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Poverty and Witch Killing

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Abstract: Existing empirical studies are typically unable to sort out the direction of causality between poverty and violent crime in less developed countries. This study uses local rainfall variation – which is plausibly exogenous and closely related to income – to estimate the impact of negative income shocks on murder in 67 Tanzanian villages across eleven years. Extreme rainfall leads to a large statistically significant increase in the murder of "witches" – typically elderly women killed by relatives – but not in other types of murders. The results are consistent with a model in which households near subsistence kill (or expel) relatively unproductive elderly household members to safeguard the nutritional status of other members. The theory is bolstered by the fact that most killings take place in low socio-economic status villages during the so-called "hungry season" of the year, and most victims are from poor households. The results provide novel evidence on the role of poverty as a cause of violent crime.

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1. Introduction

Many observers have noted that poverty and violence go hand in hand in less developed countries. For instance, there is a strong negative relationship between economic growth rates and crime across countries, as well as a robust link between low income and the occurrence of civil war.[1] Yet endogeneity and omitted variables complicate the interpretation of these patterns, and existing studies are typically unable to resolve the key econometric identification issues. To illustrate, poverty may lead to violence if desperate people with "nothing to lose" commit more crimes, but violence may in turn affect economic productivity.

This paper uses local rainfall variation to identify the impact of income shocks on murder in a poor semi-arid Tanzanian district.[2] Extreme rainfall – resulting in drought or floods – is plausibly exogenous, and is associated with poor harvests and near famine conditions in the region. Village-level data on murders and rainfall variation for 67 villages over eleven years indicates that extreme rainfall leads to a large and statistically significant increase in the murder of "witches": there are more than twice as many witch murders in years of extreme rainfall as in years of normal rainfall. As discussed below, the victims are nearly all elderly women, often killed by relatives. These results provide novel evidence on the role of extreme poverty as a cause of violent crime.

The findings are consistent with a theoretical model of within-household resource allocation in which households near subsistence levels of consumption kill (or expel) relatively unproductive elderly household members to safeguard the nutritional status of other members.[3] The theory is bolstered by the fact that most witch killings take place in low socio-economic status villages during the "hungry season" of the year, and that most victims are from poor households. The occurrence of similar killings in many

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[1] Refer to Mehlim et al (2000) and Fajnzylber et al (2002) for the crime findings, and to Collier and Hoeffler (2000) and Fearon and Laitin (2001) on civil war. Dreze and Khera (2000) find a negative relationship between murder and socioeconomic measures across Indian districts.

[2] Other social scientists have used rainfall variation to identify important relationships in studies of consumption (Paxson 1992), child health (Hoddinott and Kinsey 2001, Rose 1999), property rights and institutions (Nugent and Sanchez 1999), and election turn-out (Knack 1994).

[3] This is in contrast to other economic models of violence between social groups or classes (Grossman and Kim 1995), rather than within households. Becker (1968) is the seminal work on the economics of crime.

other poor agrarian societies also suggests that they have an underlying economic rationale. Yet it is impossible to completely rule out a competing theory, namely that elderly women are singled out as scapegoats by families in need of some explanation for their misfortunes. Moreover, the concentration of witch murders in villages where most residents follow traditional Tanzanian religions (rather than Christianity or Islam) suggests that "cultural" or "religious" explanations cannot be ignored.

The paper is structured as follows. Section 2 discusses existing anthropological and historical work on witch killings in Tanzania and other parts of the world. Section 3 lays out an economic framework for understanding witch killings. Section 4 describes the survey data used in this project, and Section 5 lays out the empirical estimation strategy. Section 6 presents the empirical results, and the conclusion summarizes the findings and discusses possible policy responses.

2. Background on Witchcraft

Witchcraft beliefs are an important social phenomenon throughout Sub-Saharan Africa, and have shown no tendency to lose salience during the post-colonial period (Moore and Sanders 2001). A belief in witchcraft allows people to make sense of the arbitrary misfortunes that affect their lives, and to pin blame for these events on a particular person rather than on chance (Evans-Pritchard 1937, Ashforth 2002). In particular, African witches – who may be male or female – are widely thought to use their occult powers to inflict harm on other community members, often people in their immediate social circle whom they envy or against whom they harbor grudges (Geschiere 1997). Witchcraft beliefs are likely to be particularly persistent and difficult to falsify in a world of mean-reverting income, weather, and health processes, since actions taken to combat witchcraft will often appear successful.

Witchcraft beliefs are strong in the ethnically Sukuma region of western Tanzania, where a large proportion of the population practice traditional religions and have never adopted Christianity or Islam. In our study area, Meatu District in Shinyanga Region, over sixty percent of 2001 household survey respondents claimed to follow traditional religions. Mesaki (1994: 49) writes:

> Belief in witchcraft is rooted in the whole Sukuma system of knowledge and morality. … [When] misfortunes strike, such as the loss of livestock or a poor harvest, explanation may be found in strained relationships with living people or perhaps the spirits of the dead. … [W]itchcraft in Sukumaland may be held responsible for almost any calamity or misfortune such as sudden storms on the lake, the sudden death of a health person, miscarriages and infertility, the failure of rain, death from snake bite, losing one's way, and various diseases.

Government statistics show a rise in witch killings in western Tanzania since the late 1960s, and some authors have tied this to the radical social transformations that followed independence, including the villagization and agricultural collectivization movements pursued by Tanzania's socialist regime (Abraham 1987). The Tanzanian government reported that 3,072 accused witches were killed in Sukumaland from 1970 to 1988, more than two-thirds of the national witch murder total. According to these figures, approximately 80 percent of victims were women and their median age was between 50 to 60 years old – an advanced age for Tanzania, where life expectancy is only 51 years (UNDP 2002).

Residents of western Tanzania and anthropologists who study the area claim that relatives, kin, and neighbors are usually behind the murders, and this is consistent with research from other parts of Africa suggesting that "witchcraft is the dark side of kinship" (Geschiere 1997: 11). The following 1991 account of a seventy-year old woman who fled from her home (near our study area) and subsequently lived homeless near the railway station in the regional capital, suggests that negative health and income shocks are prime motivations for the killings (Mesaki 1994: 59):

> I ran away from Rusule in Shinyanga District after being suspected of being a witch. … There were many deaths in the family … then rumour began to spread in the village that I was the one who killed them … [M]y own children started to hate me, … some of them started taunting me as a witch. I tried to explain but they did not give me the chance to vindicate myself. I knew what would befall me in view of what had happened to others previously, for they were brutally killed. Thus, when … one of the grandchildren whispered to me that they were about to kill me, I left the same evening. … They had discussed the issue in front of the children and this saved my life. I have lived in this camp for three years now, and though I love my family, there is no way of going back to face certain death.

Many women are not this fortunate and are brutally massacred in their homes, usually with machetes.

Although public witchcraft accusations have been illegal since the British Witchcraft Ordinance of 1928, and the law remains nearly unchanged to the present day (Green 1994: 23-24), Tanzanian government efforts to stop the killings have been largely unsuccessful. In one notable episode, the Shinyanga regional government did pursue an aggressive program to prosecute individuals suspected of carrying out witch killings during the late 1970s, arresting 897 individuals. Yet the project was ultimately called off after at least twelve suspects died in police custody, and "as a result the remaining suspects were set free, whereupon the killings (which had subsided) resumed again" (Mesaki 1994: 57). The aggressive prosecution of witch killers also placed government officials in a precarious political position, leading to a popular perception that they were siding with the witches.

The government reports that only seven of 1622 individuals arrested in connection with witch killings during the 1970s and 1980s were successfully convicted in court, and since then the conviction rate has fallen even lower, largely due to a lack of witnesses (not surprising given the frequent complicity of relatives in the murders). Tanzanian President Mwinyi addressed a 1987 rally in our study district with the following statement (Mesaki 1994: 58):

> You are killing innocent women, some of them your own mothers, grandmothers or old people who have all along taken good care of you: how come they suddenly become witches? Do (you) pay them back by killing them?

