Droughts and Gender Bias in Infant Mortality in Sub-Saharan Africa

By Martin Flatø*and Andreas Kotsadam‡

4th April 2014

Abstract

Are African girls more exposed than boys to risk of infant mortality during crises and if so, is the difference due to discrimination? To answer these questions, we combine retrospective fertility data on over 1.5 million births from Demographic and Health Surveys with data on rainfall variability and find a substantial gender difference favouring boys following droughts. We substantiate that this difference has social determinants by showing that the difference is only present in contexts in which we would expect discrimination of daughters. The difference is only present in communities with strong preferences for sons and in areas where fertility desires are low. In areas with low levels of female employment there is a large gender gap following droughts, especially for infants with mothers who are not working. In contrast, there is no gender difference in infant mortality after droughts in areas where many women work, irrespective of the employment status of the individual mother under consideration. As communities with strong son preferences, low fertility preferences, and low female employment display gender bias after crises also in Africa, the results are consistent with these factors explaining differences in gender biases between countries across the world.

Keywords: Rainfall, Drought, Gender, Infant mortality, Africa
JEL: I15, J13, J16, O55, Q54

*Department of Economics, University of Oslo, e-mail: martin.flato@econ.uio.no
†Department of Economics, University of Oslo, e-mail: andreas.kotsadam@econ.uio.no
‡Acknowledgments: The paper has benefited from comments by conference participants at Lund University's research school in economic demography. We would like to thank Henning Finseraas, Øystein Kravdal, Masayuki Kudamatsu and Viggo Nordvik for helpful comments. The project is part of the research activities at the Centre for the Study of Equality, Social Organization, and Performance (ESOP) at the Department of Economics, University of Oslo. ESOP is supported by the Research Council of Norway.

1 Introduction

Intra-household allocation of resources, and particularly factors that determine differential investments in female and male offspring, is an important topic in economics (e.g. Becker 1981; Björkman-Nyqvist 2013; Duflo 2012) and demography (Hill and Upchurch 1995; Riley 2005). Sub-Saharan Africa is characterised by a large female advantage in infant mortality (Anderson and Ray, 2010) and lack of systematic differences in breastfeeding and health-seeking behaviour for male and female infants (Garenne, 2003). Still, Friedman and Schady (2012) find that aggregate economic shocks increase infant mortality more for girls than for boys in Sub-Saharan Africa. Little is known about the mechanisms behind this difference in mortality, although such an understanding is critical to designing effective policies (Friedman and Schady, 2012). In this paper, we use exogenous income variation to study how income shocks affect gender differences in infant mortality and we test well established theories on factors shaping that relationship.

Several studies find that differential treatment of girls and boys is more prevalent when households face extreme circumstances such as illness or loss of income than in everyday life (Duflo, 2012). Rose (1999) finds that excess mortality of girls in India is highest in periods of drought. Excess female mortality in periods of crisis at the macro level also seems to be present in Africa as shown by Friedman and Schady (2012). Aggregate growth rate fluctuations are, however, likely to be endogenous with respect to infant mortality since a number of variables that affect both economic growth and infant mortality are omitted in the analysis, e.g. health care policies, institutions and political stability. For example, female political participation is shown to reduce infant mortality using historical data from the U.S. (Miller, 2008) and is also correlated with higher growth (Duflo, 2012). We instead use variation in rainfall to identify effects of droughts on gender differences in infant mortality. As African communities mostly rely on rain-fed agriculture, droughts induce severe income shocks that may affect both consumption and time use with implications for infant survival in the household. The shocks are defined as unusually low or high precipitation relative to what is normally experienced in a particular location. With spatial and temporal correlations controlled for, this measure is unrelated to potential confounders.

The use of rainfall to investigate gender bias in African mortality is not without precedence. Miguel (2005) finds that murders of old women by their relatives double in rural Tanzania in periods with droughts or floods, and Neumayer and Plumper (2007) find that female life expectancy is more affected than male life expectancy by droughts and famines in developing countries. On the other hand, Kudamatsu et al. (2012) do not find a robust gender difference in the effect of droughts during the last two seasons before birth on infant mortality in Africa.

The inconsistent findings of these previous studies call for a thorough investigation into the presence and social determinants of gender differences in infant mortality during crises in Sub-Saharan Africa, which is the focus of the present paper. We combine rainfall data with retrospective fertility data for more than 1.5 million births from 68 Demographic and Health Surveys (DHS) to study whether droughts cause gender differences in infant mortality in Sub-Saharan Africa.

Although droughts are exogenous shocks that affect infants through changes in household income, it is important to also note the possible presence of other channels. First and foremost, droughts reduce the prevalence of water- and vector-borne diseases, which is likely to benefit infant survival and more so for boys (Confalonieri et al., 2007; Rabassa et al., 2012). Secondly, gender-specific selection into birth may also play a role as preconception and prenatal factors influence sex ratios at birth (Pongou, 2013). The presence and size of these factors are analysed and discussed.

Noting these channels, we make use of the large variation in our data to substantiate whether the gender difference observed could be the result of a bias in household priorities favouring boys. To determine whether gender discrimination during crises differs along relevant characteristics is furthermore important to gain a better understanding of the phenomenon, as well as for policy. In particular, we focus on employment, education and preferences for sons and childbearing, as contextual variables that are believed to be important in moderating whether droughts create a gender bias in infant mortality.

We find that droughts cause significantly higher female infant mortality than male infant mortality. The contextual analysis supports the proposition that social factors play an important role as we only find a gender bias in areas where the level of son preference is higher and desired fertility rates are low. We also find that the effect is larger for non-working women and in locations where female labour force participation is low, but we do not find different effects by level of education. Taken together, the results suggest that there is substantial gender bias in the effects of droughts on infant mortality.

Extreme weather is likely to become more prevalent in Africa in the future due to climate change (Boko et al., 2007). Reducing households' vulnerability to rainfall shocks and enabling households and communities to cope with income insecurity are therefore major focus areas for development policies. The special vulnerability of young girls during crises should be taken into account in the assessment of such policies. For effective interventions, there is a need for both an understanding of the extent to which crises increase gender differences in mortality and of the conditions under which this occurs. This study contributes to this end. It also sheds light on which factors are important for the exceptionally low levels of gender discrimination in infant mortality in the sub-continent and whether this exceptionalism is likely to hold in the future. Our results are consistent both with theories arguing that discrimination between infants and at birth is relatively rare in Africa due to a high level of female employment (Sen, 1990), and theories arguing that parts of Africa with strong son preferences will catch up with Asian levels of discrimination when exposed to increased pressure to limit family size and/or technological access (Bongaarts, 2013).

2 How droughts affect infant mortality

It is not obvious that rainfall and income shocks affect infant mortality. Kudamatsu et al. (2012) do not find a robust effect of droughts during the last two seasons before birth on infant mortality in Africa. Friedman and Schady (2012) find that a reduction in GDP per capita increases infant mortality for girls, but they do not find a significant effect for boys. Similarly, Harttgen et al. (2013) find that economic growth has improved levels of stunting among children under age five in Sub-Saharan Africa, but that the magnitude has been very small. Working with historic European data, Oris et al. (2004) do not find effects of cereal prices and real wage fluctuations on mortality of infants under six months. Still, we argue in this section that droughts may increase infant mortality by affecting constraints on consumption and time usage, and reduce infant mortality through effects on the disease environment. It is these constraints that may lead to a gender bias if the survival of female and male infants is differentially prioritised during lean times, and diseases may also affect male and female infants differently. We therefore review the literature on how droughts and income shocks may affect infant mortality at different stages of inuterine and infant development, as the theories of causality differ according to gestational and postnatal age.

Droughts affect the yield of farmers, reducing their income, increasing food prices, reducing the nutritional quality of the food produced and negatively affecting the local economy (Haile, 2005). With incomplete consumption smoothing, the subsequent consumption shocks may lead to maternal and infant malnutrition. Maternal malnutrition during the last two trimesters of pregnancy causes low birthweight, which is an important determinant of infant mortality and morbidity (Strauss and Dietz, 1999). Thereafter, maternal undernutrition has little effect on the volume and composition of breast milk unless malnutrition is severe, although the concentration of micronutrients (particularly vitamin A) may be affected and cause infant depletion (Black et al., 2008; Alien, 1994). The fraction exclusively breastfeeding for the recommended six months is as low as 20 % in Western and Central Africa and 41 % in Eastern and Southern Africa, although the rates sharply increased through the 1990s (UNICEF, 2006). This gives additional importance to the nutritional value of complementary food for infant mortality, which is particularly poor in Sub-Saharan Africa and is more than ever in the life cycle important for infants as their rapid development implies very high nutritional requirements (Lartey, 2008; Dewey, 2003).

In a study using data from Colombia, Miller and Urdinola (2010:116) argue that in developing countries, 'the most important determinants of child health are inexpensive but require large amounts of time (e.g. bringing pure water from distant sources, practicing good hygiene, and travelling to distant facilities for free preventive and primary health services)'. Kim (2010) also finds that the opportunity cost of time matters for infant survival in West Africa. In particular, Kim (2010) finds that positive rainfall shocks increase mortality for children born in the rainy season, which she attributes to increased opportunity costs of labour when yields are high, resulting in less breastfeeding. This could imply that in a year with low yields, mothers work less and more infants survive. However, commonly found coping strategies after droughts are both to diversify into non-agricultural work and to increase the workload of less productive family members (Haile, 2005). It may also be the case that the same tasks are more laborious during droughts. For example, women might have to walk farther to fetch water. Distress factors, illness and exhaustion may also reduce child care efforts even if time allocated to labour declines. A particularly dramatic effect of drought is expected if time constraints result in earlier termination of breastfeeding (Black et al., 2008). A final income effect is that income shocks may lead to less health-seeking behaviour if the infant gets ill, as the practices may be expensive and/or time consuming.

