Exploring the linkages between fertility and climate in low fertility contexts: parity transitions in select Eastern European and Central Asian countries

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Abstract

Climate change is anticipated to increase rainfall and temperature variability and extremes across the planet. Researchers have begun to focus attention on the behavioral and biological health effects of climate change but research addressing behavioral and biological aspects of women's reproductive health and fertility in a context of climate change is extremely limited. This project uses an innovative combination of climate, livelihood, and population data to investigate births in different middle-income countries with different and uneven levels of development. Related population-environment research has historically focused only on wealthy countries or on the primarily high fertility countries in sub-Saharan Africa. We expand on this research focused on reproductive outcomes and climate through an examination of childbearing with a focus on parity progression and birth timing in communities where both contraception and abortion are widely available, culturally acceptable, and routinely used. The research demonstrates the use of climate variables to help explain seasonal trends or timing trends in childbearing; it also highlights the linkages between climate, livelihoods, and fertility, in middle income, lower fertility countries.

Introduction

Climate change is anticipated to increase rainfall and temperature variability and extremes across the planet. Although researchers have begun to focus attention on the behavioral and biological health effects of climate change - research focused on women's reproductive health and fertility outcomes is extremely limited (Grace 2017). Reproductive health and fertility reflect biological and behavioral responses to environmental conditions, including climate and weather, and can therefore be impacted in the short- or long-term by these contextual events. For example, households and communities that are dependent on rainfall for their livelihoods - to produce either agricultural products for consumption or income - are vulnerable to resource instability associated with climate change (Brown et al. 2014, Brown and Funk 2009). These households may therefore modify their fertility behaviors to avoid pregnancies (which might require costly doctor visits or hospital stays) during lean years or seasons. Alternatively, rainfall variability may increase food insecurity and increase physical labor demands which may result in an overall reduction in sperm quality or the biological ability of a woman to reproduce, reflecting a short-term biological response.

Other climate related examples occur in response to heat-waves or increased temperatures. Hotter temperatures may increase the risk of thermal stress, especially if people are increasing their physical labor to make-up for potential losses as temperatures increase (Call et al. 2017). Thermal-stress may impact either the biological or behavioral aspects of reproduction as they may modify a couples' sexual activity as well as their body's ability to reproduce (Lam and Miron 1996). Adding additional complexity, exposure to variable climate conditions has a heterogeneous impact on individuals depending on the household's or individual's ability to modify their behaviors or mitigate against the extreme events (Davenport et al. 2017). In other words, for households or communities without adequate infrastructure to limit individual exposures to extreme heat (through air conditioning, fans, etc.) or reduce vulnerability to inconsistent rainfall, exposure to weather variability may result in more significant impacts for certain members of a household or community.

In this paper we focus on short-term childbearing behaviors and outcomes in four climate sensitive countries -, Albania, Armenia, Moldova and Tajikistan. Specifically, we use event-history methods to focus on the conditions surrounding transitioning into first and later parities. Given that climate and weather may be related to either (or both) behaviors and biological conditions relating to childbearing, we separate our analyses of the transition to first birth (parity 1) from the transition to higher order births (second, third, and fourth births) because parity transitions are also related to biological and behavioral factors. To conduct this analysis we rely on recently collected reproductive health survey data from the Demographic and Health Surveys (DHS) for each country. We combine this data with high frequency rainfall data from the Climate Hazards Center (CHIRPS) and daily temperature data from the Global Dataset of Meteorological Forcings version 3 (Sheffield et al., 2006). Monthly rainfall and temperature summaries are combined with the spatial DHS data and the relationships between climate and individual conceptions are evaluated using event history models (Allison 1982) adjusting for covariates with established links to birth outcomes and pregnancy timings, including month, year, and place of conception.

Background

Climate extremes, like heatwaves, droughts or floods are expected to occur more frequently andwith more intensity and of greater duration in the near future (Kent et al. 2014, Meehl and Tebaldi 2004). Long- and short-term adverse health outcomes resulting from these kinds of events have been well documented (Kovats and Hajat 2008, Basu 2009, Isen et al. 2017, Strand 2011). Childbearing women and infants are uniquely vulnerable because the physiological demands of pregnancy and breastfeeding compound the effects of exposure to extreme events, like heatwaves (Basu 2016, Strand 2011, Lam and Miron 1996, Asamoah et al. 2018). Further, women and children living in disadvantaged households and communities face even greater challenges than their better-off counterparts because they have fewer resources to help mitigate against the effects of heat stress and climate extremes.

In addition to the varying impact of exposure timing and intensity, spatial variability in exposures must also be considered. In other words, we know from climate-health research that countries, regions within countries, and communities within regions experience and respond to climate and weather events in very different ways (Brown et al. 2015, Brown and Funk 2008, Husak and Grace 2016). The time it takes for a heat wave to induce electrical outages or tax local health systems, for example, varies depending on the level of development and the community's or country's experience with the event. Further, individuals within communities face differential risks depending on individual-level factors (Kudamatsu et al. 2012, Berry et al. 2018) and consequently respond in different ways. In other words, identifying human responses to climate and weather events depends on fine spatial scale detail – specifically community- and individual-level characteristics. It is therefore typical practice, and reflects the strategy that we will implement, to approach this type of analysis with a focus on relatively fine-scale climate and weather conditions and individual-level factors (Grace et al. 2016, Balk et al. 2005, de Sherbinin 2011, Shively 2017, Shively et al. 2015). In this project we focus on how individual-level fertility is impacted by variation in temperature and rainfall. We theorize that the links between these weather conditions and birth timing and spacing are related to individual-level behaviors and biological responses.

Behaviorally, couples or individuals may choose to avoid pregnancy or sexual activity during specific times of year because of the physical demands of harvest or weeding, for example (Grace 2017, Mosher 1979, Panter-Brick 1996, Pasternak 1978). Agriculturally-dependent households are unique because it is common to use family labor (all or partial) (Mukhopadhyay 1994); this means that the indirect costs of childbearing—i.e., opportunity costs of women related to substituting care for productive labor (Becker, 1981)—may increase if a higher demand for agricultural labor increases the value of women's time spent in productive labor. While there is a small body of recent research investigating how land use impacts the demand for children (Brauner-Otto and Axinn, 2017, Biddlecom et al. 2005, Ghimire and Axinn 2010), this research does not routinely incorporate weather or climate.

Household- and individual-level income or resource access are routinely considered in studies of MRCH. In rich countries, resource instability is associated with changes in fertility goals and fertility timing (Sobotka et al. 2013, Goldstein et al. 2013, Kreyenfeld et al. 2012). For poor people in poor countries, resources that are available to the household are uniquely dynamic because they are often strongly related to factors dependent on climate and weather - agricultural production, livestock or labor needs. Income levels can contribute to determining the resources available for children or can be related to the demand for children (Montgomery et al. 2000). Income and access to income can also relate to women's empowerment and agency in the household which may impact their fertility levels, contraceptive use or family size goals (Hogan et al. 1999, Upadhyay et al. 2014), as well as their capacity to access contraception and pre/post-natal health care (CITE).