The rise of witch killings has also been tied to the resurgence of a pre-colonial local political institution, the male elders council, called *Sungusungu*. The *Sungusungu* first appeared in western Tanzania as a response to a wave of cattle theft that exploded during the economic crisis of the early 1980s, and they are popularly credited with having put an end to disorder in rural areas by organizing patrols of young men to punish suspected thieves and recover stolen property (Abrahams and Bukurura 1992: 94-95). In many villages, the *Sungusungu* also organize mutual insurance and emergency credit schemes for village residents, and are entrusted with collecting funds for local development projects.

But in addition to these activities, the all-male *Sungusungu* also consider combating witches central to their overall mission of promoting village security. They have been implicated in many witch killings, as well as in the expulsion of suspected witches from the village, after receiving "credible" information on the witchcraft activities of a particular individual, usually from a traditional healer hired by relatives of the “witch” (Abrahams 1994). A recent news report confirms that witch killing is widely viewed as public service: “In the Sukuma community, if you kill a witch it is not really considered a crime. It’s like you are doing something for the community” (BBC 2002). Witchcraft is a tangible reality for many Tanzanians and its perpetrators are viewed as criminals just as dangerous as ordinary thieves and murderers, and thus from the point of view of most residents, the witch killers are simply pursuing justice[4] – a view that runs against both Tanzanian law and international human rights norms.

2.1 Witch Killing Around the World

Witch killings are not unique to Tanzania. Attacks follow a similar pattern in rural northern Ghana, where thousands of women have been attacked and driven from their villages in the past decade, often following struggles over household resources (BBC 2001, EWD 2002). Witch killings of elderly women have also been documented in Kenya, Mozambique, and Uganda, and in Zimbabwe, where “old widows in rural areas, especially those living alone risk being branded as witches, abused, and stoned.” (EWD 2002). At least 400 suspected witches have been killed since 1985 in South Africa’s poor Northern Province (Niehaus 2001).

Witchcraft accusations in Africa are not restricted to elderly women. In the face of recent economic crises in Congo, young children have become common culprits (BBC 1999, 2003), and many are kicked out of their home or killed by family members (The Economist 2002):

> By one estimate there are 40,000 street children in Kinshasa, of whom 80% have been kicked out of their homes because their families thought they were witches. … Death or disease in the family is often taken as evidence of sorcery. Failed crops, lost jobs and bad dreams also arouse suspicion. Midway through last year, several hundred children were turfed onto the street of Mbuji-Mayi, a mining town, after a sudden drop in diamond prices.

In Andean regions of South America, isolated indigenous communities punish suspected witches with expulsion or execution, and a significant community of such expelled witches has developed in the Bolivian city of Santa Cruz. Yet it is not only witches who are sometimes killed in

[4] Not all Tanzanians take this stance, and in fact several local human rights groups have actively campaigned against witch killings in recent years, most notably the Tanzania Media Women’s Association (TAMWA).

these communities: "there are also cases where the community practice is to kill or abandon infant twins or babies born handicapped, female or to large families, as well as old or very sick people, because they are considered to be a burden on the community" (Von Cott 2000: 222). Witch attacks have also been documented in Bihar, the poorest state in India (EWD 2002):

> [I]n tribal communities, widows are sometimes killed as witches. The underlying motivation is economic: the accusers tend to be the male relatives, brothers-in-law or step-sons who want to control the land. It is reported that in the Jharkland region of Bihar, of 95 [murder] cases … over a 30-year period, 46 were witch killings of which 42 of the victims were [female] widows.

There are also parallels between contemporary witch killings and those in Europe and North America in the 16th to 18th century, during which at least 40,000-50,000 individuals were murdered (Rowlands 1998). Most European victims were also women, predominantly poor and elderly, and often widows (Rowlands 1998: 300). Witches in early modern Europe were credited with power over weather, crops, and health (Behringer 1999: 339). Many of Europe's leading political and ecclesiastical authorities opposed witch killings in their territories, but the killings continued nonetheless, though typically in poor and outlying agrarian regions (Behringer 1999: 341). There is also recent historical evidence that extreme weather – mainly heavy precipitation and low temperatures – that lowered crop yields was often a proximate cause of witchcraft accusations in Europe and North America during this period (Behringer 1999: 344; Oster 2002), including possibly the Salem witch trials, which occurred during years of particularly unfavorable weather.

3. Resource Allocation in Extremely Poor Households and the Elderly

This stylized theoretical framework emphasizes the importance of within-household conflict over resources in the aftermath of negative income shocks as the underlying cause of witch killing.[5] There are four main assumptions. First, resource allocation choices are made entirely within the household, abstracting away from community-wide insurance networks. This is a reasonable starting point for

[5] The model is related to Ray (1998: 279). This framework is also potentially relevant for understanding within-household allocation issues during famines, such as the massive Chinese famine of 1958-61 (Jasper Becker 1996).

years of extreme rainfall and generalized local crop failure, when such networks are weakened or break down. Second, and crucially, there is one household member – the "Patriarch" – who determines resource allocation within the household. Third, there is a minimal level of food consumption needed to maintain life and below which an individual dies of starvation or disease.[6] In reality there is no sharp starvation threshold, but similar results hold if the mapping from food consumption to the survival probability is increasing and sufficiently convex at low consumption levels. Fourth, household members are identical except in terms of future economic production, and the elderly have lower future production than either young adults or children.

The Patriarch divides current income among household members to maximize a household utility function. Current income is a function of rainfall in the period, and is significantly lower in years of extreme rainfall, due to crop failure. The Patriarch maximizes the sum of future household production taking into account the survival of household members (since individuals who consume less than the subsistence level $\underline{C}$ perish) and subject to the household budget constraint. The consumption of individual *i* in household *h* and village *k* during period *t* is represented by C_{ihkt}, and the probability of survival is an increasing function $s(C_{ihkt})$ of individual consumption[7], where $s(C_{ihkt}) = 1(C_{ihkt} \geq \underline{C})$; the future production[8] of an individual is represented by V_{ihkt}; an indicator variable for extreme rainfall in village *k* during period *t* is R_{kt}; and household income Y_{hkt} is a function of a vector of household and village socioeconomic characteristics, X_{hkt}, and is decreasing in extreme rainfall. The maximization problem can thus be represented as:

$$\underset{\{C_{ihkt}\}}{Max} \sum_i s(C_{ihkt}) \cdot V_{ihkt} \quad \text{s.t.} \quad \sum_i C_{ihkt} = Y_{hkt}(X_{hkt}, R_{kt}) \qquad (1)$$

There are two cases. In years of *normal rainfall*, there is sufficient income to sustain all household members above subsistence. In years of *extreme rainfall*, crops are more likely to fail and there may not be sufficient income to meet the minimum nutritional needs of all household members, in

[6] Basal metabolism demands roughly two-thirds of normal nutritional requirements (Dasgupta 1993).
[7] Differential food consumption needs by age are not included in the model, but could be easily incorporated.
[8] V_{ihkt} could also be thought of as time-discounted future individual production.

which case spreading resources equally among all members would be disastrous, putting all at risk of starvation. Instead the Patriarch – in a harsh but possibly unavoidable calculus – chooses the individual (or individuals) with the lowest future production to be reduced to zero consumption, and concentrates resources on survivors. As Ray (1998: 279) writes: "The potential merit of unequal division [of resources] is that it helps some individuals in the household to be minimally productive under extreme circumstances."[9] Reducing someone to zero consumption can be thought of as starving her to death, neglecting her, driving her out of the household, or murdering her.

The elderly have the lowest future income of all household members, and by the logic of the model are thus most likely to be reduced to zero consumption. The model also suggests there are likely to be disproportionately many witch killings in poor areas, where households are closer to subsistence consumption.[10] Infants are the other obvious target, since they remain unproductive for many years, and are particularly susceptible to mortality from reduced food consumption, neglect, and violence.

The decision of whom to target for zero consumption has political as well as economic dimensions, and elderly women's fate in rural Tanzania can be seen as an extreme manifestation of pervasive gender inequalities in East Africa. For instance, local political leaders are almost entirely male, which means that elderly men – most of whom serve on the *Sungusungu* – provide households with valuable access to political power but elderly women cannot. Patrilocal marital exogamy (in which women move out of their natal village upon marriage) is commonly practiced in our study area, and this further contributes to the social marginalization of women and perhaps makes them more vulnerable to

[9] Kochar (1999) documents that household medical spending on the elderly is strongly positively correlated with their labor productivity in rural Pakistan, further evidence that productivity considerations enter into within-household allocation choices. The framework also relates to Rosenzweig and Schultz (1982), who examine within-household resource allocation across girls and boys in India as a function of local labor market opportunities for women. However, the implications of this model do not resonate with Becker's (1981) seminal work on within-family resource distribution. Becker shows that even selfish individuals are likely to act in a restrained manner toward other household members due to the redistributive actions of the benevolent household "dictator". The current study examines a situation of extreme resource scarcity where this prediction breaks down.

