Poverty and Witch Killing

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BREAD Working Paper No. 041
August 2003

B R E A D

Working Paper

Bureau for Research in Economic Analysis of Development

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JEL Codes: D13, I30, J14, J16, O12, Z12
Keywords: Poverty, Violence, Gender, Witchcraft

ABSTRACT

This study uses rainfall variation to estimate the impact of income shocks on murder in rural Tanzania. Extreme rainfall (drought or flood) leads to a large increase in the murder of "witches" – typically elderly women killed by relatives – but not other murders. The results are consistent with a model where households near subsistence kill (or expel) relatively unproductive members to safeguard the nutritional status of other members. The findings provide novel evidence on the role of poverty as a cause of violent crime in less developed countries.

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1. Introduction

Many observers have noted that poverty and violence go hand in hand in less developed countries. There is a strong negative relationship between economic growth and crime across countries, as well as across Indian districts, and a link between low income and the occurrence of civil war.[1] Yet existing studies are typically unable to resolve the key econometric identification issues of omitted variable bias and endogeneity. To illustrate, the unobserved quality of local government institutions may affect both income growth and crime rates, and poverty could 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 rural Tanzanian district.[2] Extreme rainfall – resulting in drought or floods – is exogenous and is associated with poor harvests and near-famine conditions in the region, and a large increase in the murder of "witches": there are twice as many witch murders in years of extreme rainfall as in other years. The victims are nearly all elderly women, typically killed by relatives. These econometric results, across eleven years in 67 villages, are novel evidence on the role of extreme poverty as a cause of violent crime, and also provide insights into witchcraft, an important social phenomenon in Sub-Saharan Africa not traditionally studied by economists.

The empirical 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, in response to negative income shocks.[3] The theory that extreme poverty is the driving force behind the murders 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. Although it is

[1] Refer to Mehlim et al (2000) and Fajnzylber et al (2002) on crime, and Fearon and Laitin (2001) on civil war. Dreze and Khera (2000) find a 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 (Rose 1999, Hoddinott and Kinsey 2001), and institutions (Nugent and Sanchez 1999).
[3] This is in contrast to other economic models of violence, which focus on violence between social groups or classes (e.g., Grossman and Kim 1995) rather than within households.

difficult to disentangle this theory from an alternative theory – that victims are singled out as "scapegoats" by families in need of someone to blame for their suffering – examining the effects of two different "shocks" provides suggestive evidence in favor of the poverty explanation. Extreme rainfall and disease epidemics are both shocks that "witches" can control (according to the ethnographic literature on Tanzania) and which have negative welfare consequences for households. The scapegoat theory thus predicts that both types of shocks should lead to more witch murders, as households eliminate the "cause" of their misfortune. However, only the shock that leads to poverty (extreme rainfall) results in more witch murders, while disease epidemics lead neither to poverty nor to witch murders empirically.

The remainder of the paper is structured as follows. Section 2 discusses existing anthropological and historical research on witch killing. Section 3 develops an economic framework for understanding witch killings. Section 4 describes the data, and Section 5 lays out the estimation strategy and presents the empirical results. The conclusion discusses possible policy responses.

2. Background on Witchcraft

Witchcraft beliefs are widely held 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 pin blame on a particular person rather than on chance (Evans-Pritchard 1937, Ashforth 2002). In particular, African witches – who may be female or male – 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). Note that 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.[4]

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[4] For a model of failed learning in the context of mean-reverting health processes, refer to Das (2000).

Witchcraft beliefs are strong in the ethnically Sukuma region of western Tanzania, where a large proportion of the population practices traditional religions and have never adopted Christianity or Islam. In our study area, Meatu District in Shinyanga Region, nearly two-thirds 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 1960s, and some have tied this to the radical reforms pursued by Tanzania's socialist regime following independence, including villagization and agricultural collectivization (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 typically 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 household misfortunes are prime motivations for witch killing (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.

Those unwilling or unable to flee are brutally massacred in their homes, usually with machetes.[5]

Former 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?

Although public witchcraft accusations have been illegal since the British Witchcraft Ordinance of 1928, and this law remains nearly unchanged to the present day (Green 1994: 23-24), Tanzanian government efforts to stop the killings have been unsuccessful. In one notable episode during the late 1970s, the Shinyanga regional government did arrest 897 individuals suspected of carrying out witch killings, yet the campaign 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 campaign 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 convicted, and since then the conviction rate has apparently fallen even lower, largely due to a lack of witnesses (not surprising given the complicity of relatives).

Witch killings have also been tied to the resurgence of a pre-colonial village political institution, the male elders council, called *Sungu-sungu*. The *Sungu-sungu* 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 is popularly credited with having put an end to disorder in rural areas by organizing village patrols to punish suspected thieves and recover stolen property (Abrahams and Bukurura 1992: 94-95). In many

[5] Note that women like the one cited in the above excerpt are unlikely to be included in the dataset used in this paper since they fled before an actual attack.

villages, the *Sungu-sungu* also organizes mutual insurance and emergency credit schemes, and is entrusted with collecting funds for local development projects.

But in addition to these activities, the all-male *Sungu-sungu* consider combating witches central to their mission of promoting village security. They have been implicated in the expulsion of suspected witches from the village, as well as in witch killings, 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). Witchcraft is a tangible reality for many Tanzanians and witches are considered criminals just as dangerous as ordinary thieves and murderers. From this point of view witch killers are simply pursuing justice,[6] a view that runs against both Tanzanian law and international human rights norms. A recent news article reports 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).

2.1 Witch Killing Around the World

Witch killings are not unique to Tanzania. Attacks follow a similar pattern in northern Ghana, where thousands of women have been attacked or 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 … risk being branded as witches, abused, and stoned." (EWD 2002). At least 400 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 have been kicked out of their homes or killed by family members (The Economist 2002):

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[6] Of course, not all Tanzanians take this stance, and in fact several local human rights groups have actively campaigned against witch killings, most notably the Tanzania Media Women's Association (TAMWA).

> 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.

Witch murders extend beyond Africa. In Andean regions of South America, isolated indigenous communities punish suspected witches with expulsion or execution, and a significant community of witch refugees has developed in Santa Cruz, Bolivia. Yet it is not only witches who are sometimes killed in 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 "tribal" communities in Bihar, the poorest state in India (EWD 2002).