From a perspective considering the value of children, we might expect that the demand for children may also increase when the need for children's labor in agricultural production increases (Caldwell 1976; Schultz 1973). Evidence to support this direction of relationship exists for Nepal (Brauner-Otto and Axinn, 2017; Biddlecom et al. 2005), but research on other settings is scarce. Whether this relationship is widespread is unclear, given that it relies on women and children having a very low status in society, where their labor is required for household subsistence (O'Neill, MacKellar, & Lutz, 2001; Biddlecom et al. 2005).

Proximate Determinants of Fertility

Building on the work of Davis and Blake (1956), Bongaarts (1978) established a foundational approach for examining fertility. These scholars suggested that fertility varied over time and space due to variations in the proximate determinants – fecundity (biological ability to reproduce), contraception (including induced abortion), conception/exposure (exposure to sex), and gestation (maintaining a pregnancy until a successful live birth). All women, no matter where or when they lived, must meet these conditions to produce a live birth. Distal determinants, they argued - including factors like education, income, women's empowerment, and a host of others - reflected social and cultural conditions that indirectly impacted fertility rates through their impact on the proximate determinants. Distal determinants have featured prominently in demographic research especially in wealthier countries.

Recent scholarship, however, echos earlier research that gave more weight to the proximate determinants. Results from this recent research indicates the potential importance of individual-level characteristics or exposures related to the proximate determinants in fertility outcomes – with attention to both short-term and long-term outcomes. Researchers suggest that individuals may modify their short-term behaviors relating to sexual activity or contraceptive use based on environmental conditions (Brauner-Otto 2014, Sassen and Weiden 2017) or that biological conditions supporting conception may be impacted by climate and weather conditions (Wilde et al. 2017, Barreca et al. 2018). This work moves beyond seasonal approaches to fertility because the questions are not focused on confirming that seasonality in births and conceptions exists, but rather aims to identify what aspects of climate and weather conditions, which may have been driving seasonal patterns in fertility, actually are associated with shifts in the proximate determinants.

Applying the proximate determinants, this research highlights how fecundity and sexual activity can be impacted by heat and rainfall, primarily through thermal stress, by nutritional constraints related to food insecurity, and by seasonal factors related to infectious disease. In our setting, with regard to precipitation, rainfall patterns may be associated with disease transmission or potentially with drinking water quality. In small-scale farming communities, like some of the communities under investigation in this analysis, where agricultural production and labor demands are heavily tied to rainfall, rainfall variability can serve as a measure of seasonal and annual variations in physical labor demands and food production or food availability (see Grace et al. 2015 and Brown et al. 2014). Nutritional status may also influence conceptions due to lactational infecundability related to the previous child as well as the duration of the fertile period in women. Individual fertility responses to climate variability and the associated failures in the food system or household food insecurity likely vary according to a variety of individual characteristics.

Heat and rainfall may also represent changes in time use (holidays), daily activities (physical labor) or life course developments (such as marriage) to the extent that measures of seasonality do not capture fine-scale differences across space that may be due to or correlated with weather. Marriages may also be put on hold during lean years in agricultural settings, which has the potential to lower the proportion of women in cohabiting unions and coital frequency. We would expect that factors such as the timing of marriage would be relevant mostly for conceptions leading to first parity transitions and not higher parity transitions in societies where non-marital childbearing is low.

In general, and based on prior research, we anticipate that more hot days or greater temperatures would be associated with fewer conceptions. In some settings we anticipate that an increase in rainfall variability would lead to a reduction in conceptions through the food insecurity or disease pathway. Higher rainfall variability may be associated with increased food insecurity or disease in some settings and these conditions are linked to increase risk of preterm birth and reduced likelihood of conception. Given that there is a great deal of heterogeneity in climate and the associated agricultural production, individuals and communities are expected to vary in terms of their vulnerabilities and responses. Individual-level analyses that consider multiple scales of influence are necessary for developing an improved understanding of the proximate determinants in both high fertility and low fertility countries. In summary, climate (heat and rainfall) may impact the proximate determinants of fertility and the nature of these effects can vary dramatically within a country and according to general livelihood strategies (this data will be discussed in the data section).

Setting

Tajikistan, Albania, Moldova and Armenia **were** state-socialist countries belonging to the former Eastern Bloc until the 1990s. This shared history includes universal health care and education as well as a command economy that extended to collectivized agricultural production (Lerman et al. 2004). After the fall of communism, the three countries maintained universal basic education and health care, but underwent radical privatization reforms (Lerman et al. 2004, Alcantara et al. 2013, Muller and Munroe 2008). Most relevant to climate issues is the privatization of agricultural production, which essentially ended national level collectivization and central planning of agricultural practices. Given the time periods covered by the data used in this project, we are able to observe the relationship between climate instability and fertility primarily during the period of private land ownership while in a context of relatively high educational attainment and accessible medical care.

Substantial variation exists among living conditions in the four countries we study; economically, Albania out-performs the other three and Tajikistan fares the worst. According to the 2016 Human Development Index (United Nations Development Program), Albania ranks highest (69th), in comparison to 84th in Armenia, 110th in Moldova and 127th in Tajikistan. These three countries are similar in terms of relatively low fertility levels, parity progression patterns (Billingsley & Duntava 2017), and agricultural dependence. They are all climate-sensitive countries in which the economy relies heavily on its agricultural sector and large shares of the population are engaged in agricultural labor: 41% of labor force in Albania, 36% in Armenia, 32% in Moldova, and 43% in Tajikistan (World Factbook 2019). Nevertheless, each country has its own unique demographic and cultural profile, as well as geographical, climate and agricultural characteristics. Our study benefits from these between-country differences because it allows us to observe women and children across varied weather and land use patterns to identify whether climate influences fertility consistently across different conditions as well as the ways in which they may be context specific.

Historically, Tajikistan, Albania, Moldova and Armenia share notable characteristics related to their formerly state socialist systems, which provides us with within-country change that is similar across our case studies. These include women's early integration into the labor force, universal basic education and health care, and collectivized agricultural production. After the fall of communism, the three countries all underwent radical privatization reforms that essentially put the fate of agricultural production in the hands of individual farmers, laborers and land-owners' hands (UNRISD 2002; Mathijs& Noev 2004; Gorton 2001).

Unique Aspects of the Setting for the Analysis

Tajikistan, Albania, Moldova, and Armenia also provide an important setting for expanding research of climate-fertility because of two unique aspects of their data 1) spatially referenced data from the time of conception and 2) high quality data on births and pregnancies with few missing values and details on induced versus spontaneous abortion. DHS data almost always includes a question related to length of time at current residence. This question allows us to match individuals to the climate or weather conditions at the time of conception through to the end of pregnancy and beyond. Outside of other DHS countries, data with this type of residency information is virtually non-existent for wealthier countries where place of conception information is rarely available at a country-level scale. Additionally, unlike in many other contexts with DHS data, pre-natal care, contraception, and abortion are wide-spread, culturally acceptable and often free of charge in these countries (AIC 2004; Institute of Statistics 2010; NCPM 2006), although induced abortion appears to be under-reported in the Albanian DHS. Similarly, education is widely available (mandatory) resulting in high rates of female literacy. These factors together result in data with extremely detailed pregnancy data that can be easily matched to relevant climate and weather data. Observing the link between climate and childbearing in a setting of high female literacy, fertility control/pre-natal care, therefore, allows us to investigate the ways that fertility and climate are related while considering a range of relevant individual and household characteristics.