[10] Unfortunately, the dataset from Tanzania does not allow us to examine whether negative shocks also lead to differential increases in the average morality of the elderly relative to younger adults from all causes.

attack.[11] Wandel and Homboe-Ottesen's (1992) study in the nearby Rukwa region finds that women bear the brunt of food insecurity: while men largely maintain their body weight throughout the harvest cycle, adult women lost an average of 3.1 percent of their weight during the pre-harvest "hungry season" even in relatively good years, and children in low socioeconomic status households also showed substantial deterioration in nutritional status. Dercon and Krishnan (2000) reach a similar conclusion regarding the relative bargaining power of men and women in rural Ethiopian households, with men once again securing the lion's share of resources in low income years.[12]

The period of the year during which women are likely to be especially vulnerable to attacks in rural western Tanzania is the "hungry season". The agricultural year is roughly divided in two periods: the post-harvest period from August to January – during which food is relatively plentiful – and the hungry season from February to July, during which time food becomes increasingly scarce, in the months before the next harvest. The 2001 Household Survey data (described below) indicates that most household food stores from the previous harvest are depleted by January or February of the following year, after which time households dip into their limited savings, sell assets (e.g., cattle), or labor on other farms to survive. These tough household resource choices need to be made during the hungry season, when households have run out of other options.

3.1 Perspectives from Anthropology

There is an extensive literature that claims poor pre-industrial societies frequently responded to acute environmental stress by killing the elderly (geronticide) or infants, when they were seen as a burden on the community. Brogden (2000: 67) writes:

[11] There are roughly equal numbers of women and men aged 50 years and above in this area according to the 2001 survey data, so it cannot simply be the case that elderly women are disproportionately targeted for attack among the elderly solely because they are much more numerous than men.

[12] Yet the situation may be even worse for women without husbands in the household: Rahman et al (1992) and Chen and Dreze (1992) document the sharp increase in mortality among elderly female widows relative to non-widows in Bangladesh and India, respectively.

> Many societies, from the Artic to the tropics, when they perceive a resource threat to the common good … kill expendable persons, thereby stabilizing their conditions. The expendable persons were the very young or the very old.

Over one-third of the pre-industrial societies surveyed in Simmons (1945), Glascock (1987), and Silverman and Maxwell (1984) engaged in "death-hastening" activities for the elderly, including food being withdrawn, abandonment, or murder, and these authors find that available resources are often the key determinant of the treatment of the elderly.[13] Shalinsky and Glascock (1988) note that a similar logic applies to the treatment of infants. Maxwell, Silverman, and Maxwell (1990: 77) claim that "geronticide is usually … the result of decisions made by an intimate group of kinsmen".

The model presented above highlights these potential economic motivations behind witch killings, but in no way seeks to diminish the importance of other explanations, which should be seen as complements to economic theory. For instance, other studies have emphasized that witches serve an important social role as scapegoats for local misfortunes (Abrahams 1994, Behringer 1999). Since scapegoating is most likely to emerge in periods of severe economic insecurity, negative income shocks are the underlying cause of witch killings in a reduced-form sense even if scapegoating is a proximate cause. Thus, the two explanations – extreme poverty and scapegoating – are not necessarily in conflict, and in practice it is difficult to distinguish them empirically. Claiming – and believing – that the murder victim was truly a witch may also alleviate the social stigma and psychological trauma associated with the murder of a relative, allowing killers to justify their actions both to themselves and the community.

4. Data and Measurement

4.1 Survey Data

Data collection for two survey instruments – the Village Council Survey and the Household Survey – was carried out in two waves during 2001-2002 by the field staff of a local non-governmental organization (ICS Africa) with the cooperation of Meatu, Tanzania District Council authorities.

[13] "Where resources were even more meager, as with the Amassalik Inuit, the decrepit elderly, when perceived as a community burden … were abandoned on an ice floe when the tribe was out fishing" (Brogden 2000: 65).

The Village Council Survey was administered in all 71 villages and relied both on interviews with Village Council members and local administrative records. Four villages are missing data for at least some survey component, reducing the sample to 67 villages. We asked the Village Council the following question: *"Has this village faced any natural disasters or calamities in the past ten years? (Prompt: For example, drought, famine, floods, locusts.)"* There was broad consensus on what constituted a "natural disaster or calamity" among the village officials, five to fifteen of whom typically participated in the interview. We also collected information on outbreaks of human disease epidemics and livestock epidemics by year.

Unfortunately, precise village-level rainfall measures (in millimeters of rain, for example) do not exist for all of these villages. However, we did obtain annual rainfall data over six years from the rainfall station in the district capital, and compared these figures to Village Council Survey reports from villages located in the same administrative ward as the capital to validate the accuracy of the survey reports. The correlation between millimeters of rainfall and average reported flooding in these villages is over 0.8 (and highly statistically significant), and the correlation between millimeters of rainfall and reported drought is -0.6 (marginally statistically significant), and a similarly strong pattern holds for days of rainfall.[14] Appendix Figure A1 graphically illustrates the strong relationship between Village Council Survey rainfall reports and millimeters of rainfall in the district capital.

In a separate section of the survey, we asked Village Council members whether there had been any murders in the village during the previous ten years, and if so, the number and years of the murders. The collection of violent crime data in each village in the presence of multiple local officials is a strength of the current project, since such interviews are likely to yield more reliable information than government crime statistics in rural Tanzania. Murders are sufficiently rare events that they are widely remembered in the village, and there was a high degree of consensus among Village Council members on the events. There was also a remarkable openness to discuss witch killings and the interviews raised

[14] Mean annual rainfall in the district capital (Mwanhuzi) during 1996 to 2001 was 633 mm and 45 days of rain.

no obvious concerns about data reliability.[15] (Recall that witch murders are rarely if ever punished in Tanzania.) If a witch killing had ever occurred in a village, we also collected information on the personal characteristics of the most recent victim, including gender, age, and ethnic group; wealth relative to others in the village; whether or not she lived alone; and the month of the murder. The number of witch attacks by year was also collected, although this variable is more difficult to capture than murder, since in practice we tried to include those who were "forced out" of the village as well as those actually physically assaulted, and individuals who flee in anticipation of an attack may be missed. Retrospective questions on non-violent crimes (e.g., property crimes) were not included in the survey because it was felt that recall data stretching back across several years would not be sufficiently reliable for such common crimes.

The Household Survey was administered to 15-20 households from each village, and in all, 1293 households were surveyed in 2001. Surveyed households were randomly sampled from the Village Tax Register, and a random neighbor of each sampled households was also surveyed, in order to obtain a representative sample. The Household Survey collected detailed socioeconomic, migration, and demographic information, as well as a consumption expenditure module for a subset of households. The principal food crop in the district is corn (maize), which is grown by 84 percent of households, while the main cash crop is cotton, grown by 64 percent of households. Note that this area is very poor: only two percent of households use irrigation rather than rain-fed agriculture, only six percent have a household member with a salaried formal sector job, and on average 75 percent of income goes toward food consumption. Poor roads to neighboring districts, an inadequate formal financial infrastructure, and low grain storage rates combine to produce large fluctuations in the local price of grain through the calendar year, further evidence on the high degree of food insecurity in this area.

[15] Regarding the possibility that rainfall reports would somehow contaminate murder reports, or vice versa, by making certain years particularly "salient" to respondents, we note that there is no obvious reason why witch murders would be over-reported in years of extreme rainfall but not in years of other calamities (for example, disease epidemics), or why witch murders, but not other types of murder, would be over-reported in extreme rainfall years. As reported below, there is no significant correlation between witch murders and other local calamities, or between extreme rainfall and non-witch murders (see Table 5), partially ameliorating these concerns.