There are also parallels between contemporary Tanzania and witch killing in Europe in the 16th-18th century, during which time at least 40,000 individuals were murdered (Rowlands 1998). Most European victims were women, often widows, and were predominantly poor and elderly (Rowlands 1998: 300). As in Tanzania, witches in early modern Europe were credited with power over weather, crops, and health (Behringer 1999: 339). Many of Europe's leading political and church authorities opposed the witch killings, but the killings continued nonetheless, 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; Baten and Woitek 2001; 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

The stylized theoretical framework presented in this section emphasizes the importance of within-household resource conflicts in extremely poor households as the underlying cause of witch killing.[7] The model makes four plausible 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 years of extreme rainfall and generalized local crop failure, when networks are weakened or break down. Second, 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;[8] 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 convex at low consumption levels. Finally, household members are identical except in terms of future economic production.[9]

The Patriarch divides current income among household members to maximize a household utility function. Income is a function of current rainfall, and is significantly lower in years of extreme rainfall, due to crop failure. The Patriarch maximizes total future 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 consumption, where $s(C_{ihkt}) = 1(C_{ihkt} \geq \underline{C})$; the time-discounted future production 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 household and village characteristics, X_{hkt}, and is decreasing in extreme rainfall. The simple maximization problem can thus be represented as:

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

[7] The model is related to Ray (1998: 279), and Dasgupta and Ray (1986).
[8] Basal metabolism demands roughly two-thirds of normal nutritional requirements (Dasgupta 1993).
[9] Differential food consumption needs by age are not included in the model, but could be easily incorporated.

There are two cases. In years of *normal rainfall*, there is sufficient income to sustain all household members above subsistence consumption. 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 which case spreading resources equally among all members would put all at risk of starvation. Instead the Patriarch – in the harsh but unavoidable calculus of triage – reduces the individual (or individuals) with lowest future production 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."[10] Reducing someone to zero consumption can be thought of as literally starving her to death, driving her out of the household, or murdering her. Yet given strong within-household food-sharing norms in rural Tanzania, and the control that women often have over household food stocks, the most effective way to reduce elderly women to zero consumption in this setting might be expulsion from the household or murder.

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

The decision to target elderly women rather than elderly men for witch killing 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 *Sungu-sungu* –

[10] Mirlees (1975) was the first to make this theoretical point on the desirability of unequal resource distribution within poor households. The framework also relates to Rosenzweig and Schultz (1982), who find within-household resource allocation differentials across girls and boys in India as a function of local labor market opportunities for women. 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.

provide households with valuable access to political power but elderly women cannot. Patrilocal marital exogamy – a norm 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. The greater average physical strength of men may also play some role in women's increased vulnerability to attack. Wandel and Homboe-Ottesen's (1992) study in the nearby Rukwa region finds that women do in fact bear the brunt of food insecurity in this area: 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.[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 women are disproportionately attacked because they are more numerous than men.

The period of the year during which women are likely to be especially vulnerable to attack in rural western Tanzania is the "hungry season". The agricultural year in this area 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 coming harvest. The 2001 Household Survey data (described below) indicates that most household food stores from the previous harvest are typically depleted by February of the following year, after which time many households dip into their limited savings, sell assets (e.g., cattle), or labor on other farms to survive. Tough resource choices need to be made during the hungry season, when many households have run out of other options (and also note that the rainfall shock for the upcoming harvest has been realized by this point).

3.1 Related Perspectives from Anthropology

[11] 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.

An extensive literature in anthropology finds that 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:

> 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 the availability of food resources is often the key determinant of the treatment of the elderly.[12] As in Tanzania, Maxwell, Silverman, and Maxwell (1990: 77) claim that "geronticide is usually … the result of decisions made by an intimate group of kinsmen". A variety of norms developed to justify violence against the elderly in extremely poor societies, and "witch" killing in Tanzania can thus be seen as but one of many possible manifestations of this more general phenomenon.

Although the model presented above highlights economic motivations behind witch killing in Tanzania, it in no way seeks to diminish the importance of other explanations for witchcraft beliefs in Africa (Moore and Sanders 2001). Nor does the model imply that individuals in western Tanzania do not genuinely believe in witchcraft. Believing that a murder victim truly is a witch plays an important role, since it may alleviate the psychological trauma and social stigma associated with the murder of a relative, allowing killers to justify their actions both to themselves and to the community.

Regarding the alternative theory, if scapegoating is most likely to emerge during periods of severe economic insecurity, income shocks can be seen as the underlying cause of witch killings in a reduced-form sense, even if scapegoating is the proximate trigger. Thus, the two explanations that have been emphasized – extreme poverty and scapegoating – are not necessarily mutually exclusive.

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[12] For instance, "[w]here resources were even more meager, … 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). Icelandics, Amazonian Bororos, Siberian Chukchees, Fijians, North American Hopis, Gabon Fang, southern African San, and Australian Tiwi are a few of the many other groups that are thought to have practiced death-hastening activities against the elderly.

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 local non-governmental organization (ICS Africa) enumerators, with the cooperation of Meatu District Council authorities.

The Village Council Survey was administered in all 71 villages and relied both on interviews with Village Council members and on 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 (usually cholera or measles) by year.

Unfortunately, precise village-level rainfall measures (in millimeters, for example) do not exist for most 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, to validate the accuracy of the survey reports. The correlation between millimeters of rainfall and reported flooding in these villages is over 0.8 (and statistically significant) and the correlation between millimeters of rainfall and drought is -0.6 (marginally significant).[13]

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 village officials is a

[13] Mean annual rainfall in the district capital (Mwanhuzi) during 1996 to 2001 was 675 mm (s.d. 226 mm). Appendix Figure A1 graphically illustrates the strong relationship between Village Council Survey rainfall reports and millimeters of rainfall.

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 a village, and there was a high degree of consensus among village officials on the events. There was also a remarkable openness to discuss witch killings, and the interviews raised no serious concerns about data reliability.[14] (Recall that witch murders are rarely if ever punished.) If a witch killing had ever occurred in the village, we also collected information on the personal characteristics of the most recent victim, including gender, age, and ethnic group; asset ownership relative to others in the village; and month of the murder. The number of witch attacks by year was also collected; however, this variable is more difficult to capture than murder, since although in practice we sought to collect information on those who were "forced out" of the village as well as those actually physically assaulted, many individuals who flee in anticipation of a witch attack are likely to be missed.[15] Retrospective questions on non-violent (e.g., property) crimes were not included in the survey because it was felt that recall data stretching back across many years would not be sufficiently reliable for very 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 household was also surveyed, in order to obtain a representative sample. The Household Survey collected detailed socioeconomic and demographic information, as well as a consumption expenditure module for a subset of households. The survey also collected a roster of household members, providing information on the age and sex composition of each village; in particular, we use this data to test whether there are smaller cohorts of children born in years of extreme rainfall, as discussed below.

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[14] 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, partially ameliorating these concerns.

[15] There is evidence from another context that refugee flows in response to violence may be large: Schultz (1971) estimates that 18 additional people out-migrated from rural Colombian districts for each additional political murder committed there during the 1950s and 1960s.