Both Rabassa et al. (2012), who study the effect of droughts on child health in Nigeria, and Henry and Santos (2013), who considered rainfall and child mortality in Burkina Faso and Mali, discuss the effect of rainfall on the disease environment as a possible confounding factor. More rainfall in developing countries is typically linked to higher incidence of important water- and vector-borne diseases (Confalonieri et al., 2007). Water scarcity during dry seasons in Sub-Saharan Africa is however associated with higher prevalence of diarrhoea due to increased consumption of unsafe water and reduced hygiene practices (Bandyopadhyay et al., 2012), yet there is no conclusive evidence that this also holds in the rainy season which we consider. The large female advantage in infant mortality in Africa is linked to the high burden of communicable diseases, mainly because male infants have weaker immune systems (Hill and Upchurch, 1995; Waldron, 1998). If more rainfall increases the burden of diseases, droughts may reduce the infant mortality rates for both sexes, yet more so for males than for females.

A final channel is that droughts may affect sex ratios at birth by affecting the occurrance of miscarriages and factors in the preconception environment, and that such gender-specific selection may thereafter affect sex ratios in infant mortality (Pongou, 2013). We rule out that our results are driven by this mechanism as we do not find any difference in sex ratios at birth between the drought-affected and the control group (results available upon request).

3 How context matters

From the previous section, we are left with two factors that might explain a gender difference in infant mortality following droughts: one operating through less diseases and another through household priorities. If the difference is the result of discrimination, it should be larger for mothers and communities that we would expect to discriminate. We are also interested in whether a shock affects girls' survival in one type of household or community and not in another as such heterogeneity would provide us with a better understanding of crises and gender relations in Africa.[1]

Economists often focus on underlying economic conditions in explaining within household gender discrimination (e.g. Becker 1981; Björkman-Nyqvist2013). Rosenzweig and Schultz (1982) show that less resources are allocated to girls than to boys in areas of India where the female disadvantage in adult earnings potential (as proxied by levels of female employment) are largest. In an influential global accounting exercise regarding the number of 'missing women', Sen (1990) used the high participation of women engaged in work perceived as gainful to explain why the ratio of women to men is not as low in Sub-Saharan Africa as in India or China. Similarly, Qian (2008) found that increasing female income in China improves survival rates for girls. Female labour participation may be correlated with gender-specific survival for several reasons that are likely to operate at both the individual and contextual level. At the individual level, working mothers may have more of a say in how the income is used, which is more important for survival when earnings are lower, and such households may also be in a better position to diversify income. At the contextual level, girls may be seen as more valuable to parents as their expected future income is higher if more women work in the area, and such considerations may be more important for survival when resources are scarce. Female employment may also affect, be affected by, or simply reflect norms regarding the value of girls and women in society, which may be put to a test during crises.

Son preference, i.e. a preference for male offspring, is widespread across the world, yet there are large variations both in stated preferences and in implementation of these preferences as shown in actual gender-biased sex ratios (Bongaarts, 2013). The implementation of son preferences is manifested in the high number of missing girls at birth, particularly in Asia (Sen, 1990). Bongaarts (2013) argues that this is because the son preference in these countries is combined with fertility squeeze and access to technology that facilitates the realisation of sex selective abortion. He also shows that half of the 12 countries with the strongest son preferences are in Africa, and hypothesises that sex ratios at birth will increase in these countries. Even though these son preferences do not alter sex ratios at birth in Africa, it is possible that they are related to more infant girls dying during droughts. Guilmoto (2009) argues that depriving female infants of a fair share of household resources is the low-technological equivalent of sex-selective abortions. However, such neglect does not invariably cause female mortality in the Asian setting as most girls survive childhood even if subjected to discrimination, which may be different in periods of crises when resources are scarcer. Such neglect following droughts is likely to occur either if the mother herself has a preference for sons, or if there is a culture of son preference which influences how the mother is assisted by other household members and the wider community.

As mentioned, based on research from Asia, there is much evidence that the clash between low demand for children and high demand for sons increases the discrimination of daughters (das Gupta and Mari Bhat, 1997; Belanger, 2002). Employing a difference-in-differences strategy, Li et al. (2011) find that almost all of the increase in the sex ratio at birth in China since the 1980s can be attributed to the one-child policy. This is not necessarily comparable to the mechanisms operating in Sub-Saharan Africa, where total fertility rates are still very high, although there have been substantial declines in some countries (Bongaarts, 2010). It is therefore interesting to study whether droughts cause a larger gender difference in mortality for children of mothers with a preference for relatively fewer children, particularly as we will probably see more extreme weather alongside lower fertility in the future. Fertility preferences within the community are also interesting to study as women in the same cluster have a stong influence on each other's fertility (Kravdal, 2004), and community level fertility preferences may also reflect fertility preferences of spouses or other household members.

Education is often hypothesised to be important for child survival and gender bias therein, both through individual and societal benefits. There is a debate about whether the strong correlation found between maternal education and child health is due to an independent effect or socio-economic status more generally (Caldwell, 1994; Desai and Alva, 1998; Pamuk et al., 2011). Kravdal (2004) argues for a contextual effect of education above and beyond that of the mother's own education via social learning, social influence and institutions. Monden and Smits (2013) find that the male-female child mortality ratio increases with more education, also in Sub-Saharan Africa. They hypothesise that maternal education may increase health knowledge of mothers, give them more power vis-a-vis males in the household and lead to more equal gender values. However, they do not find a robust effect of maternal education on gender differences in neonatal and post-neonatal infant mortality in Sub-Saharan Africa. Still, a few studies may indicate that such a relationship might exist during crises. Kiros and Hogan (2001) show that both maternal and paternal literacy reduces the increases in child mortality following wars and famines in Tigray, Ethiopia, and Baird et al. (2010) find a greater risk of excess female deaths after aggregate economic shocks among the low educated across developing countries.

4 Data

4.1 Demographic data

We use micro data from all Demographic and Health Surveys (DHS) from Sub-Saharan Africa that were accessible without restrictions on 1 January 2013 and that provided GPS coordinates. In DHS studies, all women of childbearing age (15-49) in the sampled households are asked about the timing of all births, whether the child survived, and if not, the age in months at which the child died. In total, we use 68 surveys from 29 countries conducted 1986-2011 in 24,304 survey clusters, which contains a total of 801,054 boys and 773,442 girls born a year or more before the time of the survey during the period 1980-2010. The dependent variable is an indicator variable for whether the child died before age 1. Infant mortality rates for girls and boys in the sample are 83 and 97 per 1000 live births, respectively.

Apart from the birth recodes, most of the DHS datasets also contain background information on the mothers and the households. Variables on son and fertility preferences, employment, and education are constructed from these datasets. Mothers are asked to think of the time when they had no children and say how many children they would ideally have in their lives. This is the measure we use for fertility preferences. A follow-up question then asks them to state how many of these children they would like to be boys, how many they would like to be girls and for how many the gender does not matter. Using this information, we create a measure of son preference as an indicator variable that takes the value of one if the reported ideal number of sons exceeds the reported ideal number of girls. Mothers with the same ideal number of girls and boys are coded as zero. Following Bongaarts (2013), we also code people answering that it is up to God or that they do not have a preference as having zero son preference and as missing fertility preference. Employment is measured by a survey question asking whether the mother was working last year, and those answering yes are coded as working. Education is measured both in years of schooling and in highest level attained, and we classify mothers having no education or only primary education as being low-educated, and those with more education as high-educated.

There are at least two concerns with these data. One is that the variables are measured at the time of interview, and may therefore differ from the levels at the time of birth. The measures of preferences are perhaps most problematic in this respect as they may suffer from a rationalisation based on the current family size and composition (Bongaarts, 2013). A second issue is that of measurement error. A study by Langsten and Salem (2008) compares the reported levels of occupation in a DHS survey in Egypt with an alternative method where women are asked about their daily activities. The alternative method raised levels of female labour force participation from 21 % to 65 %, documenting widespread under-reporting. As 71 % of the mothers in our sample are working, we do not believe the under-reporting to be of the magnitude that was observed in Egypt, yet it may nevertheless be substantial. However, we believe the variable captures relatively well the types of activities that are perceived as gainful work by the women and their communities.

To generate variables at the community level, we first aggregate the information on preferences, employment and education into averages at the DHS cluster level, excluding the individual's own observation. This method (also known as *jackknifing*) ensures that the individuals' own characteristics are not conflated with those of the surrounding community. With respect to son and fertility preferences, the cluster aggregates have the advantage of picking up widely held norms rather than the mothers' adaptive preferences.

4.2 Drought data

The data on total precipitation comes from the ERA-Interim project and is produced by the European Centre for Medium-Range Weather Forecasts. Rainfall from 1 January 1979 to 31 December 2011 is recorded twice daily on a 0.75 x 0.75 degrees grid level, and an overwhelming majority of the observations come from satellites (Dee et al., 2011). The NCO programme produced by Zender (2008) was used to produce monthly aggregates.

As our interest lies in mortality stemming from income shocks created by droughts, we need to specify relevant seasons when agricultural yields are affected by rainfall and we use rainy seasons as a proxy for months when crops are sensitive to rain.[2] We follow the method of Liebmann et al. (2012) in constructing rainy seasons that are consistent for all parts of Africa. We identified the rainy season in each grid cell as a continuous sequence of calendar months with average monthly rainfall above the yearly average. If there were multiple sequences, we chose the sequence during which the sum of monthly levels of precipitation was the largest. Total precipitation during each rainy season in

1979-2011 was then summed, and the mean and standard deviation across the 32 years were used to create a normalised index. A drought event was defined as a season with rainfall less than two standard deviations below the mean, and a symmetric measure was used for floods.[3]

5 Empirical strategy

As the African continent generally does not enjoy abundant and reliable rainfall, adjusting crops, planting and harvest times to the rainy season is crucial to maximise agricultural production (Liebmann et al., 2012; Ati et al., 2002). If we assume that farmers make adjustments that are reasonably optimal over time, we should therefore expect that rainfall during the rainy season when rainfall is plentiful matters the most for yields. Droughts lead to smaller yields that affect income first when harvested, and it may take even longer before income affects consumption and infant mortality. We therefore analyse effects on infant mortality of droughts during the last rainy season before birth.