Data

To conduct this analysis we rely on three different types of data - population/health survey data, climate data based on remote sensing, and livelihood data.

Population Data

The Demographic and Health Surveys (DHS) is the world's primary source of information on fertility, contraceptive use, infant and maternal health. While the DHS are generally considered cross-sectional data, they contain detailed information on the timing of births for each surveyed woman. We will maximize the longitudinal potential of the DHS by using this retrospective birth data to investigate the timing of births relative to different individual, community, and livelihood/climate characteristics. The DHS also collects Global Positioning System (GPS) coordinates for the DHS clusters - villages and towns where they collect data. There are approximately 20 households within a "cluster". Each rural cluster is shifted up to 5 km, with 1% shifted up to 10 km, to maintain confidentiality among respondents. We accommodate this random displacement by assuming that the cluster can be located anywhere within a 10 km radius of the provided latitude/longitude (DHS cites). We use all available DHS data for post-socialist countries that contain GPS information and information on the length of time at the current residence (this condition is required to ensure that environmental exposure is properly linked to each woman) - Moldova 2005; Albania 2017/18; Armenia 2015/16 and Tajikistan 2017.

Climate Data

To estimate agricultural production at the level of the rural DHS cluster, we use two recently developed datasets which provide high quality, fine-temporal scale, remotely sensed based estimates of temperature and precipitation. For **precipitation** we use the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset (Funk et al. 2014a). The CHIRPS data set, developed recently by USGS scientists in collaboration with Climate Hazards Group at University of California at Santa Barbara, combines a high resolution (0.05°) climatology (Funk et al. 2012; Funk et al. 2015) with time-varying station data and observations from geostationary weather satellites. In other words, this data relies on station data as well as high resolution remotely sensed data. CHIRPS is currently in use by USAID supported projects for monitoring and forecasting drought conditions in Africa and Central Asia (Funk et al. 2014).

The **temperature** dataset used in this analysis was developed by Sheffield et al. (2006). This dataset has been widely used in various global studies (Sheffield and Wood, 2008a, 2008b; Shukla et al., 2013) and also supports Princeton University's Africa Food and Drought Monitor. The National Center for Environmental Prediction's reanalysis (Kalnay et al., 1996; Kistler et al., 2001) derives the temperature data through a reanalysis process. This process requires a long record of global analyses of atmospheric and surface data, such as air temperature, radiations, wind speed, sea-level pressure and sea-surface temperature.

To generate temperature data as used in this analysis, Sheffield et al. first interpolated reanalysis air temperature from its native resolution of approximately 1.9° latitude × 1.875° longitude to a 2.0° regular grid while allowing for elevation related changes (Sheffield et al., 2006). These gridded data were then spatially downscaled to an 0.5° regular grid using bilinear interpolation with adjustments for change in the elevation. The monthly averaged temperature data was then corrected to match the monthly temperature values of the Climate Research Unit's 0.5° gridded temperature data (New et al., 1999, 2000). This step was undertaken to remove any bias in the temperature data that is inherent in reanalysis products. Finally, the daily values from the uncorrected temperature dataset were shifted so that the monthly values match the corrected monthly averages. This data has been used in a variety of applied health and demography studies and serves as the primary source of temperature data for poor countries (see also Davenport et al. 2017, Grace et al. 2015).

Livelihood Data

Because climate variables may impact people, communities or households differently depending on how people use the land, we include information on general livelihood strategies of a particular area. Additionally, because we do not have specific information on individual-level food production strategies or outputs, we must consider a slightly coarser spatial community-scale. These areas can be thought of as qualitative differentiations of the landscape into broad areas described by a general category of how most people in an area produce food or earn money (we call this a livelihood). Instead of using political boundaries to help contextualize our DHS clusters and climate variables, we rely on specific livelihood maps. These maps are constructed somewhat differently based on specific country needs but provide the same type of information on general livelihood strategies. Livelihood data and corresponding reports for Albania, Moldova, and Armenia come from the recent World Bank reports on climate change vulnerability and agriculture - Albania (Sutton et al., 2013a), Moldova (Sutton et al., 2013b), and Armenia (Sutton et al. 2013c). These reports provide detailed information on land use within each broad livelihood zone. They also provide information on land use before and after the transition, food insecurity, and climate sensitivities. Table 1 provides a summary of the environmental data that will be used in this study.

Table 1. Environmental datasets

Dataset	**Uses**	**Spatial Resolution**	**Temporal Resolution**	**Measure for use in analysis**
CHIRPS precipitation	Rainfall variability and associated disease or food insecurity	~5 km	Daily, monthly, 1981-present	Monthly totals; monthly standard deviations
Temperature - Sheffield reanalysis	Temperature variability, heatwaves	~25 km	Maximum temperature values, daily, 1981-present	Monthly mean of maximum values; count of days over 100F and 95F
World Bank Livelihood zones	Food and income acquisition; climate vulnerability	N/A	N/A	

Analysis

To analyze the transition to parenthood and higher parities, we approximate a piecewise constant event history model that is paired with monthly climate data by using discrete-time multilevel hazard analysis (Allison 1982; Barber et al. 2000). We use a logit specification that estimates the odds of having an event at a given age or time compared to having the event at a later time, conditional on the event not having occurred yet. This modeling approach allows us to include women who may not yet have experienced the event of interest by properly censoring these observations. It also allows us to consider the relevance of time-varying factors to the timing of parity transitions. For the first parity transition models age is used as the time-scale, whereas years since the previous birth reflects the baseline hazard for higher parity models.

Because we are matching climate data to place of residency and we do not have detailed migration histories, we observe women only as far back in time as January after the year they moved to their current residence. This means that some births may be unobserved and women enter the sample for whichever parity they have reached at the time of moving to the current location. In other words, some women's parity transitions are left-censored and therefore unobserved. For the first parity transition models, we begin observing women when they reach age 16 or move to the current location if they had not yet had a first child until they enter parenthood or they were interviewed. For the higher parity transition models, women are observed from the month of the previous birth until they have another child or are interviewed. We pool together all higher parity transitions as we assume climate does not relate to second, third and fourth parity transitions differently.

As common in parity transition research, we pre-date the birth to the conception period (birth – 9 months) to be sure that relevant factors are tied to climate factors and decision making at the time of conception and not at childbirth. Studying parity transitions instead of all pregnancies that ever occur mean we do not observe pregnancies that ended in a non-live birth due to abortion, miscarriage or stillbirth. These outcomes are also potentially linked to climate and require a different analytical approach, where the unit of analysis is the pregnancy.

We adjust for non-independence of observations in different ways, depending on the sample. Because women are nested within geographical clusters, we adjust the standard errors to account for the potential that women within the same cluster are more similar than when comparing across clusters. We additionally explore random and fixed effects specification to address this clustering, which allows the intercept to vary across locations (Rabe-Hesketh & Skrondal 2012, Gelman and Hill 2004).