Meatu district is extremely poor. Just 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 75 percent of income goes toward food consumption on average. 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. Unpaved roads to neighboring districts, a minimal formal financial infrastructure, and poor grain storage conditions combine to produce large fluctuations in the local price of grain through the calendar year. Although formal crop insurance is unknown, fully 73 percent of villages had received at least some food relief aid from the Tanzanian government or a non-governmental organization in the recent past (although we unfortunately do not have the years of relief), highlighting the chronic food insecurity in this area.

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] NDVI is related to the level of photosynthetic activity, and thus vegetation, and to rainfall (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).

A main strength of the satellite data relative to the Village Council Survey reports is that it is not prone to recall error. However, the data also has several important drawbacks. First, the NDVI data has eight 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 neighboring villages;

[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 formula: 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. The NDVI values have been normalized to lie within the unit interval. The NDVI series in western Tanzania has unfortunately been increasingly unstable since May 2000. For more information: http://www.fews.net/current/imagery/index.cfm.

in total, there are 51 distinct vegetation readings (pixels) for the 67 villages. Error can also result 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 measure.[17] A potentially more serious possibility is that local cropping choices – for example, the decision to leave land fallow – can impact measured NDVI, leading the vegetation measure to diverge from rainfall. 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.[18] We focus on the absolute value of this deviation, and construct indicator variables for large deviations, although we also experimented with a variety of other measures that yielded similar findings.

4.3 Descriptive Statistics

There are 0.2 murders per village-year on average, or roughly one per village every five years (Table 1, Panel A).[19] 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. In total, there were 138 witch murders or non-lethal attacks during the period, which is equivalent to an annual 1 in 500 chance that a woman over age 50 was killed or attacked as a witch.

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[17] The village GPS location data we collected and the official administrative boundaries data are somewhat inconsistent – perhaps due to the use of different GPS projections – and as a result several sample villages located near the borders with neighboring districts appear to fall slightly outside the boundaries of Meatu. Any mismeasurement in village location would introduce further error in the NDVI measures.

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

[19] The annual murder rate in Meatu from 1992-2002 is roughly 6 per 100,000 population, lower than the U.S. rate of 8 per 100,000 population during the 1990s (http://www.ojp.usdoj.gov/bjs/) but higher than the Indian rate of approximately 4 per 100,000 (Dreze and Khera 2000).

Extreme rainfall occurs approximately once in 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. Famine and human disease epidemics also typically occur approximately once every six years (the means are 0.18 and 0.15, respectively). The average vegetation (NDVI) level in the rainy season during this period is 0.35, the average absolute deviation from normal vegetation is 0.06, and the deviation is at least 0.09 in roughly one-quarter of all years and at least 0.1 in nearly one-fifth of years (Table 1, Panel C). As with the Village Council reports, about two-thirds of the large 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 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 rate of adherence to traditional religions, at 64 percent. There are only two women's community groups per village on average. Among children under ten years of age, there are slightly more boys than girls.

Witch killing victims are nearly all female (96 percent – Table 2, Panel A), with relatives living in the village (98 percent), and ethnically Sukuma (96 percent). Both the median and mean victim age is over 50 years. Although 87 percent of victims lived with relatives at the time of the murder, a non-trivial proportion lived alone (we unfortunately did not collect information on widow status, but it is reported anecdotally that those living alone are often widows). The profile of witch murder victims is in sharp contrast to the victims of non-witch murders, 59 percent of whom were male and over 70 percent of whom were killed during armed robberies (typically related to cattle theft).[20]

[20] These figures on the characteristics of non-witch murder victims should be interpreted with caution: this information was only collected for a subset of the non-witch murders in the form of open-ended descriptions, unlike the explicitly coded survey questions on witch murder victims.

Along three dimensions of wealth, witch murder victims tend to come from households either "below average" or "average" for the village (Table 2, Panel B). For example, in terms of ownership of household goods (e.g., radios, bicycles) 69 percent of victims' households were below average for the village, 31 percent were average, and none above average. Similarly for livestock ownership, 55 percent were below 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 the rainfall shock for the next harvest has been realized and most food stores already 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.

5. Empirical Results

5.1 Estimation Strategy

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

There is longitudinal rainfall and murder data for 67 villages over eleven years, 1992-2002. In Equation 2, M_{kt} represents the number of witch murders in village *k* during year *t*. Murder is a function of X_{kt}, village socioeconomic, demographic, and disease characteristics, as well as a function 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*; alternative measures of extreme rainfall from satellite vegetation data are used as a robustness check. To the extent that weather reports are "noisy", coefficient estimates will be biased toward zero and thus serve as lower bounds on the true rainfall effects.[21] The idiosyncratic village-year disturbance term, ε_{kt}, is included in all specifications, and we allow regression disturbance terms to be correlated (clustered) across years for the same village, but to be independent across villages in all specifications.[22] 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, although, as we show below, the results are largely robust to the use of murder rates.

The ethnographic evidence asserts that illness often leads to witchcraft accusations, and to explore this possibility we include controls for disease epidemics in certain specifications. We also interact village explanatory variables with the rainfall shock 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, so in Equation 3, $\widetilde{X}_{kt}$ 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.[23] This yields the preferred specification:

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

The possibility of food relief in famine years somewhat complicates the interpretation of the coefficient estimate on extreme rainfall: if relief aid blunts the within-household resource conflicts that

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[21] This will be non-classical measurement error (refer to Aigner 1973). Still the resulting bias will be toward zero as long as error is not too severe (the actual condition is that Pr(Type I error) + Pr(Type II error) < 1).
[22] Spatial correlation of witch murders across villages is minimal according to a variety of measures, including Moran's I coefficient (approximately 0.01). Regression estimates do not change appreciably when using spatially correlated disturbances, with the non-parametric method in Conley (1999) (results not shown).
[23] Including both village fixed effects and year indicators captures 29 percent of the variation in extreme rainfall.

we argue above are an underlying cause of witch murders, coefficient estimates should be interpreted as lower bounds on the effects in the absence of relief.[24]

5.2 Witch Killing Results

Extreme rainfall leads to large income drops in Meatu district: regressing average village income in 2001 on an indicator for extreme rainfall in that year, as well as on geographic division indicators and 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). In contrast, human disease epidemic years are not associated with per capita income (regression 2); a priori, human disease outbreaks may either increase or decrease per capita income, depending on the labor productivity of disease victims. Floods have a somewhat more negative effect on income than droughts, but we cannot reject the hypothesis that floods and drought have the same effect (regression 3, p-value = 0.45), and thus the extreme rainfall indicator is used as the main explanatory variable in the analysis below. Extreme rainfall is also associated with famine: the coefficient estimate on extreme rainfall is 0.47, while disease epidemics are not associated with famine (regression 4). Extreme rainfall is uncorrelated with human disease epidemics (regression 5).