Places that receive more and less rain are likely to differ in a number of ways that are correlated with health and gender roles, such as distance to the coast and crop use. Controlling for all such confounding factors is impossible. We therefore identify seasons in which rainfall was unusually low relative to what is normally experienced in a particular location, creating what Kudamatsu et al. (2012:3) call 'a gigantic set of natural experiments'. As all places have identical probabilities of receiving a weather shock, the occurance of a drought would not have been correlated with predetermined health factors if the observations were independent. However, variation in rainfall during rainy seasons depends on large-scale weather systems that are spatially correlated. Typically, several grid cells on one side of a mountain chain therefore receive the same shock, and grid cells on the other side receive another. These natural boundaries are bound to be correlated with cultural characteristics and even ethnic divisions, which are correlated with gender roles and infant mortality. This feature makes it necessary to adopt a fixed effects framework where we control for gender-specific mortality between grid cells so that the infants are only compared with other infants of the same sex born in the same location. Given the location, the distribution of rainfall across rainy seasons is exogenous. Still, long-run trends in rainfall may be correlated with long-run trends in infant mortality rates (Kudamatsu et al., 2012), as well as trends in gender differences. Thus, we also need time controls. There are furthermore some possible indirect effects of droughts on infant mortality at the national level that may be macroeconomic or institutional. We want to control for these time-variant indirect effects, which is why we control for the gender-specific mortality by year of birth in each country. Our specification is therefore:

$$m_{i,e,t} = \beta_{\mathbf{1}} d_{g,e,t} + \beta_{\mathbf{2}} f_{g,e,t} + \alpha_{g,x,y} + \alpha_{g,e,l} + \epsilon_{i,e,t} \tag{1}$$

where m is a binary variable for infant mortality of child i, born in grid cell e at time t, the variables d and f indicate droughts and floods during the last season before time t that are sex and grid specific, $\alpha_{g,x,y}$ are gender g and country x specific year of birth y fixed effects and $\alpha_{g,e,l}$ are gender- and grid cell-specific calendar month l of birth fixed effects.[4] The grid cells are defined by the weather data yet split if covering areas in several countries for computational ease. The drought index $d_{g,e,t}$ equals 1 if the last rainy season before birth in the grid cell received less rainfall than two standard deviations below the mean, and the flood index is symmetric. By considering the last rainy season before birth, we leave some time for the drought shock to affect income and infant mortality through the multiple channels described earlier. We also considered earlier and later seasons, and found no statistically significant effects of droughts on infant mortality (results are available upon request).

Artadi (2005) shows that children born in the 'hungry season' right before harvest display increased infant mortality as labour demand is high and food stocks are low. As the seasonal pattern in infant mortality depends on the agricultural seasons, we would need fixed effects for calendar month of birth at the grid cell level to control for this. This is done by Kudamatsu et al. (2012) but is not necessary for unbiased estimators in our case, as the same drought will affect all children born in the next 12 months. However, the seasonal variation is controlled for in our preferred spesification as it improves precision.

Table 1: Observations by treatment group and gender

Treatment	Observations		Share	
	Boys	Girls	Boys	Girls
Extreme drought (<-2)	6,674	6,474	0.83 %	0.84 %
Severe drought (<-1.5)	32,453	31,781	4.05 %	4.11 %
Severe flood (>1.5)	66,603	64,147	8.31 %	8.29 %
Extreme flood (>2)	28,240	27,177	3.53 %	3.51 %

In Table 1, we show the distribution of male and female births after drought and flood incidents, for both extreme and severe droughts. We see that the distribution of normalised rainfall during the rainy season is right-skewed, which creates fewer drought shocks than flood shocks.[5] Both Kudamatsu et al. (2012) and Friedman and Schady (2012) argue that as infant mortality is a quite extreme event, we should only expect to observe increases after substantial income shocks. As girls do not seem to be disfavoured during normal years, we furthermore hypothesise that any gender gap in mortality stemming from droughts will occur only after extreme shocks. We therefore chose to focus on droughts below -2 standard deviations from the mean, but also present results for droughts below the -1.5 level.[6]

6 Results

6.1 Main results

Our preferred specification is in column 1 of Table 2, which shows a statistically significant gender difference following droughts. The gender difference is also sizeable: droughts cause the deaths of 11.9 more girls per 1000 births than boys, which almost cancels the female advantage in mortality. This effect is similar to that found by Friedman and Schady (2012), who relate a negative deviation in GDP per capita of two standard deviations (which equals -6.8 % growth) to a gender difference of 14 girls per 1000 births. However, we find no statistically significant effect of droughts for neither male nor female infant mortality separately at this level, which could be due to income and disease effects cancelling each other out.

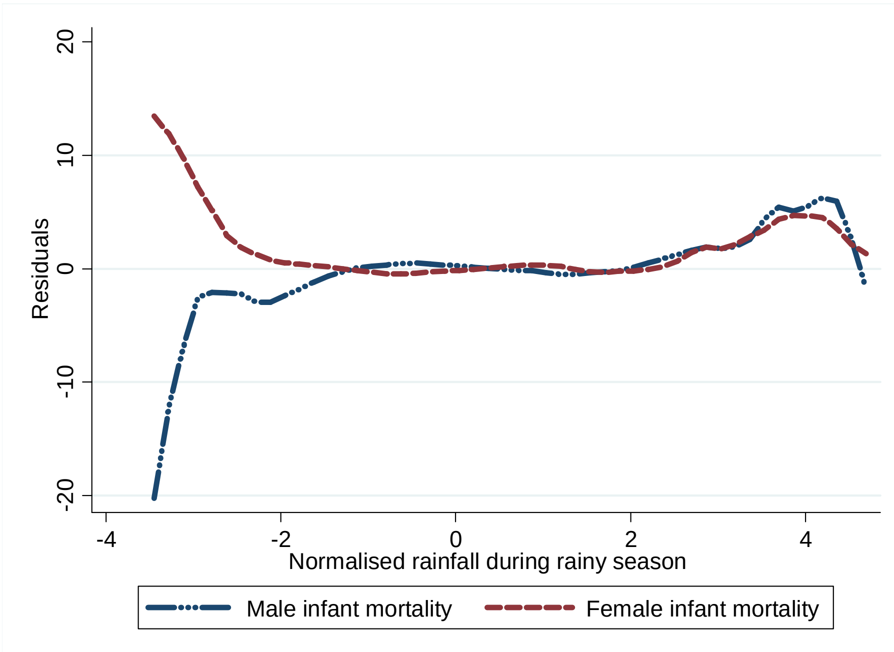
Table 2: Baseline results

Infant Mortality	(1)	(2)
Severity	+/− 2 SD	+/− 1.5 SD
Drought*Female	11.9**	6.28**
	(5.63)	(2.64)
Drought	-3.62	-4.42**
	(4.62)	(1.97)
Flood*Female	-0.44	-1.47
	(3.07)	(2.03)
Flood	3.17	1.07
	(2.17)	(1.52)
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,574,496	1,574,496
R-squared	0.044	0.044

Where $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

From column 2 in Table 2, we see that the effect is smaller but still significant with a lower cut-off of +/- 1.5 standard deviations. To study at what levels of rainfall the mortality rates diverge, it is useful to plot the residuals against normalised rainfall during the rainy season. The residuals from an empty model with the same controls as reported in Table 2 (yet without the variables for drought and flood) are shown in Figure 1. We see from the figure that both mortality ratios are relatively stable at rainfall levels between -2 and 2 standard deviations from the mean, perhaps with a slight widening of the gap under 1 standard deviation below the mean. Yet under two standard deviations below the mean, female infant mortality is sharply increasing with less rain whereas male infant mortality is flat and then sharply dropping below -3 standard deviations. Mortality increases for both genders following floods, and as expected slightly more so for males.

Figure 1: Residuals by rainfall



Residuals are per 1000 live births, and the regression includes gender and country specific year-of-birth fixed effects and gender and grid cell specific month-of-birth fixed effects. Local polynomial smoothed lines were fitted.

The results remain very similar without the seasonal controls, when mother characteristics are controlled for, and when including an additional month of mortality due to heaping in reported mortality on one year. We also reduced the sample to women who have lived their whole lives in the same place, as we may worry that drought-induced migration has altered the sample. The gender difference is even larger for non-migrants, yet no longer statistically significant (see the Appendix C for these and other robustness checks of the main specification).

6.2 Contextual variation

In this section, we test whether there are different effects of rainfall shocks in contexts that differ in respects likely to be of importance for a gender bias to emerge. In particular, we investigate whether levels of female employment and education as well as preferences for sons and children are important moderators for the gender bias in drought-induced infant mortality. If they are, the results suggest that the gender bias is at least partly social. We create community level averages where a community is defined to be a DHS cluster since we believe that this level is the most important one for social interactions. Each woman will not interact directly with all other women in the cluster, but she will most likely interact with some of them, and they may in turn interact with other women in the same cluster (Kravdal, 2004).

The results report contextual variation on two levels, as the samples are split by aggregate values at the cluster level and interaction terms are included for variation between individuals or households. All contextual level results control for the age and age squared of the mother at the time of interview, birth order and multiple birth fixed effects, gender- and country-specific year-of-birth fixed effects as well as gender- and grid cell-specific month-of-birth fixed effects. The standard errors are clustered at the ERA-Interim grid levels. Furthermore, all contextual results point in the same direction and the conclusions remain the same if we 1) use shocks as defined by 1.5 standard deviations from the mean, 2) restrict the sample to only include non-migrants, 3) add controls for the mothers' employment and education and 4) restrict the sample to rural areas (results are available upon request).