The 2001 Household Survey also collected a roster of household members, allowing us to estimate the age and sex composition of each village among the subsample of surveyed households. In particular, we construct the proportion of the 2001 village population composed of girls (boys) born in each year from 1992 to 2001, and use these figures to test whether there are fewer surviving children born in years of extreme rainfall, as discussed in greater detail below.

4.2 Satellite Vegetation Data

We employ satellite imagery on local vegetation levels – the normalized difference vegetation index (NDVI) – as a second source of information on weather variability.[16] The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation, and higher values indicate greater amounts of vegetation, and are correlated with higher rainfall levels (Nicholson et al 1990): "comparative data show that there is a near linear relationship between NDVI and precipitation in a range of semi-arid lands of Africa" (Anyamba et al 2002: 138). The NDVI values in this study have been normalized to take on values lying within the unit interval.

The principal strength of the satellite data relative to the Village Council Survey reports is that it is not prone to recall errors. However, the data also has several important drawbacks. First, the NDVI data has 8 kilometer spatial resolution, and as a result, when we match up the satellite data to village GPS locations we are sometimes unable to distinguish between vegetation levels across nearby villages; in total, there are 51 distinct vegetation readings (pixels) for the 67 villages. Error can also be introduced when the data are collected under "non-standard conditions", for instance, if it is cloudy. These two sources of inaccuracy are likely to lead to attenuation bias toward zero in coefficient estimates on the satellite vegetation measures in the empirical analysis. A potentially more serious

[16] NDVI is derived from data collected by National Oceanic and Atmospheric Administration (NOAA) satellites, and processed by the Global Inventory Monitoring and Modeling Studies (GIMMS) at the National Aeronautics and Space Administration (NASA). NDVI is calculated from two channels of the AVHRR sensor, i.e., reflected solar radiation in the near-infrared (NIR) and visible (VIS) wavelengths, using the following algorithm: NDVI = (NIR - VIS)/(NIR + VIS). Characteristics of these NDVI data include: spatial resolution of 8.0 km; Albers equal area (conic) projection; calibration for inter- and intra-sensor degradation; and calibration for El Chichon and Mt. Pinatubo volcanic events. For more information: http://www.fews.net/current/imagery/index.cfm.

possibility is that local cropping choices – for example, the decision to leave land fallow – can impact measured NDVI, thus leading the vegetation measure to diverge from rainfall levels. Yet despite these potential concerns, it is reassuring that the correlation across years between the vegetation index and millimeters of rainfall in the district capital is high (at nearly 0.8), as presented graphically in Appendix Figure A2, and the data thus appear sufficiently reliable to be used in the analysis.

The principal measure of extreme weather using the NDVI data is the deviation from average vegetation during the rainy season (which runs from October of the previous calendar year to February).[17] We focus on the absolute value of this deviation, and construct indicator variables for large absolute deviations, using values similar in magnitude to those considered large in existing studies (e.g., Anyamba et al 2002).

5. Estimation Strategy

The exogeneity of local rainfall variation is central to the identification strategy. Ideally, we would also have income data for each village in each year of the study, and would employ an instrumental variable approach to identify the effect of income on murders (using rainfall as an instrument for income in the first stage). However, in the absence of longitudinal village income data, we instead focus on the reduced-form impact of extreme rainfall on murder.

There is longitudinal data for the 67 villages with complete survey information over eleven years, 1992-2002. In Equation 2, M_{kt} is the number of witch murders in village k during year t. The number of murders is a function of X_{kt}, village socioeconomic, demographic, and disease characteristics collected in the 2001-2002 surveys (described above), as well as of an indicator variable for extreme rainfall, R_{kt}, which takes on a value of one if a drought or floods occurred in village k during year t according the Village Council reports, and zero otherwise[18]; the alternative measure of extreme rainfall

[17] Average vegetation is computed over the entire period for which we have data, 1982-2002.

[18] There are a number of reasons to focus on rainfall variation rather than reported famine. First, famine is partly a function of village institutional capacity and the strength of political links to district authorities, and both of these

from satellite vegetation data is used as a robustness check in some specifications. To the extent that these weather reports are "noisy", coefficient estimates will be biased toward zero and thus serve as lower bounds on the true rainfall effects. The idiosyncratic village-year disturbance term, ε_{kt}, is included in all specifications, and we allow regression disturbance terms to be correlated across years for the same village, but to be independent across villages. The estimation equation becomes:

$$M_{kt} = \alpha_2 + X_{kt}{}' \beta_2 + \gamma_2 R_{kt} + \varepsilon_{2kt} \qquad (2)$$

We primarily focus on the number of murders rather than rates, although, as we show below, results are largely robust to the use of rates.[19]

Ethnographic evidence from Tanzania claims that witch killings often occur after a series of unexplained deaths of people or livestock, and to explore this possibility we include controls for disease epidemics in certain specifications. We also interact village explanatory variables with extreme rainfall to test whether villages with particular characteristics are prone to killings in extreme rainfall years.

Village fixed effects (α_k) capture time-invariant omitted variables – most obviously geographical factors – that could be correlated with both rainfall and with murder, as in Equation 3, and now X_{kt} includes only time-varying village characteristics such as the disease epidemic controls. Nineteen percent of the variation in extreme rainfall is explained with village fixed effects, indicating that the bulk of the variation is across years rather than across villages.[20] This yields our preferred specification:

$$M_{kt} = \alpha_{3k} + X_{kt}{}' \beta_3 + \gamma_3 R_{kt} + \varepsilon_{3kt} \qquad (3)$$

In an extension, year fixed effects are sometimes included to capture any district-wide time trends.

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characteristics may also affect witch murders. Since these characteristics vary through time, and hence are not captured in village fixed effects, we prefer to focus on rainfall variation, which is exogenous. Another concern relates to the Village Council's classification of famine years: the coefficient estimate on famine will be downward biased if years when food aid arrives are considered "famines", but years when food aid does not arrive are less likely to be considered famines, even if conditions are equally bad. Nonetheless, specifications including an indicator for famine as the key explanatory variable generate results broadly similar to – though somewhat weaker than – specifications with extreme rainfall (results not shown).

[19] Most villages experience zero or one murders in a given year, and thus the "rate" mechanically becomes an inverse function of population, which we avoid by using the number of murders.

[20] Including both village fixed effects and year indicators captures 29 percent of the variation in extreme rainfall.

The possibility of food relief in famine years somewhat complicates the interpretation of the coefficient estimate on extreme rainfall. The 2001 survey indicates that 73 percent of villages in Meatu district had received some free food aid from the Tanzanian government or a non-governmental organization in the recent past (although we unfortunately do not have information on the precise years of relief), highlighting the chronic food insecurity in this district. If relief aid boosts income and blunts the within-household resource conflicts that we argue above are an underlying cause of witch murders, case coefficient estimates should be interpreted as lower bounds on the effects in the absence of relief.

6. Empirical Results

6.1 Descriptive Statistics

There are 0.2 murders per village-year on average, or roughly one per village every five years (Table 1, Panel A).[21] Murders are nearly evenly divided between witch murders and non-witch murders, with a total of 65 witch murders and 68 non-witch murders during the period. Figure 1 presents witch murders by village, geographic location using GPS data. There are also approximately as many non-fatal witch attacks as witch murders.

Extreme rainfall occurs approximately once every six years, typically from drought but also from flooding (including the massive 1998 El Niño floods – Table 1, Panel B). Villages experience two consecutive years of extreme rainfall in 0.08 of all years.[22] Famine and human disease epidemics also typically occur approximately once every six years (the means are 0.18 and 0.15, respectively), while livestock epidemics are rare during the period. The average vegetation (NDVI) level in the rainy season during this period is 0.35, the average absolute deviation from this normal vegetation level is 0.06, and the absolute deviation is at least 0.09 in roughly one-quarter of all years and at least 0.1 in nearly one-

[21] The annual murder rate in Meatu from 1992-2002 is roughly 6 per 100,000 population, slightly lower than the U.S. rate of approximately 8 per 100,000 population during the 1990s (http://www.ojp.usdoj.gov/bjs/), and somewhat higher than the Indian rate of approximately 4 per 100,000 (Dreze and Khera 2000).
[22] Extreme rainfall is only moderately serially correlated: the first-order autoregressive coefficient estimate is 0.18.

fifth of years (Table 1, Panel C). As with the Village Council reports, about two-thirds of large rainfall deviations are due to drought rather than flooding.