In the main empirical result of the paper, extreme rainfall is strongly positively associated with witch murders (Table 4, regression 1): extreme rainfall is associated with 0.085 more witch murders per

[24] There are a number of reasons to focus on rainfall variation rather than famine. First, famine is partly a function of village institutional capacity and the strength of political links to district authorities, and both of these characteristics may also affect murder. These characteristics could also vary through time, and hence would not be captured in village fixed effects. Another concern relates to the classification of famine years: the coefficient estimate on famine will be downward biased if years when food aid arrives are more likely to be considered "famines" by the Village Counil, ceteris paribus. Nonetheless, specifications including an indicator for famine as the key explanatory variable generate results broadly similar to – though somewhat weaker than – regression specifications with extreme rainfall (results not shown).

village-year (significant at 95 percent confidence) in the village fixed effects specification, which implies that there are twice as many witch murders in years of extreme rainfall as other years. [25] Drought and flood 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. Including geographic division indicators and village characteristics yields similar results (regression 2, coefficient estimate 0.076, standard error 0.037) – although note that these non-fixed effect estimates may suffer from bias due to endogeneity, since the village characteristics were collected at the end of the study period (in 2001-2002); we discuss this issue in greater detail below, in relation to the results in Table 7. 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 3), neither of which is significantly associated with witch murder.[26]

Disease epidemics are not significantly associated with witch murders (Table 4, regression 4), a finding that bolsters the poverty theory over the scapegoat theory. Extreme rainfall and disease epidemics are both shocks that witches can control (according to the ethnographic literature), and which have negative welfare consequences for households. The scapegoat theory thus predicts that both types of shocks should lead to more witch murders, as households eliminate the "cause" of misfortunes. However, only the shock that leads to poverty (extreme rainfall) results in more witch murders, while disease epidemics lead neither to poverty (Table 3) nor to witch murders.

The rainfall results are also largely robust to the inclusion of year fixed effects (Regression 5), although in this case the point estimate falls from 0.085 to 0.056 and becomes only marginally significant (p-value = 0.14).[27] This drop is not unexpected since large parts of the district are subject to

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[25] Results are similar with Poisson, negative binomial, ordered probit and probit estimation (Appendix Table A1).

[26] 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.

[27] 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

common weather shocks in certain years, such as the 1998 El Niño floods; Figure 1 graphically illustrates the proportion of villages experiencing extreme rainfall and witch murders by year. To test for outliers, we also dropped one village at a time and the resulting estimates range from 0.07-0.11 and are significantly different than zero at 90 percent confidence in all cases (results not shown).[28, 29]

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 thus an increase in income from the Meatu average to the Tanzanian national average of $256 would reduce witch murders by –0.1 per village-year.

Coefficient estimates on indicator variables for large absolute NDVI deviations range from 0.047 to 0.062 (Regressions 2-4), and in the case of the 0.09 deviation indicator, the coefficient estimate is statistically significant at 90 percent confidence. The finding of somewhat smaller coefficient estimates on the satellite weather variables relative to the Village Council reports may be due to attenuation bias from measurement error in NDVI, as discussed above. Although not definitive on their own, these results using a second independent source of weather data corroborate the main findings in Table 4, namely, that extreme weather leads to more witch murders.[30]

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in this post-harvest period). Nonetheless, dropping the 2002 data leaves the main results essentially unchanged (coefficient estimate 0.086, standard error 0.046).

[28] We also investigated using world cotton prices as an alternative source of exogenous variation in income, but the cotton price is not significantly related to witch killings (results not shown). However, note that there is just a single world price of cotton and hence no variation across villages, and, moreover, the cotton price series is quite 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).

[29] 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 full-blown famine may still be associated with a negative income shock, i.e., the exclusion restriction may not hold.

[30] The use of NDVI measures as an instrument for Village Council rainfall reports produced imprecise two-stage least squares coefficient estimates (results not shown). 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 graphical results, since they are only moderately informative.

The witch murder results are robust to the use of a murder rate per 1000 households[31] (Table 6, row 2), and coefficients are similarly large and positive, although not always statistically significant, when the number of witch killings plus attacks is the dependent variable (rows 3-4).[32]

Yet, 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). Note that this result appears to rule out the possibility that a general breakdown in local law enforcement is the true underlying cause of increased witch murders in extreme rainfall years, since non-witch murders would presumably also be affected in that case. Taking both types of murder together, extreme rainfall has a positive but only marginally statistically significant effect on total murders (rows 7-8).

The next set of results examines the relationship between village characteristics (measured in 2001-2002) and the number of murders during the entire 1992-2002 period (Table 7). Due to the timing of data collection on village characteristics, these regressions may suffer from endogeneity, and hence the results of this table are more tentative than the fixed-effects specifications presented above. 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.

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): 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 19 percent of the average number of murders. This is despite attenuation bias, which is likely since the

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

[32] One plausible explanation for the weaker results in rates is the possibility that elderly women vulnerable to witchcraft accusations flee villages that have experienced even a single recent witch attack. It is possible that more such women flee larger villages, although unfortunately we cannot capture these flows due to data limitations.

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 income across households – suggests that the true effect of the increase in income would be a 33 percent reduction in murders. The difference between the panel data fixed-effects estimate of the impact of extreme rainfall on total murders (Table 6) and the cross-sectional estimate of the impact of village income (Table 7) could be due to multiple factors, including endogeneity bias in the cross-sectional regressions; differential effects of temporary versus permanent village income shocks on violent crime; or the possibility that village income could be serving as a proxy for another village characteristic – such as local institutional quality – that also affects violent crime.

Witch murders in extreme rainfall years are concentrated in villages where more residents practice tradition religions: the coefficient estimate on the interaction between extreme rainfall and the proportion practicing traditional religions, in a specification again without village fixed effects, is 0.27 (standard error 0.14, regression not shown). This suggests that both poverty and strongly held witchcraft beliefs are necessary for witch killings – although it remains possible that this term is actually capturing some unobserved dimension of local socioeconomic status correlated with the strength of traditional religion. In contrast, the effect of extreme rainfall is not significantly different in villages with more income, education, Sukumas, households growing cash crops, total households, or local women's groups (results not shown).