6.2.1 Effects by female employment

An important hypothesis in the literature with respect to gender bias in infant mortality relates to female employment. As the mechanisms for why female employment affects gender bias in infant mortality are likely to operate at both the individual and community level, we analyse them both.

The community level of employment is based on the average share of women working in the area where the woman lives (excluding the individual's own observation), and we classify clusters with more than the median average female employment levels as working communities and those with less as non-working communities. The median of the community average female work participation in our areas is 68.75 percent. We interact our drought and flood indicators with a dummy variable that equals 1 if the mother is working in order to see if there are different effects of droughts for working and non-working mothers. We also split the sample into working and non-working areas to see if there are different effects of drought in different contexts and whether the individual level variables moderate the drought effects differently in the different areas. Table 3 shows the results where the excluded category is non-working women. The main effects are therefore to be interpreted as effects for children of mothers who do not work. Column 1 presents the results for all areas. We see that there is a gender difference in the effects of droughts favouring boys for the children of non-working women. Interestingly, this gender difference is somewhat cancelled out for working mothers, although the differences between working and non-working mothers are not statistically significant for either gender.

In columns 2 and 3, we split the sample into areas where more women work and areas where fewer women work. It is evident from these sample splits that the effect of droughts on the gender difference for non-working mothers is driven by areas where fewer women work (as seen in column 3). In such areas, the gender difference in the drought effect is large. For infants with working mothers in these areas, there is a much smaller gender bias (as seen by looking at the coefficient for Drought*Working*Female), although the difference is not statistically significant. In areas where many women work, there is no statistically significant gender difference irrespective of the employment status of the mother under consideration, as seen in column 2. Hence, we find strong support for the importance of female employment, and while individual female employment seems to protect against gender bias, there is an additional protective effect of being surrounded by women who work also for women who do not.

Table 3: Work

Infant Mortality	(1)	(2)	(3)
Sample communities	All	More work	Fewer work
Drought variables			
Drought*Female	20.6*	13.4	24.6**
	(10.6)	(24.5)	(12.4)
Drought	-11.6	-20.8	-13.2
	(7.30)	(18.9)	(8.27)
Drought*Working*Female	-11.9	-0.021	-21.4
	(13.4)	(27.3)	(16.8)
Drought*Working	11.5	21.9	8.56
	(9.12)	(20.9)	(11.5)
Controls			
Working*Female	-0.18	-3.49	0.79
	(1.20)	(2.81)	(1.37)
Working	4.02***	2.98	0.89
	(1.06)	(2.18)	(1.26)
Symmetric flood controls	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,449,595	727,058	722,532
R-squared	0.063	0.081	0.078

Working refers to mothers who are working. The more work sample of communities refers to clusters with average female labour force participation above the median 68.75 % when the mother herself is excluded. Symmetric flood controls are Flood*Female, Flood, Flood*Working*Female, and Flood*Working. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

6.2.2 Effects by level of son preference

If the gender difference in infant mortality is due to discrimination, we should find differences across areas depending on the level of son preference in the community. We therefore split the sample by the median of the community average for female son preference, which is 19 percent. To investigate how individual level son preference impacts the gender-specific risk of infant mortality following weather crises, we interact our drought and flood indicators with a dummy variable that equals 1 if the mother has a preference for sons. Table 4 columns 2 and 3 show the effects of shocks in different areas depending on the level of son preference in the area. The excluded category is women without son preference, and the main effects for droughts and floods (as well as the additional effects for girls) are now to be interpreted as effects for children of mothers without a stated preference for sons. Column 1 shows results for the total sample once we include mother-level variables for son preference. There is no statistically significant gender bias in the drought effect for mothers without son preference, and while the gender bias is larger for mothers with son preference (as the effect of the interaction term for girls, Drought*Son preference*Female, is positive), this difference is not statistically significant. We also see that more girls and fewer boys die in normal periods in families where the mothers have a son preference.

Turning to the contextual results, we show the results in areas with a high degree of son preference in column 2. We see a large and statistically significant difference between the effects of droughts on boys and girls in these areas, implying that many more girls than boys die during droughts. While we see a large additional effect for the individual mothers with son preferences in these areas (as demonstrated by the coefficient for Drought*Son preference*Female), the difference is not statistically significant. Hence, there is a large gender bias in infant mortality following droughts in areas with high degrees of son preference even for the mothers without a stated son preference. In column 3, we see that there is no gender difference in the drought effect in areas without son preference, neither in terms of magnitude of the coefficients nor in terms of statistical significance. In fact, there is not even a positive gender bias in these areas for the mothers with a stated son preference. These findings lend strong support to the notion that excess female infant mortality during droughts is most pronounced in areas with a culture favouring sons over daughters.

Table 4: Son preference

Infant Mortality	(1)	(2)	(3)
Sample communities	All	High son pref.	Low son pref.
Drought variables			
Drought*Female	12.2	24.1**	2.38
	(7.66)	(12.2)	(10.9)
Drought	0.96	-1.15	3.53
	(5.92)	(7.62)	(8.72)
Drought*Son pref.*Female	10.4	18.2	-2.04
	(16.4)	(21.2)	(23.5)
Drought*Son pref.	-13.6	-19.5	-3.71
	(10.2)	(12.7)	(16.4)
Controls			
Son pref.*Female	12.9***	12.0***	14.6***
	(1.37)	(1.73)	(2.40)
Son pref.	-7.05***	-6.31***	-8.51***
	(1.06)	(1.28)	(1.80)
Symmetric flood controls	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,337,827	678,195	659,627
R-squared	0.066	0.085	0.087

Son preference refers to mothers who state that they would ideally have more sons than daughters. The high son preference sample of communities refers to clusters with average son preference above the median of 19 % when the mother herself is excluded. Symmetric flood controls are Flood*Female, Flood, Flood*Son preference*Female, and Flood*Son preference. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets.
* significant at 10 %, ** significant at 5 %, *** significant at 1 %.

6.2.3 Effects by levels of fertility preference

We would also expect more discrimination against daughters if there are individual or community preferences to limit family size. An interaction term is included for women whose ideal number of children is above five or more. Also here, we split the sample by the median community average desired fertility excluding the woman herself, which is 5.05 children.

Column 1 in Table 5 shows that mothers who wish to have many children generally have higher infant mortality, which may reflect a number of factors (Lloyd and Montgomery, 1996). Given the correlation between preferences and actual fertility, having many children and short spacing between them may increase infant mortality. Also, women who are poor and less educated typically have higher fertility preferences than other women. However, there is no significant difference in the gender gap in infant mortality by fertility preference, neither in normal years nor following droughts.

The effects of norms to limit family size within the community are studied in columns 2 to 3, where we separate the sample into high and low fertility preference areas. We see that there is only a significant gender difference in infant mortality following droughts in the sub-sample with low fertility preferences, and not in the sub-sample with high fertility preferences. The gender effect of droughts is not significantly different according to the mother's own fertility desire in either sub-sample. However, the effect in the sub-sample with low fertility preferences is if anything larger for mothers who share the low fertility desires of her community (as the coefficient for Drought*Wants 5 or More*Female is negative but insignificant).

Table 5: Fertility preference

Infant Mortality	(1)	(2)	(3)
Sample communities	All	High fertility pref.	Low fertility pref.
Drought variables			
Drought*Female	10.1	-2.90	19.6**
	(8.96)	(21.4)	(9.76)
Drought	3.84	11.0	-0.27
	(7.62)	(17.8)	(8.96)
Drought*Wants 5 or More*Female	10.8	33.6	-6.49
	(10.7)	(22.2)	(12.7)
Drought*Wants 5 or More	-13.4	-28.2	-1.86
	(9.12)	(18.7)	(10.1)
Controls			
Wants 5 or More*Female	1.34	2.16	0.92
	(1.19)	(2.28)	(1.39)
Wants 5 or More	2.78***	-1.97	2.63**
	(1.02)	(1.83)	(1.15)
Symmetric flood controls	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,287,065	622,844	664,182
R-squared	0.066	0.090	0.067

Wants 5 or More refers to mothers who want 5 children or more. The high fertility preference sample of communities refers to clusters with average fertility preference above the median of 5.05 children when the mother herself is excluded. Symmetric flood controls are Flood*Female, Flood, Flood*Wants 5 or More*Female, and Flood*Wants 5 or More. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets.
* significant at 10 %, ** significant at 5 %, *** significant at 1 %.

6.2.4 Effects by levels of education

Another important hypothesis in previous literature is that maternal education, and female education in general, protects against gender bias in infant mortality. In Table 6, we therefore show the effects of shocks in different areas depending on the level of female education in the area. Column 1 shows the results for the total sample, where the baseline category consists of having no education or primary education only (86.6 percent of the sample) and *High Education* corresponds to having more than primary education. While we find that having high education is strongly correlated with lower infant mortality (the effect of the high education variable is negative and statistically significant), our results confirm the finding of Monden and Smits (2013) that the gender bias under normal circumstances does not differ by level of maternal education (as the coefficient for the interaction term High Education*Female is small and not statistically significant). However, contrary to the expectations based on previous literature, we do not find a smaller gender bias for the more educated following droughts. In fact, the coefficient even points to the contrary conclusion (as seen by inspecting the positive albeit insignificant coefficient for Drought*High Education*Female).