Annual per capita income in 2001 was only $197 (Table 1, Panel D), meaning that households in this area are poor even for Tanzania, one of the poorest countries in the world with per capita income of approximately $256 (UNDP 2002). The average household survey respondent had about four years of education, again below the Tanzanian average (United Republic of Tanzania 1999). The Sukuma ethnic group make up approximately 90 percent of the population, and the district has a high rates of adherence to traditional religions, at 64 percent. There are only two women's community groups per village on average. Among young children under ten years old, there are slightly more boys than girls.

Witch killing victims are nearly all female (96 percent – Table 2, Panel A)[23], with relatives living in the village (98 percent), and ethnically Sukuma (96 percent). Both the median and mean victim age is over 50 years, and a non-trivial proportion lived alone at the time of the attack (we unfortunately did not collect information on victims' widow status, but it is reported anecdotally that they are often widows). Along three dimensions of wealth, victims tend to come from households either "below average" or "average" for the village (Table 2, Panel B). For example, in terms of livestock ownership, 55 percent of victims' households were below average for the village, 38 percent were average, and only 8 percent above average. Similarly for ownership of household goods (e.g., a radio) 69 percent were below average and none above average, although the figures are more balanced for land ownership.

Witch murders are concentrated in the six month pre-harvest period (the "hungry season") from February to July, when most food stores have been exhausted, and there is a sharp drop in witch murders immediately after the harvest, which usually ends in July or August (Table 2, Panel C). The hypothesis that the proportion of witch murders is the same in the pre-harvest and post-harvest periods is rejected at 99 percent confidence.

[23] In fact, only two victims during this period were male. In one case, the victim was the husband of the intended female "witch", but he was reportedly killed with bows and arrows while walking around his homestead at night when the killers mistook him for his wife; the intended victim subsequently fled the village for safety.

6.2 Witch Killing Results

Extreme rainfall leads to large income drops in Meatu district. Regressing average village income in 2001 (from the Household Survey) on an indicator for extreme rainfall in that year, as well as on geographic division indicators and other village characteristics – average educational attainment, proportion of households growing a cash crop, proportion Sukuma, proportion who follow traditional religions, number of households in the village, and the density of women's groups – indicates that average income is approximately 51 U.S. dollars lower (standard error 25 dollars) in villages experiencing extreme rainfall – about 25 percent of average income – and this effect is statistically significant at 95 percent confidence (Table 3, regression 1). Floods have a somewhat larger negative effect on income than droughts, but we cannot reject the hypothesis that floods and drought have the same effect (regression 2, p-value = 0.45).

Extreme rainfall is also associated with famine: the coefficient estimate on extreme rainfall is 0.46 (Table 3, regression 3). Drought and flood entered separately are both also highly significant predictors of famine (regression 4), though drought has the larger effect. Extreme rainfall is uncorrelated with human disease epidemics and livestock epidemics (regressions 5-6), which is somewhat surprising since malnutrition often leads to disease.

In the main empirical result of the paper, extreme rainfall is strongly positively associated with witch murders in these villages (Table 4, regression 1). Extreme rainfall is associated with 0.085 more witch murders per village-year (significant at 95 percent confidence) in the village fixed effects specification, which implies that there are over twice as many witch murders in years of extreme rainfall as other years.[24] Figure 2 graphically illustrates the positive relationship between the proportion of villages experiencing extreme rainfall and witch murders by year from 1992 to 2002. Drought and flood

[24] Results are similar with ordered probit or binomial probit estimation, where the dependent variable in the latter case takes on a value of one if a witch murder occurred in the village. Village characteristics are included as controls rather than fixed effects in these specifications. To illustrate, in the binomial probit specification the estimated marginal effect of extreme rainfall is 0.071 (standard error 0.036).

both have a similar impact on murders – with point estimates of 0.099 and 0.080, respectively (regressions not shown) – and hence we focus on the single extreme rainfall indicator variable.

The main witch murder result is similar when controls for extreme rainfall in the previous year and in two consecutive years are included (Table 4, regression 2), neither of which is significantly associated with witch murder.[25] The result is also robust to the inclusion of explanatory variables for disease epidemic outbreaks (regression 3). Human disease outbreaks may either increase or decrease household per capita income depending on the labor productivity of the victim, and thus the within-household resource allocation model yields ambiguous predictions for how disease should affect witch murders. The rainfall results are also largely robust to the inclusion of year fixed effects (Regression 4), although in this case the point estimate falls from 0.085 to 0.056 and becomes only marginally significant (p-value = 0.14).[26] This drop is not unexpected since large parts of the district may be subject to common weather shocks, such as the 1998 El Niño floods. To test for outliers, we dropped one village at a time and found the resulting coefficient estimates range from 0.07-0.11 and are significantly different than zero at 90 percent confidence in all cases (results not shown).[27] Using a two-sample instrumental variable approach related to Angrist and Krueger (1992), we estimate the structural relationship between average village income (in U.S. dollars) and witch murders as (0.085) / (–50.7) = –0.00167, and this implies that an increase in average village income from the Meatu average of $197 to the Tanzanian national average of $256 would reduce witch murders by –0.1 per village year.

[25] One possible explanation for the weak effect of two consecutive years of extreme rainfall is the possibility that the most vulnerable elderly die (of either natural or unnatural causes) during the first extreme rainfall year. An indicator for extreme rainfall in the following year is not a significant predictor of witch murders (estimate 0.046, standard error 0.050, regression not shown), which serves as a specification check.

[26] The 2002 Village Council surveys were collected from mid-July through late-August 2002, and hence the 2002 data may miss some murders committed after August (although Table 2 suggests that very few witch killings occur in this post-harvest period). Nonetheless, dropping the 2002 data leaves the main results essentially unchanged (coefficient estimate 0.086, standard error 0.046).

[27] We also investigated using world cotton prices as an alternative source of variation in income, but the cotton price is not significantly related to witch killings (results not shown). However, there is a single world price of cotton in a given year, and hence no variation across villages, and, moreover, the cotton price series is reasonably stable during 1992-2002, leading to imprecise coefficient estimates. The effect of extreme rainfall on witch murders is robust to the inclusion of the cotton price as an additional explanatory variable (result not shown).

The coefficient estimate on the absolute deviation from average vegetation (NDVI) during the rainy season is positive but statistically insignificant (Table 5, regression 2). Coefficient estimates on indicator variables for absolute deviations greater than 0.08, 0.09, and 0.1 range from 0.047 to 0.062 (Regressions 3-5), and in the case of the 0.09 deviation indicator, the coefficient estimate is statistically significant at 90 percent confidence (0.062, standard error 0.037). The finding of somewhat smaller coefficient estimates on the satellite weather variables relative to the Village Council reports may be due to attenuation bias, as discussed above. Although not definitive on their own, these results corroborate the main findings in Table 4, namely, that extreme weather leads to more witch murders.[28]

The witch murder results are robust to the use of a murder rate (per 1000 households[29] – Table 6, row 2), and coefficients are similarly large and positive when the number of witch killings plus attacks (rows 3-4) is the dependent variable. Yet, perhaps surprisingly, extreme rainfall is unrelated to the number of non-witch murders in these villages: the point estimate on extreme rainfall is near zero (Table 6, rows 5-6). Taking both types of murder together, extreme rainfall has a positive but marginally statistically significant effect on total murders (rows 7-8).

Villages with higher average socioeconomic status have fewer witch murders, and this is particularly true for villages with higher educational levels (Table 7, regression 1); the proportion of residents who follow traditional religions, who are Sukuma, and the density of women's groups are not significantly associated with witch murders. In a related result, average income is strongly negatively related to non-witch murders, while villages with larger populations have more such murders (regression 2). The only village characteristic that is robustly related to the total number of murders is average village per capita income, which is significantly negatively related to murders (Table 7, regression 3). The effect of income on murder in this area is sizeable: an increase in average village per capita income to the overall Tanzanian average is associated with nearly 0.04 fewer total murders per village-year, or

[28] We also investigated the relationship between absolute vegetation deviations and witch killings non-parametrically, and the estimated relationship is largely positive (not shown). However, the non-parametric regression confidence intervals are large (in part due to relatively small sample sizes), and thus we do not emphasize these results, since they are only moderately informative.