5.3 Infant Survival Results

The infant survival results presented in this sub-section are more tentative than the paper's other findings, 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 birth cohorts should be smaller for years in which the village experienced extreme rainfall, due to higher infant mortality rates (in the first year of life), in line with the theoretical model presented above. Of course, actual cohort size is an imperfect measure of infant survival. For example, fertility rates could change in extreme rainfall years (although we discuss a way to get around this issue below). Another obvious possibility is that parents could foster their children in the aftermath of negative income shocks, sending them to live with relatives elsewhere, and there may be a gender differential in fostering. Although fostering appears less likely, a priori, for infants under age one – who typically rely on their mothers for food – than for older children, this remains a concern.

Note that infants up to one year of age are considerably more vulnerable to mortality than older children: nearly two-thirds of all under-five mortality in Tanzania occurs before age one (UNDP 2002)[33]. Also note that, in contexts where girls and boys receive largely comparable medical care and nutrition, infant mortality is consistently 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 following negative household income shocks, it is likely to be due to the relatively low food consumption, poor medical care or plain mistreatment of girls, rather than purely to biological differences by gender.

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 (regression 2): the coefficient estimate is -0.0070 (standard error 0.0031), which implies a huge 40 percent reduction in the proportion of girls born that year relative to average cohort size (in a specification with both village and year fixed effects).[34] Comparing years in which a village had

[33] Infant mortality in Tanzania is 104 per 1000 births, nearly identical to the African average of 107 (UNDP 2002).
[34] Year fixed effects are necessary in these specifications to capture any district-wide trends in birth cohort size during the period 1992-2002 (for instance, due to reduced fertility trends over time).

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 top three coefficient estimates presented in regression 2) remains negative but falls in magnitude to -0.0023 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 two consecutive years of extreme rainfall (regression 4). Note the large negative effect of human disease epidemics on the number of surviving boys – but not on the number of girls – which is consistent with the broader claim that boy infants are generally less hardy than girls. The lack of a rainfall effect among boys implies that the drop in the number of girls cannot simply 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 number of girls is the neglect or mistreatment of girl infants (although note that the main coefficient estimate is not statistically significant in regression 6).[35, 36]

These tentative gender bias findings are somewhat unusual for an African setting, but such bias has been widely reported in other less developed country contexts, especially in South Asia (see Sen 1992 and Rose 1999 for similar results). Taken together, the witch killing and infant results paint a bleak picture for the life chances of poor females in rural Tanzania.

6. 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 a doubling of witch murders. More broadly, the

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[35] In fact, taking into account average village population, the size of girl birth cohorts, and the frequency of consecutive extreme rainfall years during this period, this translates into 412 "missing girls" in Meatu District in 2001 (using the –0.0023 point estimate).

[36] We also explored effects of extreme rainfall on number of surviving elderly, although unfortunately we again had to rely on cross-sectional information from the 2001-2002 surveys, rather than actual mortality data. In a specification analogous to those in Table 7, we found that villages that had experienced more years of extreme rainfall during 1992-2002 had a somewhat lower proportion of females among the elderly (at least 50 years of age); however, this effect is not statistically significant at traditional confidence levels (results not shown).

findings suggest that microeconomic empirical research on crime in less developed countries could be a fruitful direction for future research.

A natural question is what public policy could (or should) do to eliminate witch killings in Tanzania. The most immediate solution would be to target police apprehension efforts in the areas where most such 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 provide elderly women in this area with regular pensions, which would transform them from a net household economic liability into an asset.[37] Another possibility is to improve the system of formal insurance for extreme rainfall shocks, to provide households with better means of smoothing consumption. Given the grinding poverty of this area – and of Sub-Saharan Africa more generally – the results of this paper suggest that violence against "witches" is likely to continue until living standards improve.[38]

[37] Witch killings in Northern Province, South Africa have dropped dramatically since the introduction of the old age pension in the early 1990s (Singer 2000), although it is of course difficult to establish causality given the many other political and social changes that occurred during the same period. Unfortunately, Tanzania is too poor to afford a pension program as ambitious as the South African program without considerable donor assistance.
[38] 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."

7. References

Abrahams, Ray. (1987). “Sungusungu: Village Vigilante Groups in Tanzania”, *African Affairs*, 86(343), 179-196.

Abrahams, Ray. (1994). *Witchcraft in Contemporary Tanzania*. African Studies Center, University of Cambridge.

Abrahams, Ray, and Sufian Bukurura. (1992). “Party, Bureaucracy, and Grassroots Initiatives in a Socialist State: The Case of Sungusungu Village Vigilantes in Tanzania”, in C.M. Hann (ed.) *Socialism: Ideals, Ideologies, and Local Practice*, Routledge: London and New York.

Aigner, Dennis J. (1973). “Regression with a Binary Independent Variable Subject to Errors of Observation”, *Journal of Econometrics*, 1 (1), 49-50.

Angrist, Joshua, D., and Alan B. Krueger. (1992). “The Effect of Age at School Entry on Educational Attainment: An Application of Instrumental Variables with Moments from Two Samples”, *Journal of the American Statistical Association*, 87 (418), 328-336.

Anyamba, A., K.J. Linthicum, R. Mahoney, C.J. Tucker, and P.W. Kelley. (2002). “Mapping Potential Rift of Rift Valley Outbreaks in African Savannas Using Vegetation Index Time Series Data”, *Photogrammetric Engineering and Remote Sensing*, 68(2), 137-145.

Ashforth, Adam. (2002). “An Epidemic of Witchcraft? The Implications of AIDS for the Post-Apartheid State”, *African Studies*, 61(1), 121-143.

Ashforth, Adam. (2001). “On Living in a World with Witches: Everyday Epistemology and Spiritual Insecurity in a Modern African City (Soweto)”, in *Magical Interpretations and Material Realities: Modernity, Witchcraft and the Occult in Postcolonial Africa*, eds. Henrietta Moore and Todd Sanders. London: Routledge.

Baten, Jorg, and Ulrich Woitek. (2001). “Grain Price Fluctuations and Witch Hunting in Bavaria”, unpublished working paper, University of Munich and University of Glasgow.

Behringer, Wolfgang. (1999). “Climatic Change and Witch-Hunting: The Impact of the Little Ice Age on Mentalities”, *Climatic Change*, 43, 335-351.

Boyer, Paul, and Stephen Nissenbaum. (1974). *Salem Possessed: The Social Origins of Witchcraft*. Harvard University Press, Cambridge.

British Broadcasting Corporation [BBC]. (1999). “Child Witches in the Congo”, October 12, 1999, BBC News Online.

British Broadcasting Corporation [BBC]. (2001). “Ghana ‘Witch’ Sues Village Elders”, April 6, 2001, BBC News Online.

British Broadcasting Corporation [BBC]. (2002). “Tackling ‘Witch’ Murders in Tanzania”, October 29, 2002, BBC News Online.