The first parity transition sample includes only childless women and observes only one event, the higher parity transition model includes women's exposure to different parity events multiple times and we therefore adjust for unobserved heterogeneity (clustering) even more closely than at the cluster level. We explore adjusting standard errors at the lady-level as well as fixed effects models. For random-effects models, odds ratios indicate within- and between-zone correlations and are interpreted as the average influence of an independent variable as it changes across individuals and between zones. For fixed effects models, odds ratios are estimated on the basis of only within-woman variation and are interpreted as the average influence of an independent variable as it changes across a woman's observations.

Each observation in our data represents a person/month. The value of several independent variables change on a monthly basis, including climate variables. Odds ratios reflect the combined influence of how quickly the event of interest occurred and whether it ever occurred. To observe birth timing and spacing more closely, we interact our key climate variables with the time scale in each model.

Measures

We include standard individual level controls - age (time varying), educational attainment, still in education, month of the year and year. Month is included to capture seasonal factors and year dummies are included to capture period effects associated with secular trends in fertility rates, as well as to capture the political transition from socialist to post-socialist economies and periods of economic crisis at the national level. Additionally, we include monthly rainfall total, monthly variability (standard deviation), daily maximum temperatures averaged monthly, and monthly counts of number of days above both 95F and 100F (biologically relevant thresholds used to capture heatwaves).

Tables 2 and 3 present sample sizes for Albania and Tajikistan for the different parity samples as well as the share that experienced specific parity transitions, time periods under observation and birth cohorts included. The sample sizes are very similar for the two countries: both are slightly under 10,000 for the transition to parenthood and almost 7000 for higher parity transition analyses. Women were all born 1967 or later with the range of the youngest including the 1998-

2001 birth cohorts. A slightly lower share of Albanian women entered parenthood in the observation window, which is in line with the greater postponement of childbearing in Albania.

Table 2. Sample characteristics for analysis of parity one transition, censored at time of conception

	Number of women	Share experienced first birth	Number of observations	Time period	Birth cohorts
Albania	9171	64%	743,588	1982-2016	1967-2000
Tajikistan	9142	73%	602,855	1983-2016	1967-2000

Table 3. Sample characteristics for analysis of second to fourth parity transitions, censored at time of conception

	Number of women	Share experienced 2nd birth	Share experienced 3rd birth	Share experienced 4th birth	Number of observations	Time period	Birth cohorts
Albania	6837	74%	32%	4%	1,007,033	1981-2016	1967-2001
Tajikistan	6877	70%	49%	14%	691,472	1986-2016	1967-1998

Results

We first organize the results by country and then within country by parity transition category. The transition from no children to one child reflects a transition into parenthood that we treat separately from transitions from one or more child to the subsequent child.

Albania

In Albania, the wealthiest of all of the countries in our sample and where temperature should have an impact on birth outcomes more than rainfall, we expect to see higher temperatures associated with fewer conceptions of any parity. We do not anticipate that a rainfall linkage will have a significant impact on births or conceptions.

The results (Table 4) indicate that when the mean of the temperature daily maximum values is higher, we see an increase in the odds of first conceptions ($p<0.05$). No additional relationships demonstrated a statistically significant result.

Tajikistan

Tajikistan is the poorest country in our sample and the country with the greatest dependence on local agricultural production for livelihood stability. Here, we anticipate significant positive impacts related to rainfall variability - which may have negative impacts on crop production and therefore impact biological aspects of reproduction.

For the transition from 0 to 1, after adjusting for all the covariates listed above, total precipitation is negatively related to conceptions (p<0.05). This indicates that high precipitation levels either delay or reduce the conceptions that lead to live births. The mean of the daily temperature maximum values are positively related to conceptions (p<.0.05), indicating that an increase in temperature leads to an increase in conceptions, even after the month or place of residence or individual-level factors are considered.

The transition from parities above 1 through parity 4, indicate that the mean of the maximum daily temperature has a negative relationship with these higher order conceptions (p<0.05). Again, these results are significant even after accounting for a range of individual factors as well as month and place of residence.

When estimating these models with mother-fixed effects, in essence comparing only the climate and weather characteristics within a woman's set of observations and including only those women who have given birth to at least a second child, the relationships were no longer statistically significant.

Table 4. Selected results from discrete-time hazard analyses, odds ratios

	Temp. max mean	Hot days: 100	Hot days: 95	Precip. total	Precip. Stdv
Albania					
Parity 0 to 1	1.017*	1.025	1.008	0.999	0.999
Parity 1 to 4	0.999	0.967	0.989	1.000	1.001
FE: Parity 1 to 4	0.998	0.965	0.987	1.000	1.001
Tajikistan					
Parity 0 to 1	1.008*	0.991	0.995	0.999*	0.998
Parity 1 to 4	0.992**	0.997	0.997	1.000	1.005*
FE: Parity 1 to 4	0.993	0.998	0.998	0.999	1.003

Note: ** = p<0.01, * = p<0.05. Odds ratios adjusted for month, year, urban/rural residence, region, educational level, and still in education. Parity 0 to 1 analyses additionally adjust for age, whereas parity 1 to 4 analyses additionally adjust for parity, age at previous birth and years since previous birth.

The results thus far reflect an average effect of climate components over both urban and rural as well as varying livelihood zones. We explored whether climate was related to conceptions differentially across these diverse contexts. Interactions with climate and urban/rural areas only provided improved or similar model fits for Tajikistan and livelihood zones are not yet available for Albania, we therefore do not explore Albania further. The interactions presented here improve the model fit and are largely robust to fixed effects specifications.

Figure 1 displays the predictive margins of conception across the range of temperatures that occurred in our data and their interaction with residence. The X-axis reflects the range of values in our data. Temperature appeared to matter less for the timing of parenthood for women living in rural areas than urban areas. Whereas the predictive margins for urban women were lower than they were for rural women across the majority of the temperature spectrum, reflecting a later age overall at the timing of parenthood, they quickly surpassed rural women at temperatures over 25. Figure 2 similarly shows a difference in how climate interacts with conception depending on whether the woman lives in an urban or rural area. As precipitation moves further from the mean, rural women are more likely to enter parenthood, whereas urban women are less likely to. Because this pattern is largely similar for precipitation total, we interpret this as more rainfall than the average and not less.