[29] Total village population is missing in several villages, hence the use of households.

17 percent of the average number of murders. This is despite attenuation bias, which is likely since the village income measure is based on a subset of sampled households in each village; correcting for attenuation bias – given the number of surveys with income data (usually four or five per village), and the observed variation in per capita income across households – suggests that the true effect of the increase in village per capita income would be a nearly 30 percent reduction in murders.

Witch murders in extreme rainfall years are mainly concentrated in villages where more residents practice tradition religions: the coefficient estimate on the interaction between extreme rainfall and the proportion who practice traditional religions (in a specification without village fixed effects) is 0.27 (standard error 0.14, regression not shown), which is statistically significant at 90 percent confidence, although it remains possible that this term is capturing some unobserved dimension of local socioeconomic status in addition to the effect of traditional religion. In contrast, the effect of extreme rainfall is not significantly different in villages with more income, education levels, Sukumas, households growing cash crops, total households, or local women's groups (results not shown).[30]

6.3 Infant Survival Results

The infant survival findings presented in this sub-section are more tentative than the paper's other results, in part because we do not have actual infant mortality records. We instead rely on Household Survey data on the number of girls and boys living in each village in 2001 by birth year cohort, among the sampled households. The main hypothesis is that these birth cohorts are smaller for years in which the village experienced extreme rainfall due to higher infant mortality rates, in line with the theoretical model presented above.

Of course, actual cohort size is an imperfect measure of infant survival in the first year of life. One obvious possibility is that parents could foster their children (send children to live with relatives

[30] A specification in which extreme rainfall is used as an instrument for famine yields a point estimate of 0.20 (standard error 0.11), although this is potentially misleading since extreme rainfall that does not result in famine may still be associated with a negative income shock, i.e., the exclusion restriction may not hold.

elsewhere) in the aftermath of negative income shocks, and there may be a gender differential in fostering rates; although fostering appears less likely to be an important issue for infants under age one – who typically rely on their mothers for food – than it is for older children, this remains a concern.

Infants up to one year of age are considerably more vulnerable to mortality than older children: for instance, nearly two-thirds of all under-five mortality in Tanzania occurs before age one (UNDP 2002)[31]. Also note that, in contexts where girls and boys receive comparable medical care and nutrition, infant mortality is typically higher for boys – for example, in the U.S. (Hoyert et al 2001), Indonesia (Wahab et al 2001), and Taiwan (Yang et al 1996) – and this gender mortality differential is especially pronounced for low birthweight babies (Stevenson et al 2000). This implies that to the extent infant mortality is in fact higher for girls than for boys, it is likely to be due to the relatively low food consumption, poor medical care or plain mistreatment of girls.

There is no significant relationship between extreme rainfall and the proportion of girls born that year in the village population (Table 8, regression 1), but in 2001 there were significantly fewer living girls born in years in which the village had experienced two consecutive years of extreme rainfall relative to other extreme rainfall years (regression 2): the coefficient estimate is -0.0075 (standard error 0.0031), which implies a huge 42 percent drop in the proportion of girls born that year (in a specification with both village and year fixed effects). Comparing years in which the village had experienced two consecutive years of extreme rainfall to years in which there was not extreme rainfall in either the current or previous year weakens the result: the point estimate (the sum of the three coefficient estimates presented in Table 8, regression 2) remains negative but falls in magnitude to -0.0015 and becomes statistically insignificant.

By contrast, there is no effect of extreme rainfall on the size of boy birth cohorts, either in years of extreme rainfall (Table 8, regression 3) or years in which the village had experienced two consecutive years of extreme rainfall (regression 4). The complete lack of an effect among boys implies that the

[31] Infant mortality in Tanzania is 104 per 1000 births, nearly identical to the African average of 107 (UNDP 2002).

drop in the number of girls cannot be due to delayed fertility, miscarriage, or higher general infant mortality in extreme rainfall years, all of which would equally affect infants of both sexes. Rather, the most compelling explanation for the reduction in the girl-boy ratio in years in which the village had experienced two consecutive years of extreme rainfall (as in regression 6)[32] is the neglect or mistreatment of girl infants.[33] These tentative gender bias findings are somewhat unusual for an African setting, but gender bias has been widely reported in other less developed contexts, especially in South Asia (Sen 1992, Deaton 1997, Ray 1998). Taken together, the witch killing and infant results paint a bleak picture of the plight of females in rural western Tanzania.

7. Conclusion

Poverty is a key underlying cause of the murder of elderly women as “witches” in rural Tanzania: extreme rainfall leads to large income drops and food insecurity, and to a doubling of witch murders. The murders are more likely to occur in poor households, and in low socioeconomic status villages, during the “hungry” season of the year. Poor villages also have considerably more total murders than other villages. Taken together, these results provide evidence on a causal link running from extreme poverty to violent crime. More broadly, the findings suggest that further microeconomic empirical research on crime in less developed countries may be a fruitful direction for future research.

A natural question is what public policy could do to address witch killings in Tanzania. The most immediate solution would be to target police apprehension efforts in the areas where most crimes occur and more aggressively prosecute witch killers in the courts. However, this is likely to be strongly resisted – as past attempts have been – by residents of the region, most of whom believe that killing witches ultimately promotes community welfare. A potentially more attractive policy option is to

[32] Fifty-nine of 670 village-year observations are dropped from regressions 5 and 6 of Table 8 since, among the sample of surveyed households, there were no boys born in a particular year in a village (and thus the girl-boy ratio is undefined). Unfortunately, this could potentially lead to bias in the estimated effect of extreme rainfall on the girl-boy ratio in regression 6, and hence these results should be viewed as more tentative.

[33] In fact, taking into account the average village population, the size of girl birth cohorts, and the frequency of consecutive extreme rainfall years during this period, this translates into 251 “missing girls” in Meatu District in 2001 (using the –0.0015 point estimate).

provide elderly women in this area with regular pensions, which would transform them from a net household economic liability into an asset.[34] Given the grinding poverty of this area – and of Africa more generally – the results of this paper suggest that violence against "witches" is likely to continue until living standards improve.[35]

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[34] The number of witch killings in Northern Province, South Africa has dropped since the introduction of the old age pension in the early 1990s (Singer 2000), although it is difficult to establish causality given the other dramatic political and social changes that also occurred in South Africa during this period. Old age pensions may have positive welfare consequences for other household members (refer to Duflo 2000 for evidence from South Africa).

[35] Ashforth (2001: 221) makes a related point for urban South Africa: "[I]f people in Soweto could live lives free of worries about money, illness, and early death they would be less concerned about … witchcraft."

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9. Tables and Figures

Table 1: Descriptive Statistics

	Mean	Std dev.	Obs.
Panel A: Crimes per village-year (Village Council Data)			
Witch murders	0.09	0.33	736
Witch murders per 1000 households	0.23	0.87	736
Witch murders and attacks	0.20	0.57	736
Witch murders and attacks per 1000 households	0.47	1.56	736
Non-witch murders	0.11	0.41	736
Non-witch murders per 1000 households	0.23	1.01	736
Total murders	0.20	0.53	736
Total murders per 1000 households	0.45	1.35	736
Panel B: Natural calamities per village-year (Village Council Data)			
Extreme rainfall (drought or flood)	0.18	0.38	736
Extreme rainfall, current year and previous year	0.08	0.27	736
Drought	0.13	0.34	736
Flood	0.06	0.23	736
Famine	0.18	0.38	736
Human disease epidemic (e.g., cholera, diarrhea, measles)	0.15	0.36	736
Livestock disease epidemic	0.01	0.08	736
Panel C: Vegetation measures (NDVI) per village-year (Satellite Imaging Data)			
Average vegetation during rainy season	0.35	0.07	736
| Deviation from average vegetation during rainy season |	0.06	0.04	736
| Deviation from average vegetation during rainy season | > 0.08	0.36	0.48	736
| Deviation from average vegetation during rainy season | > 0.09	0.26	0.44	736
Deviation from average vegetation during rainy season < -0.09	0.18	0.39	736
Deviation from average vegetation during rainy season > 0.09	0.08	0.28	736
| Deviation from average vegetation during rainy season | > 0.1	0.19	0.40	736
Panel D: Village characteristics (Village Council and Household Survey Data)			
Annual per capita consumption expenditures (USD)	196.8	81.1	736
Average years of education	4.0	1.1	736
Proportion Sukuma ethnic group	0.91	0.16	736
Proportion households grow cash crops	0.62	0.22	736
Households per village	409.2	176.4	736
Proportion practice traditional religions	0.64	0.21	736
Women's community groups per household	0.0035	0.0045	736
Girls born that year as proportion of village population (for 1992-2001)	0.0177	0.0117	670
Boys born that year as proportion of village population (for 1992-2001)	0.0195	0.0122	670
Girl-boy ratio (children born that year, for 1992-2001)	1.13	1.07	611

