
	4th Mean Rainfall Quintile * % Cultivated Land				1.0041	(0.0017)	*
	5th Mean Rainfall Quintile * % Cultivated Land				1.0007	(0.0018)	
	Constant	.0636	(0.0121)	***	.0650	(0.0125)	***
	Observations	244,887			244,887		

		Model 3		
Table 6A. Interaction with Parity		**OR**	**SE**	
Demographic Controls	Age	1.1190	(0.0070)	***
	Age squared	.9962	(0.0001)	***
Marital Status	Widowed/Separated/Divorced	1.7597	(0.0824)	***
	Married	6.4280	(0.2175)	***
Educational Attainment	< Secondary Education	1.0730	(0.0172)	***
	>= Secondary Education	1.0821	(0.0200)	***
	Rural	1.1296	(0.0187)	***
	Either Resp/Partner works in Agriculture	.9846	(0.0139)	
Parity Level	Parity 1	3.5362	(0.2117)	***
	Parity 2	3.2136	(0.2013)	***
	Parity 3	4.1074	(0.2610)	***
	Parity 4	4.8520	(0.3334)	***
	Parity 5	5.6410	(0.4271)	***
	Parity 6+	9.1399	(0.7019)	***
Household Wealth	Assets	.9211	(0.0097)	***
	Assets Relative to Cluster	1.0529	(0.0123)	***
	DHS Phase 2006-2009	.9799	(0.0195)	
	DHS Phase 2010-2014	.9046	(0.0162)	***
Mean Rainfall Quintiles	2nd Mean Rainfall Quintile	.9034	(0.0525)	
	3rd Mean Rainfall Quintile	.9388	(0.0566)	
	4th Mean Rainfall Quintile	.9625	(0.0592)	
	5th Mean Rainfall Quintile	1.0145	(0.0691)	
CoV Rainfall Quintiles	2nd CoV Rainfall Quintile	.9015	(0.0265)	***
	3rd CoV Rainfall Quintile	.8000	(0.0354)	***
	4th CoV Rainfall Quintile	.7383	(0.0442)	***
	5th CoV Rainfall Quintile	.7043	(0.0490)	***
Environmental Controls	Baseline Mean: Rain 1982 - 1997	1.000	(0.0000)	***
	Baseline Mean: Diurnal Temperature 1982 - 1997	.9993	(0.0002)	**
	Baseline CoV: Rain 1982 - 1997	.0043	(0.0047)	***
	Baseline CoV: Diurnal Temperature 1982 - 1997	5.0824	(6.9582)	
	Percent Cultivated Land Per Cluster	1.0020	(0.0007)	**
	Percent Grass/Shrub/Wood/Forestland Per Cluster	1.0006	(0.0006)	
	Soil Quality Per Cluster	.9613	(0.0077)	***
	Mean NDVI Per Cluster	.3497	(0.1050)	***
	Change in Mean Rainfall Relative to Baseline	1.000	(0.0000)	
Parity	2nd Mean Rainfall Quintile * Parity 1	1.1126	(0.0785)	
	2nd Mean Rainfall Quintile * Parity 2	1.2523	(0.0901)	**
	2nd Mean Rainfall Quintile * Parity 3	1.2389	(0.0896)	**
	2nd Mean Rainfall Quintile * Parity 4	1.1927	(0.0927)	*
	2nd Mean Rainfall Quintile * Parity 5	1.4457	(0.1217)	***
	2nd Mean Rainfall Quintile * Parity 6+	1.2427	(0.1045)	**
	3rd Mean Rainfall Quintile * Parity 1	1.0659	(0.0754)	
	3rd Mean Rainfall Quintile * Parity 2	1.2540	(0.0901)	**
	3rd Mean Rainfall Quintile * Parity 3	1.2103	(0.0886)	**
	3rd Mean Rainfall Quintile * Parity 4	1.2574	(0.0981)	**
	3rd Mean Rainfall Quintile * Parity 5	1.2545	(0.1069)	**
	3rd Mean Rainfall Quintile * Parity 6+	1.2385	(0.1034)	*
	4th Mean Rainfall Quintile * Parity 1	1.0725	(0.0749)	
	4th Mean Rainfall Quintile * Parity 2	1.2803	(0.0905)	***
	4th Mean Rainfall Quintile * Parity 3	1.2052	(0.0878)	*
	4th Mean Rainfall Quintile * Parity 4	1.2279	(0.0961)	**
	4th Mean Rainfall Quintile * Parity 5	1.2285	(0.1049)	*
	4th Mean Rainfall Quintile * Parity 6+	1.1860	(0.0992)	*
	5th Mean Rainfall Quintile * Parity 1	1.0796	(0.0769)	
	5th Mean Rainfall Quintile * Parity 2	1.2284	(0.0884)	**
	5th Mean Rainfall Quintile * Parity 3	1.1105	(0.0800)	
	5th Mean Rainfall Quintile * Parity 4	.9378	(0.0729)	
	5th Mean Rainfall Quintile * Parity 5	1.0210	(0.0865)	
	5th Mean Rainfall Quintile * Parity 6+	.9817	(0.0820)	
	Constant	.0722	(0.0139)	***
	Observations	244,887		