Figure 1. Predictive margins of first conception leading to a live birth for women in Tajikistan living in urban and rural areas at different temperature max means

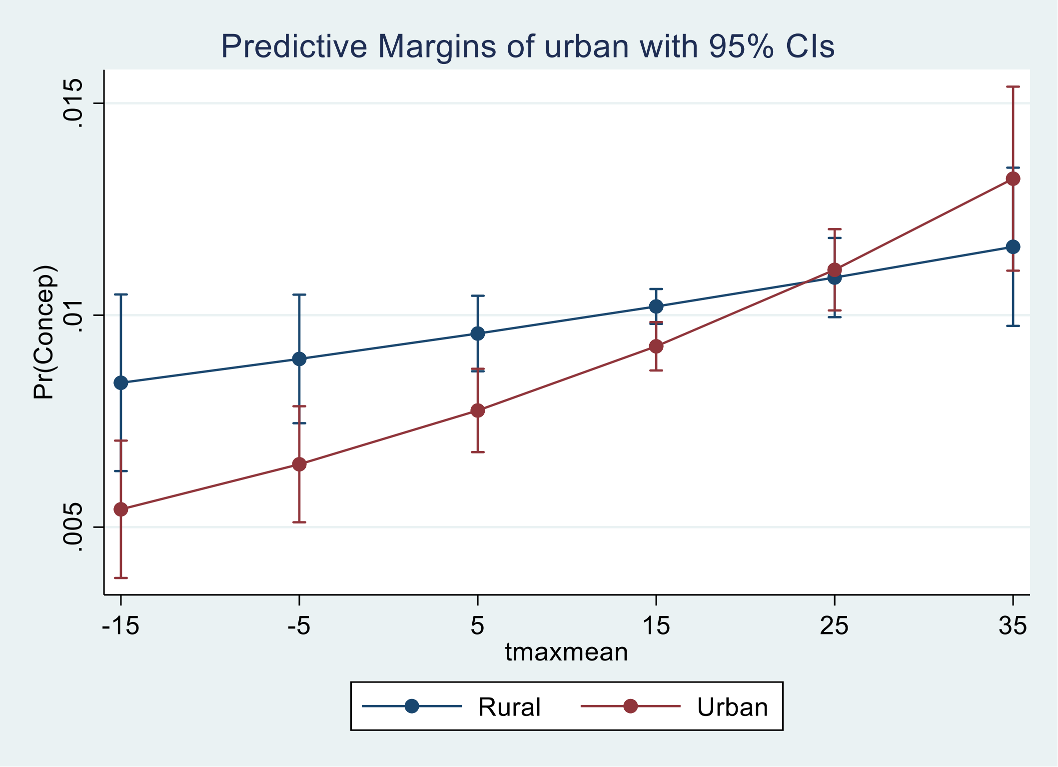
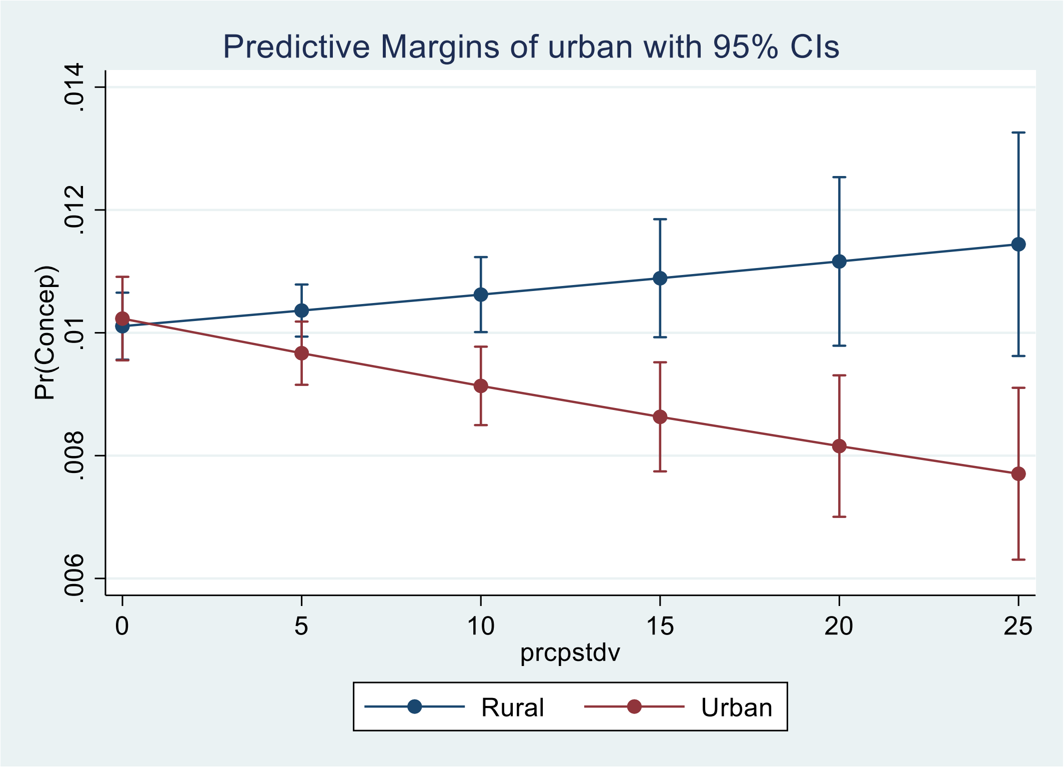


Figure 2. Predictive margins of first conception leading to a live birth for women in Tajikistan living in urban and rural areas according to the standard deviation of precipitation



For parity transitions 1 to 4, we find exactly the opposite patterns. First, conceptions in rural areas are more related to climate factors than in urban areas. Climate appears to matter very little for women living in urban areas who are at risk of having a second, third or fourth child. Second, temperature is negatively linked to higher parity transitions instead of positively. We do see some positive increase of conceptions in urban areas in relation to the number of hot days over 95 in Figure 4, however, and the predictive margins for higher parity conceptions become lower for rural women at the highest recorded number of hot days. Third, precipitation and predictive margins of conception increase together.

Figure 3. Predictive margins of second to fourth conceptions leading to a live birth for women in Tajikistan living in urban and rural areas at different temperature max means

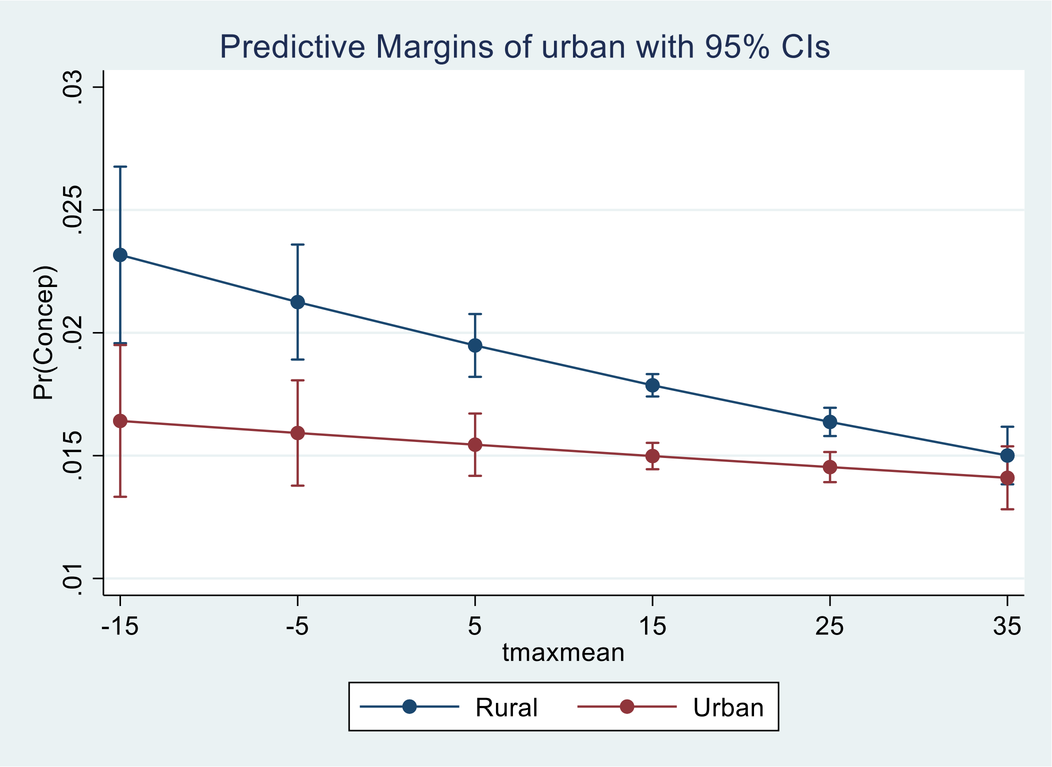


Figure 4. Predictive margins of second to fourth conceptions leading to a live birth for women in Tajikistan living in urban and rural areas according to the number of hot days over 95