Furthermore, column 2 shows that the gender bias is substantial for both education groups in areas where women have relatively more years of schooling (the median years of average cluster level schooling in the total sample is 2.94 years). Again, there is no statistically significant difference in the drought effects between more and less educated mothers in these areas for infants of either gender, although the coefficient on the gender gap for more educated mothers points in the wrong direction as compared to the hypothesis based on previous literature. In column 3, we see the results in the less educated areas. In these areas, there is no statistically significant gender difference in the effects of droughts, but the coefficients for the individual level education point in the expected direction. That is, there are indications that daughters of less educated mothers in less educated areas suffer more from gender bias during droughts than their peers with more highly educated mothers in the same areas. This difference is, however, not statistically significant. Hence, we do not find general support for the hypothesis that the gender bias following droughts is worse for daughters of less educated mothers, and contrary to our expectations, there is a larger gender bias in areas where women have higher average education.

Table 6: Education

Infant Mortality	(1)	(2)	(3)
Sample communities	All	More education	Less education
Drought variables			
Drought*Female	9.60*	15.1**	2.47
	(5.78)	(7.47)	(9.76)
Drought	-3.61	-7.20	1.45
	(4.71)	(5.24)	(7.67)
Drought*High Education*Female	20.4	24.5	-23.2
	(13.7)	(15.2)	(45.0)
Drought*High Education	-5.95	-7.35	24.6
	(9.11)	(10.1)	(35.4)
Controls			
High Education*Female	-1.59	-1.19	-6.29
	(1.35)	(1.50)	(4.43)
High Education	-23.5***	-18.7***	-28.6***
	(1.43)	(1.49)	(3.70)
Symmetric flood controls	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,535,626	770,030	765,591
R-squared	0.062	0.068	0.074

High Education refers to mothers with more than primary education. The more educated sample of communities refers to clusters with average schooling above the median 2.94 years when the mother herself is excluded. Symmetric flood controls are Flood*Female, Flood, Flood*High Education*Female, and Flood*High Education. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

7 Conclusion

Sub-Saharan Africa is plagued by high levels of infant mortality, and households are frequently unable to smooth consumption when faced with crises that may be macroeconomic, environmental or political in nature. Several studies have found that girls are more exposed to risk of death than boys during crises, in Asia as well as in Africa. Droughts represent a particularly interesting type of crisis, as it is likely to become more prevalent in the future due to climate change (Boko et al., 2007). We find a substantial and significant gender difference in how droughts affect male and female infant mortality, with 12 more infant girls per 1000 births dying following droughts than boys. By considering mortality following unusually low precipitation relative to what is normally experienced in a particular location and using a fixed effects framework, our measure is not affected by the potential confounders that have troubled previous studies on how crises affect gender differences in infant mortality in Africa.

We are not able to completely exclude the possibility that effects of droughts on the disease environment, which reduce the mortality more for boys than girls, are behind some or all of the observed gender difference.Still, we believe that the most likely mechanism for the gender gap is that households give higher priority to male than female infant survival during lean years. These priorities may be manifested in the allocation of consumption, time, or effort, which affects infant nutrition and health-promoting behaviour. Support for this theory is found in that communities that we would expect to discriminate more against female infants during lean times also display the largest gender gap.

Our findings document a larger mortality effect of droughts for girls than for boys in societies where women have a preference for sons, and where there are norms to limit family size. We find that the mother's own preference for sons matters for gender bias in mortality in general, and there is a sizeable yet statistically insignificant additional effect of son preference on gender differences in mortality following droughts. Son preferences in the community seem to be even more important for the gender difference in mortality following droughts. Similarly, a woman's own desires regarding family size do not matter significantly for gender effects of droughts, but we find discrimination following droughts only in places where average fertility desires are relatively low. The findings highlight the important role that the community might play in protecting weaker members during crises. Guilmoto (2009) sees the neglect of female infants as a low technology alternative to sex selective abortions, and norms against such practices may be weakened during crises, especially if women in the community support the idea that daughters are less wanted than boys and perhaps not wanted at all. That discrimination depends on fertility squeeze is particularly worrisome for how the gender bias might develop in the future if there is increased pressure to limit family size and crop failure at the same time becomes more frequent due to climate change.

Sen's (1990) theory that differences in female participation in gainful employment between Asia and Africa can explain differences in missing girls is indeed in line with our finding that female labour across Africa can explain gender gaps in mortality following droughts. The effect seems to be both that mothers who work are better able to protect their girls following droughts, and that communities where more women work to a larger extent are able to avoid excess deaths of daughters of non-working women. We find no statistically significant gender difference in the drought effect for mothers with high and low levels of education, and the results with respect to community-level education were contrary to our expectations. More studies on how education affects gender differences in mortality during crises are needed to explain why the differences are larger in communities with more female education. We can only speculate that this might be connected to desires to limit family size among the more educated.

These contextual factors may clearly be correlated with both each other and unobserved factors. One may therefore perhaps regard them as indicators of cultural values rather than causal mechanisms. We may conclude from the analysis that in places where girls and women have a relatively low standing, proxied by son preferences or little female employment, droughts increase mortality more for girls than for boys, which is not the case in communities with more gender equality. This makes it plausible that the difference that we document indeed constitutes a gender bias in infant mortality following droughts in Africa.

Notes

[1]More heterogeneities are provided in the Appendix (available at the end of the document) section D, where we investigate the different effects in rural and urban areas as well as per country, and in the section F where we investigate poverty and inequality.

[2]In the Appendix section B, we discuss different ways of measuring droughts and seasons.

[3]See the Appendix A for a map of the distribution of drought shocks.

[4]As the regression contains two high-dimensional fixed effects, the *reg2hdfe* programme written by Guimaraes and Portugal (2010) was used in Stata.

[5]We therefore also followed Burke et al. (2013) and constructed gamma distributions in each grid cell, which unlike the normal distribution is fully flexible in shape. We did not find any systematic differences between the gamma distribution and normal distribution with respect to spatial or temporal allocation of the shocks, and regression results proved to be similar (results available upon request).

[6]We show that our drought measure is correlated with a decrease in GDP growth per capita in Appendix section E.

References

ALIEN, L. H. (1994): "Maternal Micronutrient Malnutrition: Effects on Breast Milk and Infant Nutrition, and Priorities for Intervention," *SCN News*, 11, 21–24.

ANDERSON, S., AND D. RAY (2010): "Missing Women: Age and Disease," *The Review of Economic Studies*, 77(4), 1262–1300.

ARTADI, E. (2005): "Going into Labor: Earnings vs. Infant Survival in Rural Africa," Job market paper, Harvard University.

ATI, O. F., C. J. STIGTER, AND E. O. OLADIPO (2002): "A comparison of methods to determine the onset of the growing season in northern Nigeria," *International Journal of Climatology*, 22(6), 731–742.

BAIRD, S., J. FRIEDMAN, AND N. SCHADY (2010): "Aggregate Income Shocks and Infant Mortality in the Developing World," *Review of Economics and Statistics*, 93(3), 847–856.

BANDYOPADHYAY, S., S. KANJI, AND L. WANG (2012): "The impact of rainfall and temperature variation on diarrheal prevalence in Sub-Saharan Africa," *Applied Geography*, 33, 63–72.

BECKER, G. (1981): *A Treatise on the Family*. Harvard University Press, Cambridge.

BELANGER, D. (2002): "Son Preference in a Rural Village in North Vietnam," *Studies in Family Planning*, 33(4), 321–334.

BJORKMAN-NYQVIST, M. (2013): "Income shocks and gender gaps in education: Evidence from Uganda," *Journal of Development Economics*, 105, 237–253.

BLACK, R. E., L. H. ALLEN, Z. A. BHUTTA, L. E. CAULFIELD, M. DE ONIS, M. EZZATI, C. MATHERS, AND J. RIVERA (2008): "Maternal and child undernutrition: global and regional exposures and health consequences," *Lancet*, 371(9608), 243–260.

BOKO, M., I. NIANG, A. NYONG, C. VOGEL, A. GITHEKO, M. MEDANY, B. OSMAN-ELASHA, R. TABO, AND P. YANDA (2007): "Africa," in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel* *on Climate Change*, ed. by J. P. P. v. d. L. M.L. Parry, O.F. Canziani, and C. Hanson, Cambridge. Cambridge University Press.

Bongaarts, J. (2010): "The causes of educational differences in fertility in Sub-Saharan Africa," *Vienna Yearbook of Population Research*, 8, 31–50.

——— (2013): "The Implementation of Preferences for Male Offspring," *Population and Development Review*, 39(2), 185–208.

Burke, M., E. Gong, and K. Jones (2013): "Income Shocks and HIV in Africa," working paper, UC Berkeley.

Caldwell, J. C. (1994): "How is greater maternal education translated into lower child mortality?," *Health Transition Review*, 4(2), 224–229.

Confalonieri, U., B. Menne, R. Akhtar, K. Ebi, M. Hauengue, R. Kovats, B. Revich, and A. Woodward (2007): "Human health," in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. by M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, pp. 391–431, Cambridge. Cambridge University Press.

das Gupta, M., and P. Mari Bhat (1997): "Fertility Decline and Increased Manifestation of Sex Bias in India," *Population Studies*, 51(3), 307–315.

Dee, D. P., S. M. Uppala, A. J. Simmons, P. Berrisford, P. Poli, S. Kobayashi, U. Andrae, M. A. Balmaseda, G. Balsamo, P. Bauer, P. Bechtold, A. C. M. Beljaars, L. van de Berg, J. Bidlot, N. Bormann, C. Delsol, R. Dragani, M. Fuentes, A. J. Geer, L. Haimberger, S. B. Healy, H. Hersbach, E. V. Holm, L. Isaksen, P. Kallberg, M. Kohler, M. Matricardi, A. P. McNally, B. M. Monge-Sanz, J.-J. Morcrette, B.-K. Park, C. Peubey, P. de Rosnay, C. Tavolato, J.-N. Thepaut, and F. Vitart (2011): "The ERA-Interim reanalysis: configuration and performance of the data assimilation system," *Quarterly Journal of the Royal Meteorological Society*, 137(656), 553–597.