British Broadcasting Corporation [BBC]. (2003). “DR Congo’s Unhappy Child ‘Witches’”, January 17, 2003, BBC News Online.

Brogden, Michael. (2000). *Geronticide: Killing the Elderly*. London: Jessica Kingsley Publishers.

Bukurura, Sufian Hemed. (1994). “The Maintenance of Order in Rural Tanzania”, *The Journal of Legal Pluralism and Unofficial Law*, 34, 1-29.

Chen, M., and J.P. Dreze. (1992). “Widows and Well-Being in Rural North India”, Working Paper #40, Development Research Program, London School of Economics.

Conley, Timothy. (1999). “GMM estimation with cross sectional dependence,” *Journal of Econometrics*, 92(1), 1-45.

Das, Jishnu. (2000). “Dr. Do-Little: Do Households Learn About Doctor Quality?”, unpublished manuscript, World Bank.

Dasgupta, Partha. (1993). *An Inquiry into Well-being and Destitution*. Oxford: Oxford University Press.

Dasgupta, Partha, and Debraj Ray. (1986). “Inequality as a Determinant of Malnutrition and Unemployment: Theory”, *Economic Journal*, 96 (384), 1011-1034.

Dreze, Jean, and Reetika Khera. (2000). "Crime, Gender, and Society in India: Insights from Homicide Data", *Population and Development Review*, 26(2), 335-352.
The Economist. (2000). "Congo's Bewitched Children: Sad Little Sorcerers", Dec. 7, 2002, p.47.
Empowering Widows in Development [EWD]. (2002). "10 Country Report" (http://www.oneworld.org/empoweringwidows/10countries/).
Evans-Pritchard, E.E. (1937). *Witchcraft, Oracles and Magic among the Azande*, Oxford: Clarendon.
Fajnzylber, Pablo, Daniel Lederman, and Norman Loayza. (2002). "What Causes Violent Crime?", *European Economic Review*, 46, 1323-1357.
Fearon, James D., and David D. Laitin. (2001). "Ethnicity, Insurgency, and Civil War", presented at Annual Meetings of the American Political Science Association, San Francisco, California.
Geschiere, Peter. (1997). *The Modernity of Witchcraft: Politics and the Occult in Postcolonial Africa*. Translated by Peter Geschiere and Janet Roitman. Univ. of Virginia Press: Charlottesville, VA.
Glascock, A. (1987). "Treatment of the aged in non-industrial societies", in P. Silverman (ed.) Elderly as Modern Pioneers. Indiana: Indiana University Press.
Green, Maia. (1994). "Shaving Witchcraft in Ulanga: Kunyolewa and the Catholic Church", in Ray Abrahams (ed.) (1994). *Witchcraft in Contemporary Tanzania*. African Studies Center, University of Cambridge.
Grossman, Herschel, and Minseong Kim. (1995). "Swords or Plowshares? A Theory of the Security of Claims to Property", *Journal of Political Economy*, 103(6), 1275-1288.
Hoddinott, John, and Bill Kinsey. (2001). "Child Growth in the Time of Drought", *Oxford Bulletin of Economics and Statistics*, 63(4), 409-436.
Hoyert, D.L., M.A. Freedman, D.M. Strobino, and B. Guyer. (2001). "Annual Summary of Vital Statistics: 2000", *Pediatrics*, 108(6), 1241-1255.
Kochar, Anjini. (1999). "Evaluating Familial Support for the Elderly: The Intrahousehold Allocation of Medical Expenditures in rural Pakistan", *Economic Development and Cultural Change*, 47(3), 621-656.
Maxwell, E., P. Silverman, and R. Maxwell. (1982). "The Motive for Geronticide", *Studies in Third World Societies*, 22, 67-84.
Mehlum, Halvor, Karl Ove Moene, and Ragnar Torvik. (2000). "Crime-Induced Poverty Traps", unpublished manuscript, Norwegian University of Science and Technology.
Mesaki, Simeon. (1994) "Witch-killing in Sukumaland", in Ray Abrahams (ed.) (1994). *Witchcraft in Contemporary Tanzania*. African Studies Center, University of Cambridge.
Mirlees, J.A. (1975). "A Pure Theory of Underdeveloped Economies", in *Agriculture in Development Theory*, L. Reynolds (ed.). New Haven: Yale University Press.
Moore, Henrietta, and Todd Sanders. (2001). "Magical Interpretations and Material Realities: An Introduction", in *Magical Interpretations and Material Realities: Modernity, Witchcraft and the Occult in Postcolonial Africa*, eds. Henrietta Moore and Todd Sanders. London: Routledge.
Nicholson, S.E., and M.L. Davenport, and A.R. Malo. (1990). "A Comparison of Vegetation Response to Rainfall in the Sahel and East Africa using Normalized Difference Vegetation Index from NOAA-AVHRR", *Climate Change*, 17, 209-241.
Niehaus, Isak. (2001). "Witchcraft in the new South Africa: From Colonial Superstition to Post-Colonial Reality?", in *Magical Interpretations and Material Realities: Modernity, Witchcraft and the Occult in Postcolonial Africa*, eds. Henrietta Moore and Todd Sanders. London: Routledge.
Nugent, J. B. and N. Sanchez. (1999). "The Local Variability of Rainfall and Tribal Institutions: The Case of Sudan", *Journal of Economic Behavior and Organization*, 39, 263-291.
Oster, Emily. (2002). "Witchcraft, Weather and Economic Growth in Medieval Europe", unpublished manuscript, Harvard University.
Paxson, Christina. (1992). "Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand", *American Economic Review*, 82(1), 15-33.
Rahman, O., A. Foster, and J. Mencken. (1992). "Older Widow Mortality in Rural Bangladesh", *Social*