Table 1 Notes:
1) In the Household Survey, both men and women were surveyed, though two-thirds of respondents were men. Year 2002 data is for the period January to August 2002 (and was collected during July-August 2002). The rainy season runs from October (of the previous calendar year) to February. These averages are population weighted by the number of households per village. The number of observations falls for the demographic data on cohort size since there is no data for 2002 births (these data were collected in 2001), and falls more for the girl-boy ratio since there are some villages were no boys were born in a given year among sampled households (hence the ratio is undefined).

Table 2: Witch Murder Victim Characteristics

	Mean
Panel A: Demographic characteristics	
Female	0.96
Age	57.6
Sukuma ethnic group	0.96
Lived alone	0.13
Had relatives in the village	0.98
Panel B: Socioeconomic characteristics	
Livestock ownership:	
"Below average"	0.55
"Average"	0.38
"Above average"	0.08
Asset ownership:	
"Below average"	0.69
"Average"	0.31
"Above average"	0
Land ownership:	
"Below average"	0.32
"Average"	0.57
"Above average"	0.11
Panel C: Timing of witch murders	
Pre-harvest/harvest season (February through July)	0.74
February	0.02
March	0.07
April	0.21
May	0.12
June	0.12
July	0.19
Post-harvest season (August through January)	0.26
August	0.07
September	0.05
October	0
November	0.05
December	0.07
January	0.02

Table 2 Notes:
1) Data are from the 2002 Village Council Survey, on the most recent witch murder victim in the village. The standard deviation of victim age is 12.9 years. Asset ownership data is missing for 4 of 53 victims, and month data is missing for 11 of 53 victims.

Table 3: Extreme Rainfall and Village Calamities

	Dependent variable:					
	Annual per capita consumption expenditures (USD)		Famine		Human disease epidemic	Livestock disease epidemic
	OLS	OLS	OLS	OLS	OLS	OLS
Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
Extreme rainfall (drought or flood)	-50.7**		0.46***		-0.03	0.009
	(24.8)		(0.07)		(0.04)	(0.008)
Drought		-38.5*		0.58***		
		(21.3)		(0.08)		
Flood		-74.9		0.22**		
		(48.4)		(0.09)		
Average years of education	1.7	0.0				
	(13.0)	(12.9)				
Proportion Sukuma ethnic group	-12.0	-14.5				
	(63.5)	(65.3)				
Proportion households grow cash crops	-2.7	3.7				
	(56.2)	(56.2)				
Households per village / 1000	0.07	0.07				
	(0.07)	(0.07)				
Proportion practice traditional religions	17.2	22.7				
	(52.5)	(52.4)				
Women's community groups per household	2116	2333				
	(2492)	(2571)				
Geographic division fixed effects	Yes	Yes	No	No	No	No
Village fixed effects (67 villages)	No	No	Yes	Yes	Yes	Yes
R^2	0.14	0.15	0.26	0.29	0.06	0.11
Root MSE	81.4	81.8	0.34	0.34	0.37	0.08
Number of observations	67	67	736	736	736	736

Table 3 Notes:

1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the village level. Regression 1 only contains data for 2001, the only year in which a household consumption expenditure survey was conducted. In Regression 2, we cannot reject the hypothesis that the coefficient estimates on Drought and Flood are equal (p-value=0.45). In Regression 4, we reject the hypothesis that the coefficient estimates on Drought and Flood are equal (p-value<0.01).

Table 4: Extreme Rainfall and Witch Murders

Explanatory variable	Dependent variable: Witch murders OLS (1)	OLS (2)	OLS (3)	OLS (4)
Extreme rainfall (drought or flood)	0.085**	0.098	0.085**	0.056
	(0.042)	(0.059)	(0.042)	(0.038)
Extreme rainfall, previous year		-0.000		
		(0.042)		
Extreme rainfall, current year and previous year		-0.032		
		(0.080)		
Human disease epidemic			-0.006	
			(0.036)	
Livestock disease epidemic			-0.057*	
			(0.031)	
Village fixed effects (67 villages)	Yes	Yes	Yes	Yes
Year fixed effects (11 years)	No	No	No	Yes
R^2	0.15	0.16	0.16	0.19
Root MSE	0.32	0.31	0.32	0.31
Number of observations	736	736	736	736

Table 4 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the village level.

Table 5: Satellite Vegetation (NDVI) Data and Witch Murders

Explanatory variable	Dependent variable: Witch Murders OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)
Extreme rainfall (drought or flood)	0.085**				
	(0.042)				
| Deviation from average vegetation during rainy season |		0.31			
		(0.35)			
| Deviation from average vegetation during rainy season | > 0.08			0.047		
			(0.034)		
| Deviation from average vegetation during rainy season | > 0.09				0.062*	
				(0.037)	
| Deviation from average vegetation during rainy season | > 0.1					0.051
					(0.042)
Village fixed effects (67 villages)	Yes	Yes	Yes	Yes	Yes
R^2	0.15	0.15	0.15	0.15	0.15
Root MSE	0.32	0.32	0.32	0.32	0.32
Number of observations	736	736	736	736	736

Table 5 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the level of the satellite image pixel, and there are a total of 51 such clusters. Regression 1 reproduces the results of Table 4, Regression 1.

Table 6: Extreme Rainfall and Violent Crime

Dependent variable	Coefficient estimate on **Extreme rainfall (drought or flood)**	R^2	Root MSE
Panel A: Witch Murders and Attacks			
1) Witch murders	0.085**	0.15	0.32
	(0.042)		
2) Witch murders per 1000 households	0.173*	0.16	0.84
	(0.094)		
3) Witch murders and attacks	0.144*	0.11	0.56
	(0.082)		
4) Witch murders and attacks per 1000 households	0.206	0.11	1.56
	(0.162)		
Panel B: Non-witch Murders			
5) Non-witch murders	-0.001	0.11	0.41
	(0.036)		
6) Non-witch murders per 1000 households	-0.01	0.14	0.99
	(0.08)		
Panel C: Total Murders			
7) Total murders	0.100	0.13	0.54
	(0.068)		
8) Total murders per 1000 households	0.125	0.12	1.33
	(0.124)		

Table 6 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the village level. Village fixed effects are included in all specifications, which are analogous to Table 4, regression 1. All regressions in Table 6 have 736 observations. Each coefficient estimate is from a separate regression.

Table 7: Village Characteristics and Murders

Explanatory variable	Dependent variable: Witch murders OLS (1)	Non-witch murders OLS (2)	Total murders OLS (3)
Annual per capita consumption expenditures (USD) / 100	-0.017 (0.016)	-0.041** (0.018)	-0.058** (0.026)
Average years of education	-0.047*** (0.016)	0.011 (0.017)	-0.035 (0.026)
Proportion Sukuma ethnic group	0.13 (0.11)	-0.01 (0.12)	0.12 (0.19)
Proportion households grow cash crops	-0.02 (0.07)	-0.06 (0.10)	-0.09 (0.10)
Households per village / 1000	0.01 (0.09)	0.23** (0.09)	0.24* (0.14)
Proportion practice traditional religions	0.04 (0.07)	0.01 (0.09)	0.05 (0.12)
Women's community groups per household	0.6 (3.1)	-4.1 (3.8)	-3.5 (4.9)
R^2	0.26	0.22	0.28
Root MSE	0.12	0.13	0.17
Number of observations	67	67	67

Table 7 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. A control for the proportion of years with extreme rainfall is also included as an explanatory variable (coefficient estimate not reported).