Dercon, S. (2005): *Insurance against poverty.* Oxford University Press, Oxford.

Desai, S., and S. Alva (1998): "Maternal Education and Child Health: Is There a Strong Causal Relationship?," *Demography*, 35(1), 71–81.

Dewey, K. G. (2003): "Nutrient Composition of Fortified Complementary Foods: Should Age-Specific Micronutrient Content and Ration Sizes Be Recommended?," *The Journal of Nutrition*, 133(9), 2950–2952.

Duflo, E. (2012): "Women Empowerment and Economic Development," *Journal of Economic Literature*, 50(4), 1051–1079.

Fenske, J. (2012): "African Polygamy: Past and Present," Working Paper 20, Centre for the Study of African Economies.

Friedman, J., and N. Schady (2012): "How Many Infants Likely Died in Africa as a Result of the 2008-2009 Global Financial Crisis?," *Health Economics*, Letter 5023.

Garenne, M. (2003): "Sex Differences in Health Indicators among Children in African DHS Surveys," *Journal of Biosocial Science*, 35(4), 601–614.

Guilmoto, C. (2009): "The Sex Ratio Transition in Asia," *Population and Development Review*, 35(3), 519–549.

Guimaraes, P., and P. Portugal (2010): "A simple feasible procedure to fit models with high-dimensional fixed effects," *Stata Journal*, 10(4), 628–649.

Haile, M. (2005): "Weather patterns, food security and humanitarian response in sub-Saharan Africa," *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1463), 2169–2182.

Harari, M., and E. La Ferrara (2013): "Climate and Cells: A Disaggregated Analysis," CEPR Discussion Paper 9277, Centre for Economic Policy Research, London.

Harttgen, K., S. Klasen, and S. Vollmer (2013): "Economic Growth and Child Undernutrition in sub-Saharan Africa," *Population and Development Review*, 39(3), 397–412.

Henry, S. J., and S. Santos (2013): "Rainfall variations and child mortality in the Sahel: results from a comparative event history analysis in Burkina Faso and Mali," *Population and Environment*, 34(4), 431–459.

Hill, K., and D. M. Upchurch (1995): "Gender Differences in Child Health: Evidence from the Demographic and Health Surveys," *Population and Development Review*, 21(1), 127–151.

Ji, L., and A. J. Peters (2003): "Assessing vegetation response to drought in the northern Great Plains using vegetation and drought indices," *Remote Sensing of Environment*, 87(1), 85–98.

Jonsson, P., and L. Eklundh (2004): "TIMESAT: a program for analyzing time-series of satellite sensor data," *Computers & Geosciences*, 30(8), 833–845.

Kim, Y. S. (2010): "The Impact of Rainfall on Early Child Health," Job market paper, University of Maryland, Maryland.

Kiros, G.-E., and D. P. Hogan (2001): "War, famine and excess child mortality in Africa: the role of parental education," *International Journal of Epidemiology*, 30(3), 447–455.

Kravdal, y. (2004): "Child Mortality in India: The Community-Level Effect of Education," *Population Studies*, 58(2), 177–192.

Kudamatsu, M., T. Persson, and D. Strï¿œmberg (2012): "Weather and Infant Mortality in Africa," CEPR Discussion Paper 9222, Center for Economic Policy Research.

Langsten, R., and R. Salem (2008): "Two Approaches to Measuring Women's Work in Developing Countries: A Comparison of Survey Data from Egypt," *Population and Development Review*, 34(2), 283–305.

Lartey, A. (2008): "Maternal and child nutrition in Sub-Saharan Africa: challenges and interventions," *Proceedings of the Nutrition Society*, 67(1), 105–108.

Li, H., J. Yi, and J. Zhang (2011): "Estimating the Effect of the One-Child Policy on the Sex Ratio Imbalance in China: Identification Based on the Difference-in-Differences," *Demography*, 48(4), 1535–1557.

Liebmann, B., I. Blade, G. N. Kiladis, L. M. V. Carvalho, G. B. Senay, D. Allured, S. Leroux, and C. Funk (2012): "Seasonality of African Precipitation from 1996 to 2009," *Journal of Climate*, 25(12), 4304–4322.

Lloyd, C., and M. Montgomery (1996): "Fertility and Maternal and Child Health," in *The Impact of population growth on well-being in developing countries*, ed. by D. Ahlburg, A. Kelley, and K. Mason, Berlin. Springer.

Miguel, E. (2005): "Poverty and Witch Killing," *The Review of Economic Studies*, 72(4), 1153–1172.

Miller, G. (2008): "Women's suffrage, political responsiveness, and child survival in American history," *The Quarterly Journal of Economics*, 123(3), 1287–1327.

Miller, G., and B. P. Urdinola (2010): "Cyclicality, Mortality, and the Value of Time: The Case of Coffee Price Fluctuations and Child Survival in Colombia," *Journal of Political Economy*, 118(1), 113–155.

Monden, C. W., and J. Smits (2013): "Maternal education is associated with reduced female disadvantages in under-five mortality in sub-Saharan Africa and southern Asia," *International Journal of Epidemiology*, 42(1), 211–218.

Monfreda, C., N. Ramankutty, and J. A. Foley (2008): "Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000," *Global Biogeochemical Cycles*, 22(1).

Neumayer, E., and T. Plumper (2007): "The Gendered Nature of Natural Disasters: The Impact of Catastrophic Events on the Gender Gap in Life Expectancy, 1981-2002," *Annals of the Association of American Geographers*, 97(3), 551–566.

Oris, M., R. Derosas, and M. Breshi (2004): "Infant and Child Mortality," in *Life under Pressure: Mortality and Living Standards in Europe and Asia, 1700-1900*, ed. by T. Bengtsson, C. Campbell, and J. Lee, pp. 359–398, Cambridge and London. MIT Press.

Pamuk, E. R., R. Fuchs, and W. Lutz (2011): "Comparing Relative Effects of Education and Economic Resources on Infant Mortality in Developing Countries," *Population and Development Review*, 37(4), 637–664.

Pongou, R. (2013): "Why Is Infant Mortality Higher in Boys Than in Girls? A New Hypothesis Based on Preconception Environment and Evidence From a Large Sample of Twins," *Demography*, 50(2), 421–444.

Portmann, F. T., S. Siebert, and P. Doll (2010): "MIRCA2000 Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling," *Global Biogeochemical Cycles*, 24(1).

Qian, N. (2008): "Missing Women and the Price of Tea in China: The Effect of Sex-Specific Earnings on Sex Imbalance," *The Quarterly Journal of Economics*, 123(3), 1251–1285.

Rabassa, M., E. Skoufias, and H. Jacoby (2012): "Weather and Child Health in Rural Nigeria," Policy Research Working Paper 6214, The World Bank.

Riley, N. (2005): "Demography of Gender," in *Handbook of Population*, ed. by D. L. P. M. Micklin, pp. 109 – 141, New York. Kluwer Academic and Plenum Publishers.

Rose, E. (1999): "Consumption Smoothing and Excess Female Mortality in Rural India," *Review of Economics and Statistics*, 81(1), 41–49.

Sen, A. (1990): "More than 100 Million Women are Missing," *The New York Review of Books*, 37(20).

Strauss, R. S., and W. H. Dietz (1999): "Low Maternal Weight Gain in the Second or Third Trimester Increases the Risk for Intrauterine Growth Retardation," *The Journal of Nutrition*, 129(5), 988–993.

Tucker, C. J., J. E. Pinzon, M. E. Brown, D. A. Slayback, E. W. Pak, R. Mahoney, E. F. Vermote, and N. El Saleous (2005): "An extended AVHRR 8km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data," *International Journal of Remote Sensing*, 26(20), 4485–4498.

UNICEF (2006): "Progress for Children: A Report Card on Nutrition," Report 6, UNICEF, New York.

Waldron, I. (1998): "Sex differences in infant and early childhood mortality: Major causes of death and possible biological causes," in *Too young to die: Genes or gender?*, ed. by United Nations Population Division, pp. 64–83, New York. United Nations.

World Bank (2013): "World Development Indicators," Discussion paper.

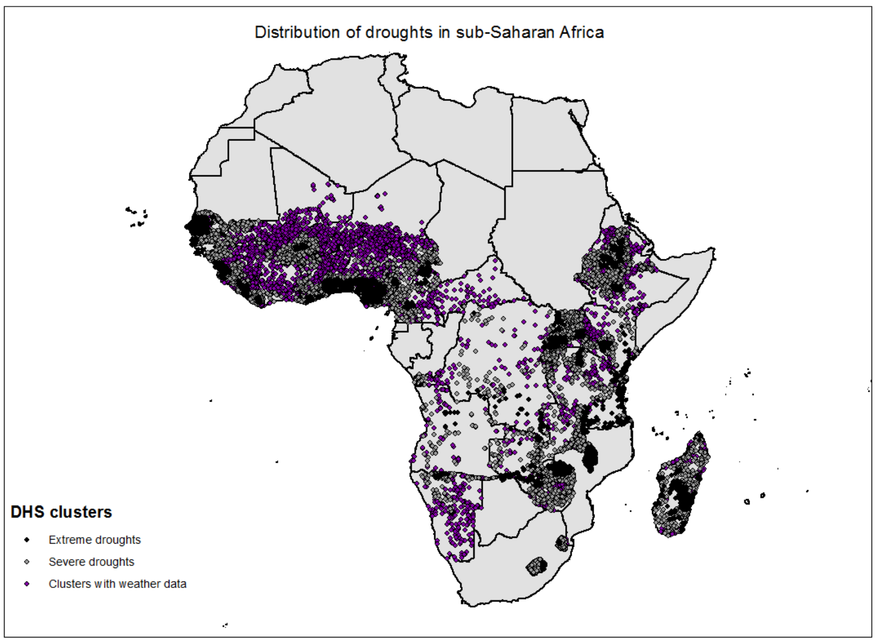
Zender, C. S. (2008): "Analysis of self-describing gridded geoscience data with netCDF Operators (NCO)," *Environmental Modelling & Software*, 23(10-11), 1338–1342.