Science and Medicine, 34, 89-96.
Ray, Debraj. (1998). *Development Economics*. Princeton: Princeton University Press.
Rose, Elaina. (1999). "Consumption Smoothing and Excess Female Mortality in Rural India", *Review of Economics and Statistics*, 81(1), 41-49.
Rosenzweig, Mark R., and T. Paul Schultz. (1982). "Market Opportunities, Genetic Endowments, and Intrafamily Resource Distribution: Child Survival in Rural India", *American Economic Review*, 72(4), 803-815.
Rowlands, Alison. (1998). "Telling Witchcraft Stories: New Perspectives on Witchcraft and Witches in the Early Modern Period", *Gender and History*, 10(2), 294-302.
Schultz, T. Paul. (1971). "Rural-Urban Migration in Colombia", *Review of Economics and Statistics*, 53 (2), 157-163.
Sen, Amartya. (1992). "Missing Women", *British Medical Journal*, 304.
Silverman, P., and R.J. Maxwell. (1984). "Cross-cultural variation in the status of old people", in P. Stearns (ed.) *Old Age in Pre-Industrial Society.* New York: Holmes and Meier.
Simmons. L.W. (1945). *The Role of the Aged in Primitive Society*. New Haven, CT: Yale Univ. Press.
Singer, Rena. (2000). "Anti-Witch Hunting Laws Create Tension in South Africa", *Christian Science Monitor*, Dec. 6, 2000.
Stevenson, D.K., et al. (2000). "Sex Differences in Outcomes of Very Low Birthweight Infants: The Newborn Male Disadvantage", *Archives of Disease in Childhood*, 93(3), F182-F185.
United Nations Development Program. (1998). *Shinyanga Human Development Report.*
United Nations Development Program. (2002). *2002 Human Development Report: Deepening Democracy in a Fragmented World*. Oxford University Press.
United Republic of Tanzania. (1999). *Shinyanga Region Socio-Economic Profile*.
Von Cott, Donna Lee. (2000). "A Political Analysis of Legal Pluralism in Bolivia and Colombia", *Journal of Latin American Studies*, 32, 207-234.
Wahab, A. A. Winkvist, H. Stenlund, S.A. Wilopo. (2001). "Infant Mortality among Indonesian Boys and Girls: Effect of Sibling Status", *Annals of Tropical Pediatrics*, 21(1), 66-71.
Wendel, Margareta, and Gerd Holmboe-Ottesen. (1992). "Food Availability and Nutrition in a Seasonal Perspective: A Study from the Rukwa Region in Tanzania", *Human Ecology*, 20(1), 89-107.
Yang, W.S., H.H. Knobel, C.J. Chen. (1996). "Gender Differences in Post-neonatal Infant Mortality in Taiwan", *Social Science and Medicine*, 43(10), 1461-1465.

8. 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
Girls as proportion of children born that year (for 1992-2001)	0.49	0.25	660

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 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 girls as proportion of all births since there are some villages were no children were born in a given year among sampled households (hence the proportion is undefined).

Table 2: Witch Murder Victim Characteristics

	Mean
Panel A: Demographic characteristics	
Female	0.96
Age	57.6
Had relatives in the village	0.98
Lived in a household with others	0.87
Sukuma ethnic group	0.96
Panel B: Socioeconomic characteristics	
Ownership household goods (e.g., radio, bicycle):	
"Below average"	0.69
"Average"	0.31
"Above average"	0
Ownership of livestock:	
"Below average"	0.55
"Average"	0.38
"Above average"	0.08
Ownership of land:	
"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. Data on ownership of household goods is missing for 4 of 53 victims, and month data is missing for 11 of 53 victims.

Table 3: Extreme Rainfall and Village Calamities

Explanatory variable	Dependent variable: Annual per capita consumption expenditures (USD) OLS (1)	OLS (2)	OLS (3)	Famine OLS (4)	Human disease epidemic OLS (5)
Extreme rainfall (drought or flood)	-50.7**	-50.1*		0.47***	-0.03
	(24.8)	(26.6)		(0.07)	(0.04)
Human disease epidemic		4.4		0.04	
		(25.7)		(0.05)	
Drought			-38.5*		
			(21.3)		
Flood			-74.9		
			(48.4)		
Average years of education	1.7	1.8	0.0		
	(13.0)	(13.4)	(12.9)		
Proportion Sukuma ethnic group	-12.0	-12.1	-14.5		
	(63.5)	(64.8)	(65.3)		
Proportion households grow cash crops	-2.7	-2.9	3.7		
	(56.2)	(56.3)	(56.2)		
Households per village / 1000	0.07	0.07	0.07		
	(0.07)	(0.07)	(0.07)		
Proportion practice traditional religions	17.2	17.4	22.7		
	(52.5)	(53.4)	(52.4)		
Women's community groups per household	2116	2083	2333		
	(2492)	(2465)	(2571)		
Geographic division fixed effects	Yes	Yes	Yes	No	No
Village fixed effects (67 villages)	No	No	No	Yes	Yes
R^2	0.14	0.14	0.15	0.26	0.06
Root MSE	81.4	82.1	81.8	0.34	0.37
Mean of dependent variable	196.8	196.8	196.8	0.18	0.15
Number of observations	67	67	67	736	736

Table 3 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. 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 3, we cannot reject the hypothesis that the coefficient estimates on Drought and Flood are equal (p-value=0.50).

Table 4: Extreme Rainfall 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)	0.076** (0.037)	0.098 (0.059)	0.085** (0.042)	0.056 (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)	
Village fixed effects (67 villages)	Yes	No	Yes	Yes	Yes
Socioeconomic controls, and geographic division fixed effects	No	Yes	No	No	No
Year fixed effects (11 years)	No	No	No	No	Yes
R^2	0.15	0.05	0.16	0.15	0.19
Root MSE	0.32	0.32	0.31	0.32	0.31
Mean of dependent variable	0.09	0.09	0.09	0.09	0.09
Number of observations	736	736	736	736	736

Table 4 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. Regression disturbance terms are clustered at the village level. Socioeconomic controls include Average years of education, Proportion Sukuma ethnic group, Proportion households grow cash crops, Households per village / 1000, Proportion practice traditional religions, and Women's community groups per household.

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

	Dependent variable: Witch Murders			
	OLS	OLS	OLS	OLS
Explanatory variable	(1)	(2)	(3)	(4)
Extreme rainfall (drought or flood)	0.085**			
	(0.042)			
| 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
R^2	0.15	0.15	0.15	0.15
Root MSE	0.32	0.32	0.32	0.32
Mean of dependent variable	0.09	0.09	0.09	0.09
Number of observations	736	736	736	736

Table 5 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. 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. When it is included as the main explanatory variable, the coefficient estimate on |Deviation from average vegetation during rainy season| is 0.31 (standard error 0.35).