Table 8: Extreme Rainfall and the Size of Female and Male Birth Cohorts

	Dependent variable:					
	Girls born that year as proportion of village population		Boys born that year as proportion of village population		Girl-boy ratio (children born that year)	
	OLS	OLS	OLS	OLS	OLS	OLS
Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
Extreme rainfall (drought or flood)	0.0003	0.0033	0.0009	0.0006	-0.01	0.25
	(0.0020)	(0.0023)	(0.0017)	(0.0023)	(0.20)	(0.29)
Extreme rainfall, previous year		0.0027		0.0006		-0.01
		(0.0016)		(0.0020)		(0.16)
Extreme rainfall, current year and previous year		-0.0075**		-0.0007		-0.73*
		(0.0031)		(0.0045)		(0.39)
Village fixed effects (67 villages)	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects (11 years)	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.20	0.22	0.19	0.19	0.15	0.16
Root MSE	1.11	1.11	1.17	1.12	1.05	1.05
Number of observations	670	670	670	670	611	611

Table 8 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the village level. These regressions are for the years 1992-2001, since the demographic data is from the 2001 Household Survey. The hypothesis that the sum of the coefficient estimates on Extreme rainfall, Extreme rainfall previous year, and Extreme rainfall current and previous year, equals zero cannot be rejected in Regression 2 (p-value=0.49) or in Regression 4 (p-value=0.89), but is rejected at 95 percent confidence in Regression 6 (p-value=0.05).

Figure 1: Total Number of Witch Murders by Village Geographic Location (1992-2002)

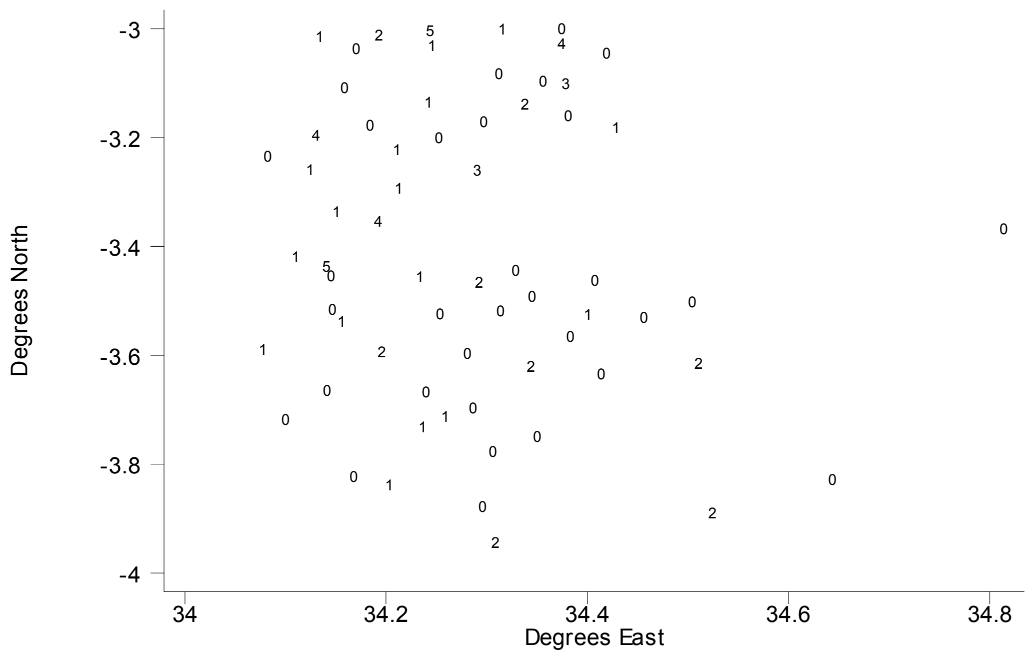
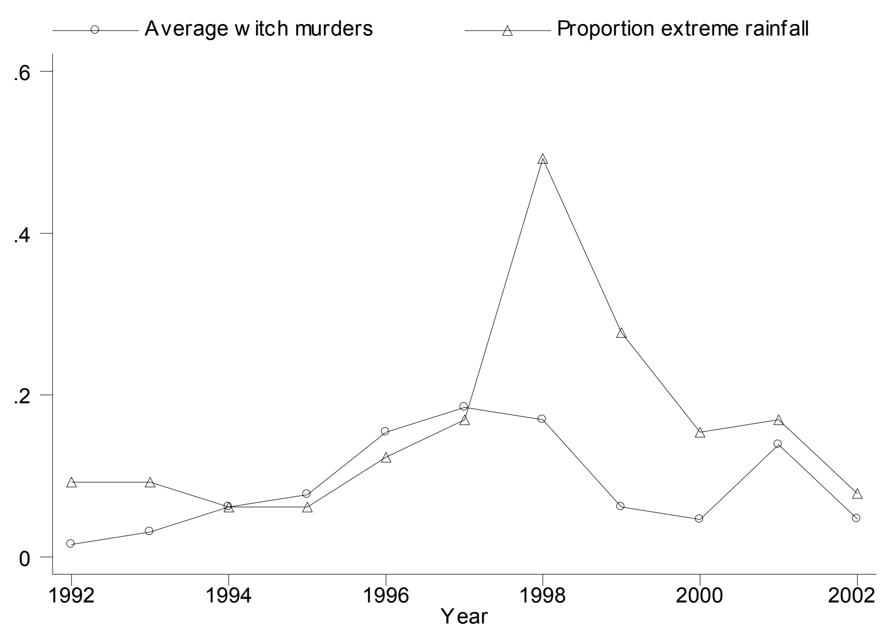


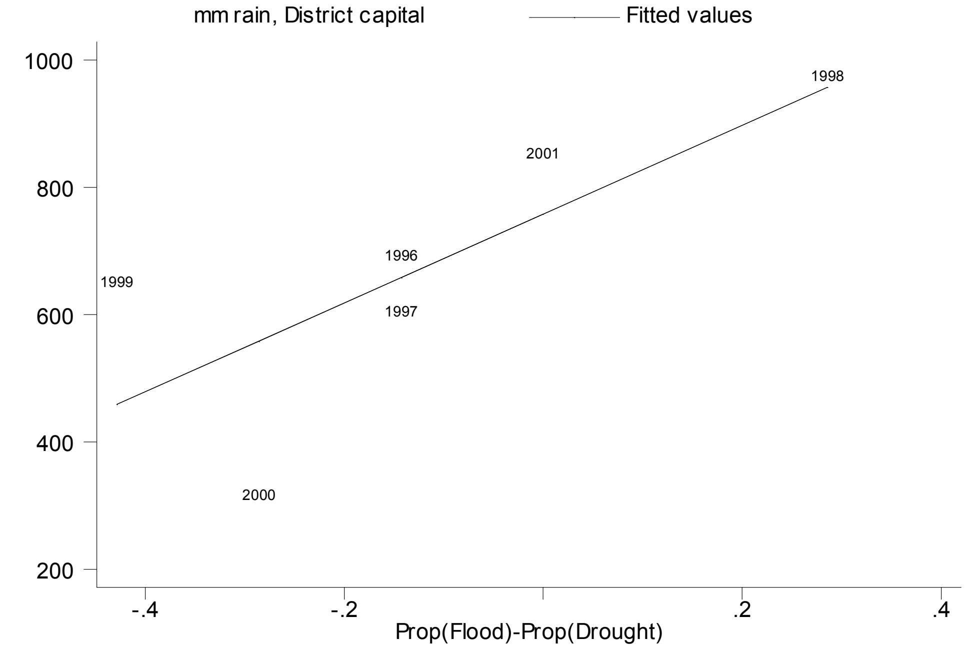
Figure 2: Proportion of Villages with Extreme Rainfall and Average Witch Murders, by year (1992-2002)



Notes: The data for 2002 are for January through July/August.

10. Appendix

Appendix Figure A1:
Proportion of villages near the district capital with floods minus the proportion with drought, versus millimeters of rainfall in the capital (by year)



Appendix Figure A2:
Average vegetation index (NDVI) of villages near the district capital, versus millimeters of rainfall in the capital (by year)