Appendix

A Distribution of droughts

The survey clusters are shown in Figure 2 below together with the distribution of clusters with at least one birth after a drought at 1.5 and 2 standard deviations below the mean. As can be seen in the figure, the data covers large parts of Sub-Saharan Africa.

Figure 2: Distribution of the DHS clusters across the sub-continent.



B Alternative measures of drought

For constructing relevant seasons when rainfall affects crops, we follow the method of Liebmann et al. (2012), which we have not seen used in a social science context before. We therefore also used two other methods to construct seasons. Kudamatsu et al. (2012) use the Normalized Difference Vegetation Index (NDVI), which is an index of levels of photosynthetic activity based on satellite images of greenness developed by the NASA GIMMS group for every

10-day period in 1982-2008 on an impressive 8 km x 8 km scale (Tucker et al., 2005). This data was then processed by the TIMESAT programme developed by Jonsson and Eklundh (2004) to find seasonal patterns in vegetation which were subsequently averaged across the time span. An alternative method was used by Harari and La Ferrara (2013), who studied the effect of drought shocks on civil conflicts in Africa. They used data developed by Monfreda et al. (2008) to identify the main crop in each 1x1 degree cell, and then used the Global Monthly Irrigated and Rainfed Crop Areas around the year 2000 (MIRCA 2000) developed by Portmann et al. (2010) to obtain local-specific growing seasons for rain-fed cultivation of the crop. The growing season durations in months from these methods are reported in Table 7. However, we believe there are some weaknesses in using the alternative seasonal measures. A study by Ji and Peters (2003) shows that the NDVI is only sensitive to drought indices at the peak of the rainy season, as different crop growth stages have different sensitivity levels to water stress, which also varies between crops. Having too wide seasons is thus more of a problem than having too narrow seasons. A second worry is that the spread of these lengths means that we are potentially capturing very different phenomena in different areas. Thirdly, the methods do not provide a logical method for selecting the most important growing season in places with multiple seasons. A fourth strength of using rainy seasons is that the seasons are exogenously given and thus not influenced by what crops are grown locally.

Table 7: Summary statistics of seasons

Variable	Mean	S.D.	Min	Max
TIMESAT growing seasons	8.13	1.95	2	12
MIRCA main crop seasons	6.58	2.81	3	12
Liebmann rainy seasons	4.91	1.35	2	9

C Robustness checks on baseline results

The minimum spatial control needed for an unbiased estimate is at the grid level, yet spatial controls at the cluster level were also attempted, and with and without the controls for seasonal variability. This is shown in Table 8. Including the seasonal controls increased the precision of our estimate (column 1 versus column 2), yet when interacted with cluster, the standard errors increased again (column 3 versus column 4), probably due to the large number of fixed effects in this case.

Table 8: Different spatial controls

Infant Mortality	(1)	(2)	(3)	(4)
Drought*Female	11.9**	9.99*	11.9	9.40*
	(5.63)	(5.56)	(8.20)	(5.47)
Drought	-3.62	-2.89	-3.48	-2.62
	(4.62)	(4.53)	(6.39)	(4.34)
Flood*Female	-0.44	-0.72	0.17	0.81
	(3.07)	(3.01)	(4.17)	(3.04)
Flood	3.17	3.31	3.27	1.91
	(2.17)	(2.13)	(3.04)	(2.19)
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
	1,566	1,566	1,566	1,566
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e}$	$\alpha_{g,c,l}$	$\alpha_{g,c}$
	41,915	3,590	489,626	48,582
Observations	1,574,496	1,574,496	1,574,496	1,574,496
R-squared	0.044	0.017	0.322	0.054

$\alpha_{g,x,y}$ are gender- and country-specific year-of-birth fixed effects, $\alpha_{g,e}$ are gender-specific grid cell fixed effects, $\alpha_{g,c}$ are gender-specific cluster fixed effects,$\alpha_{g,e,l}$ are gender- and grid cell-specific month-of-birth fixed effects and $\alpha_{g,c,l}$ are gender- and cluster-specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

In Table 9, we show the results from a number of robustness checks. We check whether the results differ when including deaths in the twelfth month (column 1) due to heaping, and find that it does not change the estimates much. We also restricted the sample to only non-migrants (column 2). As we use retrospective fertility data linked to the respondent's location at the time of interview, there is a potential problem of migration. Restricting the sample to non-migrants increases the gender difference coefficient somewhat, yet mostly affects the standard errors. We then included a number of controls of mother characteristics (column 3). These are mother's age at the time of interview and her age squared, and dummy variables for the birth order of the child and multiple births. The additional controls are only important when we explore differences on other characteristics, such as education and labour force participation. Including the controls did not change the results much. The coefficients seem smaller when mother fixed effects are included in column 4, but they are not statistically different from the baseline estimate. For one thing, the model is very restrictive in that the number of fixed effects is very large. Secondly, we may worry that both the birth and death of subsequent children are influenced by the death of an infant (Lloyd and Montgomery, 1996), which would most probably lead to an underestimation of the drought effect.

Table 9: Robustness checks

Infant Mortality	(1)	(2)	(3)	(4)
Mortality age	0-12	0-11	0-11	0-11
Sample	All	Non-migrants	All	All
Shock strength	extreme	extreme	extreme	extreme
Drought*Female	10.9*	17.8	11.5**	5.02
	(5.92)	(11.4)	(5.60)	(7.30)
Drought	-1.81	-6.92	-3.29	-1.11
	(4.94)	(8.10)	(4.56)	(5.71)
Flood*Female	-0.30	0.13	-1.07	-2.30
	(3.38)	(5.36)	(3.06)	(4.00)
Flood	3.90	2.32	3.02	2.94
	(2.39)	(3.61)	(2.19)	(2.78)
Controls	No	No	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	α_M
Observations	1,564,891	500,579	1,535,674	1,529,657
R-squared	0.048	0.090	0.061	0.33

$\alpha_{g,x,y}$ are gender- and country-specific year-of-birth fixed effects, α_M are mother fixed effects and $\alpha_{g,e,l}$ are gender- and grid cell-specific month-of-birth fixed effects. Controls are mother's age at interview, age^2 and birth order and multiple birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

D Differences across locations

In Table 10, we repeat the baseline regression for urban and rural households. In both urban and rural areas, girls are more adversely affected than boys by droughts. We also see that the effect of drought is worse for both male and female infants in rural areas than in urban areas, which is to be expected as the income effect is stronger in these areas.

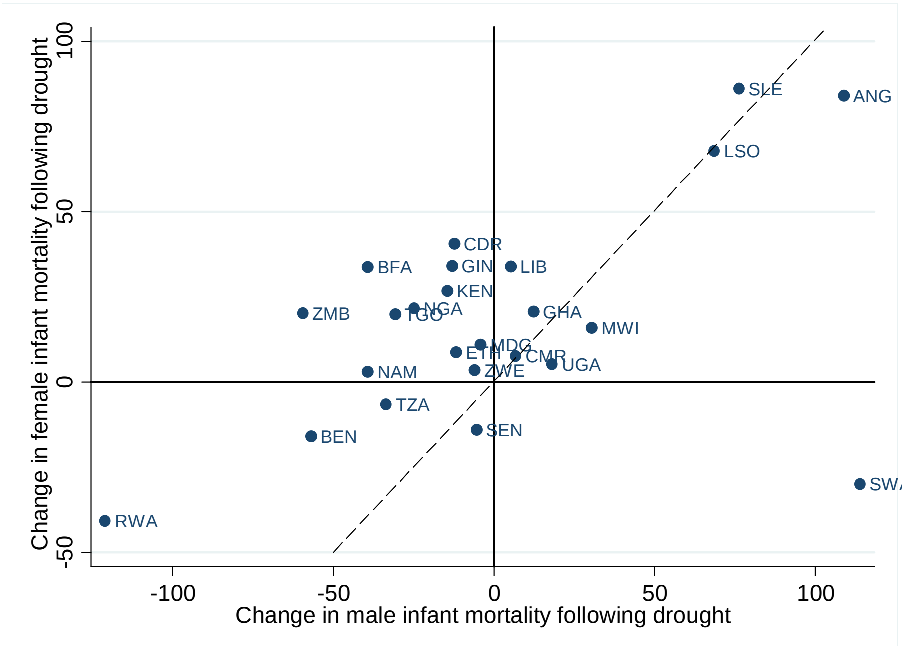
Table 10: Urban versus rural samples

Infant Mortality	(1)	(2)
Sample	Urban	Rural
Drought*Female	15.9*	7.41
	(9.59)	(6.39)
Drought	-14.7**	1.74
	(6.75)	(5.43)
Flood*Female	-2.60	-0.40
	(5.23)	(3.71)
Flood	-0.86	4.87*
	(4.01)	(2.64)
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	392,428	1,182,068
R-squared	0.078	0.052

Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

Large heterogeneities are revealed when we run separate regressions for each country. The regressions are the same as in the baseline, with controls for gender-specific year-of-birth fixed effects and gender- and grid cell-specific month-of-birth fixed effects. The coefficients for drought effects on girls is plotted along the y axis, and for boys along the x axis. The dashed line indicates equal effects on girls and boys. We see that droughts increase mortality more for girls than for boys in most countries. Some caution should be exercised in interpreting the results, however, as the gender difference is only significantly larger than 0 in Kenya and Nigeria, and smaller than 0 in Swaziland.