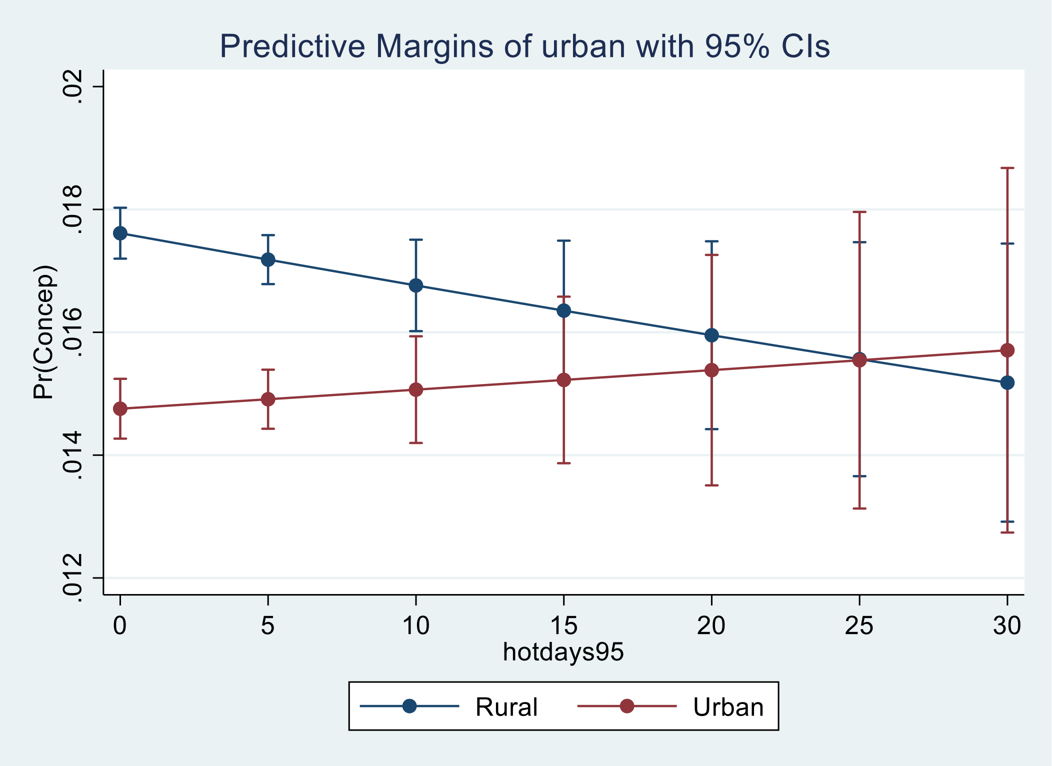
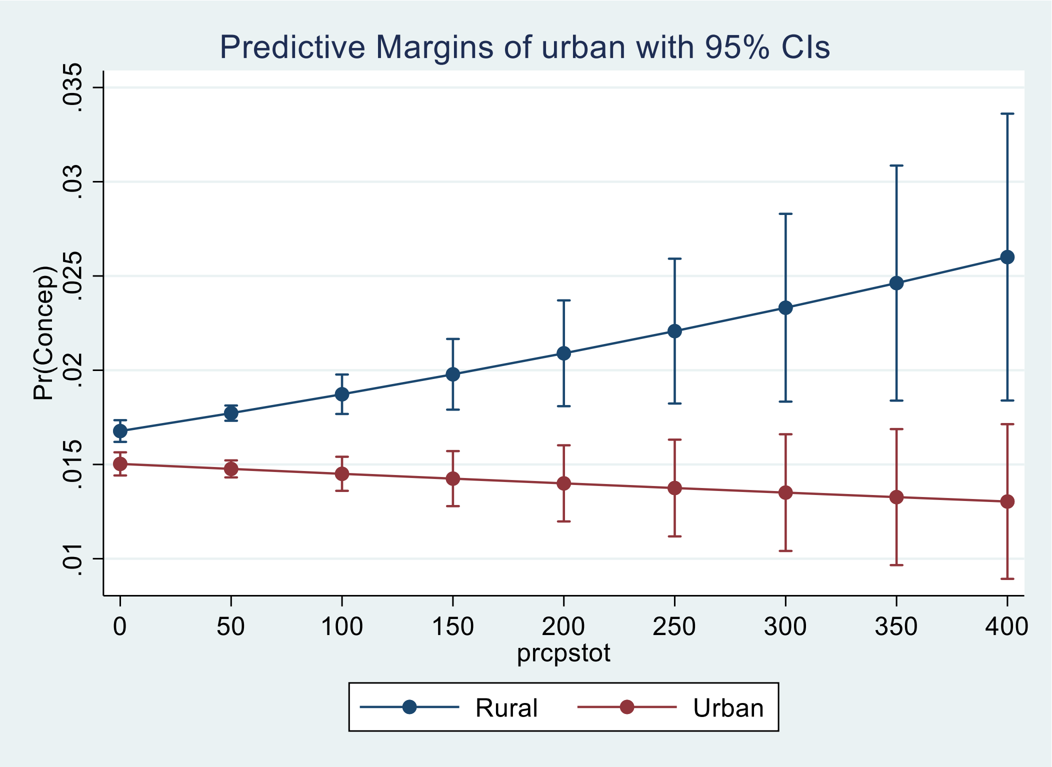


Figure 5. Predictive margins of second to fourth conceptions leading to a live birth for women in Tajikistan living in urban and rural areas according to the precipitation total



We also assessed parity transition differences across livelihood zones for Tajikistan as well as how climate may be related differently depending on the nature of the environment and common livelihoods. Table 5 shows that the average differences in first conception by livelihood zones; only in agricultural zones that are not designated as irrigated or rainfed are the odds of first conception higher than in urban and peri-urban zones. This difference is most likely related to earlier first births rather than less childlessness. The odds of first conceptions are very low, on the other hand, in migratory work zones. In contrast, we see that the odds of higher parity conceptions are greater in a few different zones, relative to urban areas. This is in line with higher overall fertility rates in rural areas than urban.