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. Observations are weighted by the number of households per village. 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 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	-0.018	-0.046^{**}	-0.064^{**}
	(0.019)	(0.020)	(0.030)
Average years of education	-0.051^{***}	0.007	-0.045^{*}
	(0.015)	(0.017)	(0.025)
Proportion Sukuma ethnic group	0.11	-0.02	0.10
	(0.14)	(0.12)	(0.22)
Proportion households grow cash crops	-0.01	-0.03	-0.04
	(0.08)	(0.10)	(0.11)
Households per village / 1000	-0.02	0.23^{**}	0.21^{*}
	(0.09)	(0.10)	(0.13)
Proportion practice traditional religions	-0.00	-0.02	-0.02
	(0.07)	(0.09)	(0.12)
Women's community groups per household	1.7	-2.9	-1.2
	(3.4)	(4.5)	(5.4)
R^2	0.29	0.26	0.34
Root MSE	0.12	0.13	0.16
Mean of dependent variable	0.09	0.11	0.20
Number of observations	67	67	67

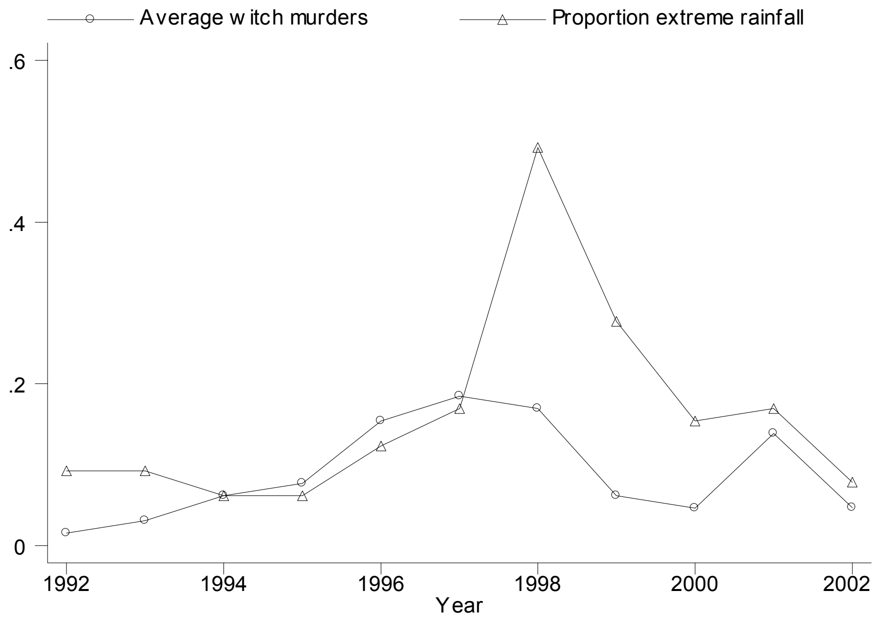
Table 7 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. Controls for the proportion of years with extreme rainfall, proportion of years with disease epidemics, geographic division fixed effects, and average village NDVI (during the rainy season) are also included as explanatory variables (coefficient estimates not reported). The dependent variables are average murders per year, over the period 1992-2002.

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		Girls as proportion of 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	0.0025	0.0009	0.0009	-0.00	0.02
	(0.0020)	(0.0025)	(0.0017)	(0.0023)	(0.04)	(0.04)
Extreme rainfall, previous year		0.0022		0.0007		0.04
		(0.0017)		(0.0019)		(0.05)
Extreme rainfall, current year and previous year		-0.0070**		-0.0000		-0.09
		(0.0031)		(0.0044)		(0.08)
Human disease epidemic	0.0012	0.0010	-0.0040**	-0.0040**	0.09***	0.09***
	(0.0013)	(0.0013)	(0.0018)	(0.0019)	(0.03)	(0.03)
Village fixed effects (67 villages)	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects (11 years)	Yes	Yes	Yes	Yes	No	No
R^2	0.20	0.21	0.20	0.20	0.12	0.13
Root MSE	0.011	0.011	0.012	0.012	0.25	0.25
Mean of dependent variable	0.0177	0.0177	0.0195	0.0195	0.49	0.49
Number of observations	670	670	670	670	660	660

Table 8 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. 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 Regressions 2, 4, or 6. Ten of 670 village-year observations are dropped from regressions 5 and 6 since there were no children born in a particular year in a village among the sample of surveyed households (and thus the dependent variable is undefined).

Figure 1: 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.

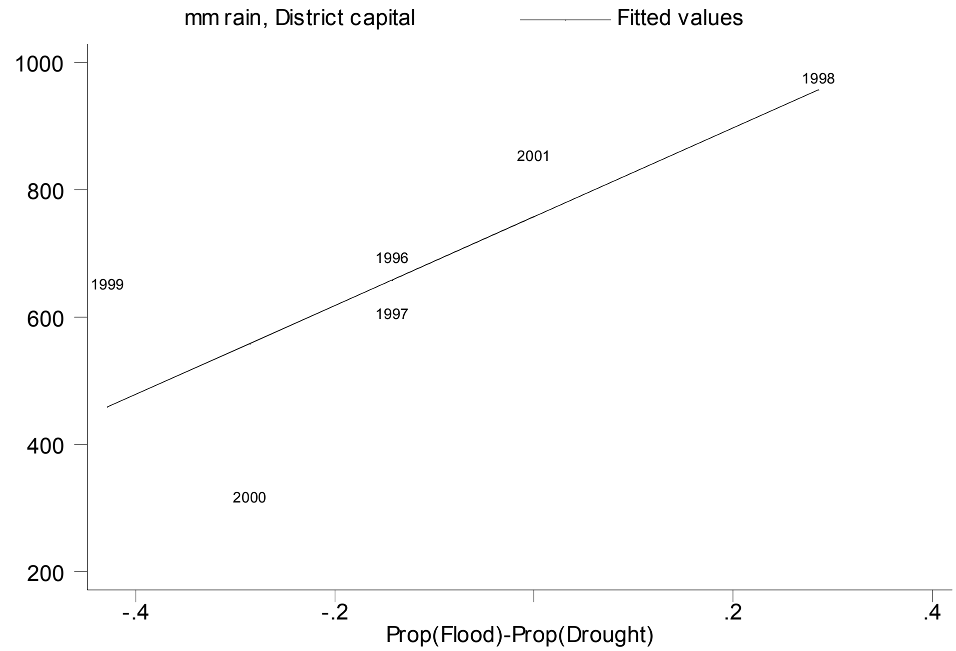
9. Appendix

Table A1: Extreme Rainfall and Witch Murders, Robustness

	Dependent variable:				
	Witch Murders	Any witch murder	Witch Murders	Witch Murders	Witch Murders
	OLS	Probit	Ordered probit	Poisson	Negative binomial
Explanatory variable	(1)	(2)	(3)	(4)	(5)
Extreme rainfall (drought or flood)	0.076**	0.071**	0.39**	0.46*	0.46*
	(0.037)	(0.035)	(0.17)	(0.27)	(0.27)
Socioeconomic controls, and geographic division fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.05	-	-	-	
Root MSE	0.32	-	-	-	
Mean of dependent variable	0.09	0.08	0.09	0.09	0.09
Number of observations	736	736	736	736	736

Table A1 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Observations are weighted by the number of households per village. Regression disturbance terms are clustered at the village level. Socioeconomic controls include Average years of education, Proportion Sukuma ethnic group, Proportion households grow cash crops, Households per village / 1000, Proportion practice traditional religions, and Women's community groups per household.

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)