Figure 3: Regressions by country



Regressions include gender-specific year-of-birth fixed effects and gender- and gridcell-specific month-of-birth fixed effects.

E Droughts and economic growth

This section studies whether droughts affect economic growth. To this end, we use yearly purchasing power parity-adjusted GDP per capita in constant 2005 international dollars in the period 1981-2011 from the World Bank (2013). We do not necessarily expect to find an effect, as GDP mainly captures formal economic activity rather than rain-fed agriculture. However, using a different measure of drought, such an effect has been found by Burke et al. (2013).

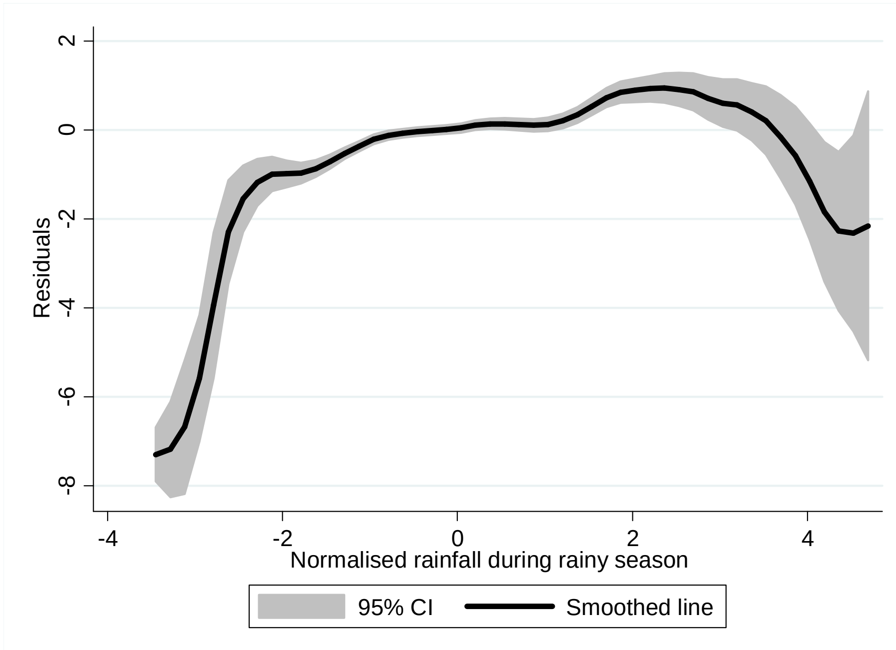
We use all rainy seasons in the 1981-2011 period in each grid where we have observations regardless of when the births occured. We then regress logged GDP per capita the year the season ended on the drought and flood events in these seasons, and weight the grids by the number of births in each grid. Following a strategy similar to Friedman and Schady (2012) but unlike Burke et al. (2013), we add country fixed effects and country-specific squared and cubic time trends as controls. The results are shown in Table 11 with squared controls in column 1 and cubic controls in column 2. The last column shows that droughts cause GDP per capita to contract by 1.5 % and that floods increase GDP growth by 1 percentage point. Both results are significant and confirm that drought shocks can be used as exogenous variation in income, even at the aggregate level.

Table 11: Effect of droughts on GDP growth

Log(GDP_{pc})/100	(1)	(2)
Sample	Weighted grids	Weighted grids
Drought	-1.33**	-1.54**
	(0.64)	(0.61)
Flood	1.54***	1.08***
	(0.38)	(0.36)
Fixed effect	α_x	α_x
Time controls	$\alpha_x(y+y^2)$	$\alpha_x(y+y^2+y^3)$
Observations	53,387	53,387
R-squared	0.970	0.973

α_x are country fixed effects and y is year. Robust standard errors in brackets.
* significant at 10 %, ** significant at 5 %, *** significant at 1 %.

An interesting further analysis is to investigate how GDP growth responds to various levels of rainfall during the rainy season. We therefore ran the cubic model without the drought and flood variables, and plotted the residuals against normalised rainfall during the rainy season. We see in Figure 4 that the effect is significantly different from 0 below -1 and above 1 standard deviation, and that the relationship is relatively linear and positive in the -2 to 2 standard deviations interval. What is most striking about the relationship is the sharp drop in GDP, which is dramatically increasing in severity below -2 standard deviations. This shows that levels of rainfall below -2 standard deviations have very different effects than rainfall above -2 standard deviations, a relationship that shows remarkable resemblance to the increase in female infant mortality. At the other end of the spectrum, we see that the increase in GDP per capita following floods reported in Table 11 is driven by increases of around 2 standard deviations, after which rainfall starts to have contractionary effects on GDP.



Residuals are % changes in GDP per capita, and the regression includes country fixed effects and country-specific cubic time trends. Local polynomial smoothed lines were fitted.

Figure 4: Residuals by rainfall

F Effects by wealth and inequality

The high male-female infant mortality ratio is found in spite of the widespread poverty and economic insecurity in Africa. It is therefore interesting to study whether there is a gender bias when income changes, and if there are different effects of income changes for households and communities that are poorer in terms of assets. The literature on coping strategies also emphasises the importance of opportunities for income diversification, asset holdings and social ties in moderating the effects of income shocks in Sub-Saharan Africa (Dercon, 2005). Rose (1999) finds that the gender bias in infant mortality in India is lower among the richest, since they face fewer life or death choices during droughts and have potential assets to sell off in bad times. We therefore considered how droughts affect gender differences in infant mortality differently according to wealth and local economic inequality.

Our measure of household wealth is based on the wealth index provided in the DHS. The wealth index is a standardised measure of assets and services for households in a given survey, such as type of flooring, water supply, electricity, and the ownership of durable goods such as a radio or a refrigerator.[7] The wealth index is standardised within the country and survey year, thus providing information on the *relative* wealth for households in a survey. In our main measure of poverty, we define the 40 percent poorest households as poor.

We also create a measure of inequality between households in the community. Following Fenske (2012), we compute the Gini coefficient for each cluster and region by re-scaling the wealth index to only include positive values and then use the *fastgini* command in Stata.

In Table 12, we explore the effects of infant mortality in clusters with high and low wealth inequality across households. Wealth inequality is measured at the cluster level by the gini coefficient of the distribution of the wealth index constructed in the DHS surveys. For these regressions, we see a large gender bias in the drought effects in unequal areas and no gender difference in more equal areas. Similar results are obtained when dividing the sample by the median cluster values in each survey instead of based on the whole sample (columns 3 and 4).

Table 12: Inequality

Infant Mortality	(1)	(2)	(3)	(4)
Sample communities	Unequal	Equal	Unequal survey	Equal survey
Drought variables				
Drought*Female	19.1*	14.4	24.4**	5.23
	(10.8)	(10.2)	(10.7)	(11.3)
Drought	-9.58	-2.86	-15.1**	4.49
	(6.92)	(7.69)	(6.98)	(8.70)
Controls				
Symmetric flood controls	Yes	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	552,902	552,186	554,390	550,698
R-squared	0.078	0.094	0.083	0.094

The unequal sample of communities refer to clusters where the gini coefficient of the wealth index is above the median, when the household itself is excluded. The unequal survey sample of communities refers to clusters where the gini coefficient of the wealth index is above the median in that survey, when the household itself is excluded. Symmetric flood controls are Flood*Female, and Flood. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.

We further investigate the effects by different wealth groups and also in areas where there are more or less poor households. Poor households are defined as those belonging to the lowest 40 percent in terms of wealth, and the baseline category is therefore being non poor. In column 1 of Table 13, we see that while poor households have more infant mortality in general, we find no statistically significant difference between poor and rich households in the effects of droughts on the gender bias in infant mortality (as the coefficient of the interaction term Drought*Poor*Female is insignificant). If anything, the coefficient for the interaction term points in the other direction, suggesting less gender discrimination among the poorest. This is different from in India, where Rose (1999) finds that the gender bias is lower among the richest. Investigating the effects further by splitting the sample into poorer and richer areas, it is evident that the gender bias is only existent in poor areas. This is in accordance with our expectations, but the poorest households have a smaller gender gap following droughts also in the poorer areas, although the individual-level effect of poverty on the gender gap still not statistically significant.

Table 13: Income

Infant Mortality	(1)	(2)	(3)
Sample communities	All	Poorer	Richer
Drought variables			
Drought*Female	24.0**	27.7**	16.8
	(9.43)	(11.7)	(16.9)
Drought	-4.34	-8.20	3.80
	(5.90)	(6.93)	(11.0)
Drought*Poor*Female	-18.0	-25.3	-3.08
	(13.8)	(16.0)	(28.1)
Drought*Poor	-5.44	3.47	-27.1
	(8.88)	(10.4)	(17.3)
Controls			
Poor*Female	0.61	-0.20	1.27
	(1.30)	(1.84)	(1.84)
Poor	14.6***	16.5***	13.0***
	(1.13)	(1.71)	(1.54)
Symmetric flood controls	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes
Fixed effect	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$	$\alpha_{g,x,y}$
Fixed effect	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$	$\alpha_{g,e,l}$
Observations	1,105,088	545,147	559,941
R-squared	0.068	0.073	0.068

Poor refers to households belonging to the 40 percent lowest in terms of wealth. The poorer sample of communities refers to clusters with an average share of poor households below the median when the household itself is excluded. Symmetric flood controls are Flood*Female, Flood, Flood*Poor*Female, and Flood*Poor. Additional controls are mother's age at interview, age^{2}and birth order and multiple birth fixed effects. $\alpha_{g,x,y}$ are gender and country specific year-of-birth fixed effects and $\alpha_{g,e,l}$ are gender and grid cell specific month-of-birth fixed effects. Standard errors clustered on the ERA-Interim grid level in brackets. * significant at 10 %, ** significant at 5 %, *** significant at 1 %.