Table 5. Odds ratios of conception at different parities related to livelihood zones in Tajikistan

	Parity 0 to 1	Parity 1 to 4
Urban and peri-urban	1	1
Irrigated zones	0.979	1.235***
Livestock zones	0.957	1.327***
Rainfed zones	1.097	0.976
Agro-pastoral zones	0.930	1.351***

Agriculture other	1.100*	1.299***
Migrant work zone	0.645***	1.038

Note: *** = p<0.001, ** = p<0.01, * = p<0.05. Odds ratios are adjusted for month, year, urban/rural residence, region, educational level, and still in education. Parity 0 to 1 analyses additionally adjust for age, whereas parity 1 to 4 analyses additionally adjust for parity, age at previous birth and years since previous birth.
Urban is all areas designated urban as well as the Khatlon Agro-Industrial Peri-urban Zone.

Irrigated zones include Rasht Valley Irrigated Potato Zone and Western Pamir Irrigated Agriculture Zone.

Livestock zones include Eastern Pamir Plateau Livestock Zone and Khatlon Rainfed Wheat and Livestock Zone.

Rainfed zones include Ghonchi and Istaravshan Rainfed Cereal, Fruit, and Vegetable Zone.
Agro-pastoral zones include Eastern and Central Zeravshan Valley Agro-Pastoral Zone and Khatlon Mountain Agro-Pastoral Zone.
Agriculture other zones include Southern Khatlon Cotton, Vegetable and Wheat Zone; North Sughd Agro-Industrial Zone; Panjakent Rice, Fruit and Vegetable Zone; and Central and Eastern Tajikistan Agro-Industrial Zone.

Migrant work zones include Western Pamir Valley Migratory Work Zone.

How climate interacts with the local environment and the way it shapes factors related to conception may be more clearly evident when looking specifically at variation across livelihood zones. We therefore interacted climate indicators with the livelihood zones and predicted the margins of conception. Many patterns related to first conceptions are similar but the notable differences we uncovered were that very hot days (Fig. 6) suppress first conceptions the most in areas dependent on rain for agriculture (rainfed zones). First conceptions were also lower for zones that rely on irrigation for agriculture. Interestingly, the pattern seems to be that any hot days at all, even as few as five days, create a substantial difference in first conceptions between these two zones and the urban areas and this difference does not continue to grow with an increasing number of hot days but rather stabilizes.

Figure 7 shows a different pattern, whereby no differences by total precipitation appear at all between the zones except for those with livestock. Here we see an upward curve in predictive margins of first conceptions that pulls away from predicted conceptions in all the other zones. This seems to indicate better conditions brought about by rain where livelihoods are heavily dependent on livestock.

Figure 6. Predictive margins of first conception leading to a live birth for women living in different livelihood zones in Tajikistan according to the number of hot days over 100F

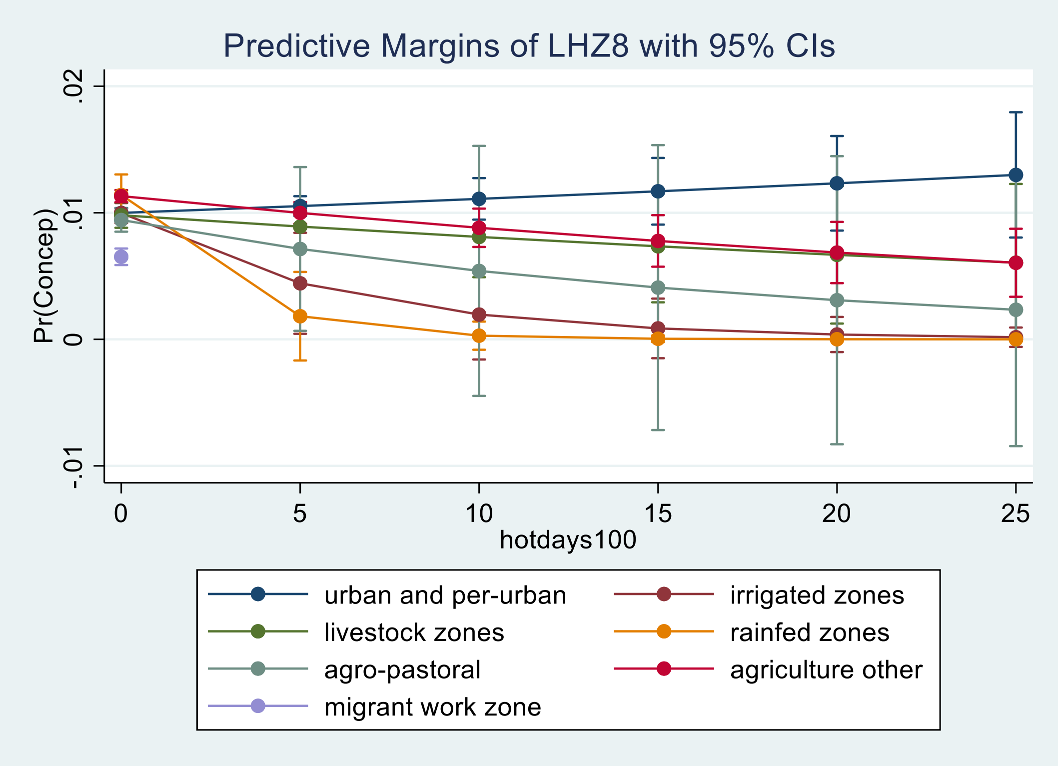
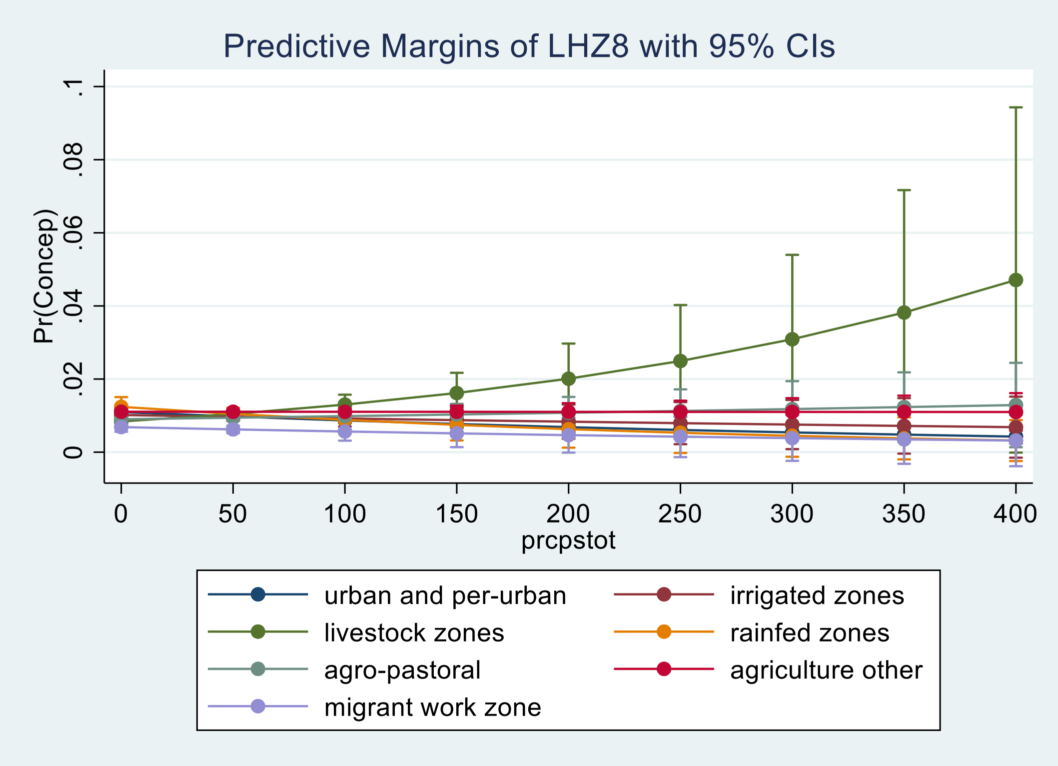
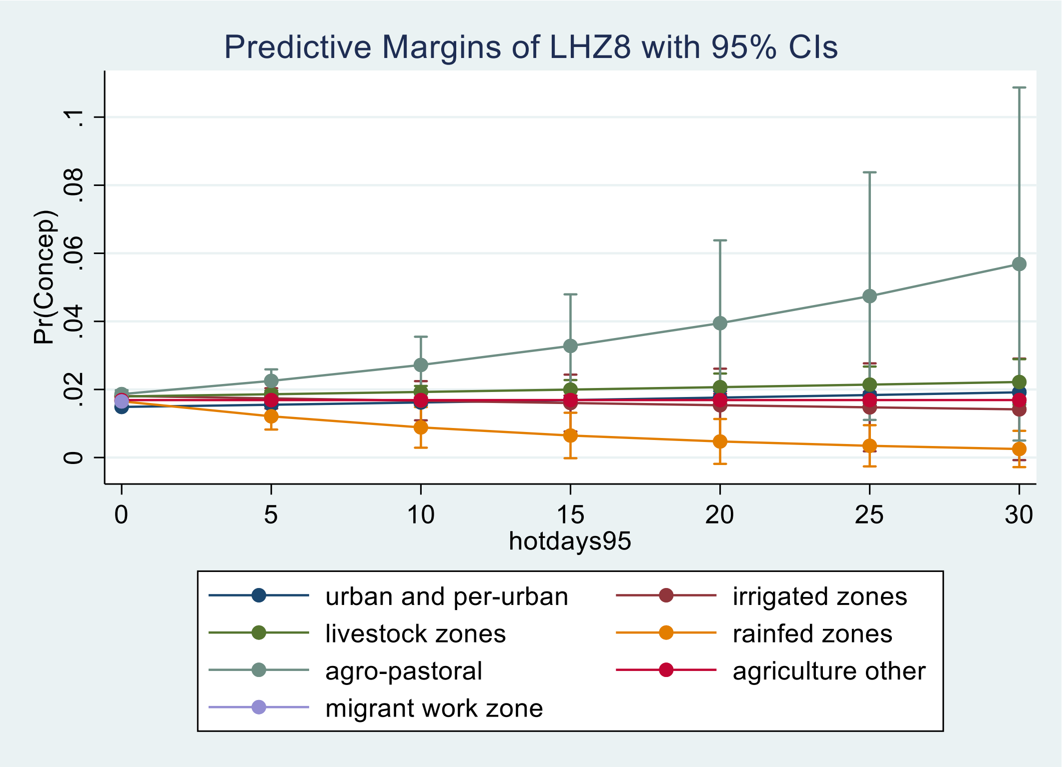


Figure 7. Predictive margins of first conception leading to a live birth for women living in different livelihood zones in Tajikistan according to the total precipitation



Higher parity transitions showed a different interaction of livelihood zones and climate. For most zones, including urban and peri-urban we do not find a difference in higher parity conceptions when the number of days over 95F increases. For rainfed agricultural areas, however, conceptions declined slightly with heat. In contrast, the slope for agro-pastoral areas turn upwards as the number of hot days increases. No other predictive margins for conceptions differed substantially across zones according to climate, although we begin to see some dispersion at higher precipitation.

Figure 7. Predictive margins of first conception leading to a live birth for women living in different livelihood zones in Tajikistan according to the number of hot days over 95F



Discussion

We set out to explore how climate matters to parity transitions in contexts that are dependent on climate extensively, but to varying degrees, for the economic stability of a substantial portion of the labor market. Both livelihoods and individuals' health are at stake in agriculturally intense economies due to climate instability because of more intense physical exposure to weather and more reliance on predictability and stability for agriculture. A main finding in this study is that the link between climate and fertility is not generalizable across countries. We find very little influence of climate on parity transitions in Albania, which is the wealthiest country in the study. Whether wealth moderates the mechanisms linking climate to fertility or whether the relationship is dependent on more idiosyncratic factors such as the specific crops or livestock supported in rural areas is an open question that requires more comparative research.

We found that very different patterns appear for conceptions related to entering parenthood and conceptions related to family expansion. One possible reason for opposite trends is that in countries with low non-marital childbearing, first conceptions are more linked to the timing of marriage. We found that the seasonality urban women's conceptions is more concentrated in months with warmer temperatures and less rain, which coincides with the timing of marriage form women in urban areas as well. In contrast, weather is not linked to urban women's higher parity conceptions. Rather, we find what we expected to see: rural women's conceptions are linked to weather, whereby heat delays conceptions and rain increases conceptions.

The proximate determinants framework used to analyze fertility identifies both biological (fecundity) and behavioral (sexual activity) aspects of reproduction that related literature suggests may be impacted by contextual and environmental factors related to climate and weather variation. Behavioral theories of fertility suggest that women or conjugal couples may choose to avoid births at inopportune or stressful and traumatic times – economic downturns, droughts, floods, conflict. These events can be either short term and result in relatively short delays or they can characterize longer periods of time and result in an overall change in completed fertility. And while these events can be experienced as catastrophes at a macro-level, in agriculturally dependent areas, the experiences with drought, sub-par growing conditions and household resource instability are often experienced at a much more local, community or household level. Related research in poor countries with low rates of contraceptive prevalence demonstrates that in communities dependent on agricultural production for the procurement of food and money, climatic variability - which can result in "boom" agricultural years for households, serious food shortages or less extreme food rationing - has both short- or long-term impacts on the quantum and tempo of fertility.

This research has further demonstrated that there are major differences in individual responses according to individual characteristics as well as reflecting the way the individual interacts with the community conditions. In other words, behavioral responses reflect individual characteristics, context and interactions between the individual and the context. In climatically sensitive and agriculturally dependent Albania, Armenia, Moldova, and Tajikistan, where contraception is widespread, the ways that women and couples space or delay conceptions or pregnancies is not well understood. Additionally, how these experiences are shaped by context and the variability in fertility behaviors within different context is also rarely examined in these countries.

This analysis is focused on conceptions that occurred after the fall of the Soviet Union. However, the impacts of a dramatically changing social and economic systems may have persisted in patterns of development and urbanization, an important consideration is related to the decline in the agricultural sector during the 1990s. As the service sector developed and individuals became freer to choose their occupations, urbanization occurred and fewer individuals continued to work in agriculture. This means that there may be substantial compositional differences in the people working and living in rural areas before and after the transition to a market economy. Our results indicate that there is a significant difference in the ways that climate and weather impact rural versus urban individuals – this result may reflect livelihood strategies and exposures, but it may also reflect broader social processes related to the compositional differences in these different areas.