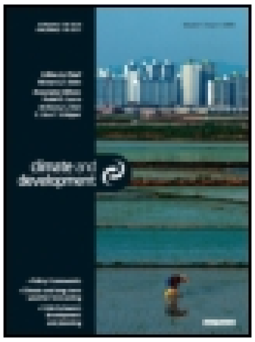

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RESEARCH ARTICLE

A mediation analysis of the linkages between climate variability, water insecurity, and interpersonal violence

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ABSTRACT
Numerous studies have examined the effects of climate change on many aspects of both human health and violence. Fewer studies have investigated the links between climate change and intimate partner violence (IPV). We expand on this literature by examining the association between climate variability and IPV, including physical, sexual, and psychological forms of violence. We examine both direct associations and potential mediation via water insecurity, in a sample of women from 15 sub-Saharan African countries. Our results suggest there is a direct effect of climate variability on IPV but also that this effect is mediated through water insecurity. These results contribute to the literature by highlighting pathways through which climate change may affect IPV, including water insecurity, and changes in soil moisture and precipitation. Our findings are important for policy makers and international development organizations as they indicate specific areas where improvements to water insecurity can help reduce the incidence of IPV globally.

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Introduction

Research on climate change and gender notes that women are particularly vulnerable to the negative physical and social impacts of increasing climate variability and frequency of extreme weather events (Alston & Whittenbury, 2013; Ampaire et al., 2020; Arora-Jonsson, 2011; Denton, 2002; Eastin, 2018). Studies have estimated that women are 14 times more likely than men to die from climate-related catastrophic events (Neumayer & Plümper, 2007). Moreover, climate change and environmental degradation further increase the incidence of gender-based violence against women (Harvey, 2020). A recent report by the International Union for Conservation of Nature (IUCN) highlighted that 59% of survey respondents experienced some type of gender-based violence arising from experiencing an environmental issue (Castañeda Camey et al., 2020). While research on the environment-conflict nexus has historically focused on armed conflict at the interstate or intrastate scale (Buhaug et al., 2015; Burke et al., 2014; Gleditsch, 2012; Gleditsch & Nordås, 2014; Hsiang et al., 2013; Hsiang & Burke, 2014; Hsiang & Meng, 2014; Link et al., 2016; O'Loughlin et al., 2012) as well as other forms of large scale collective or group violence (Brzoska & Fröhlich, 2016; Hendrix & Glaser, 2007; Hsiang et al., 2011; Ide, 2015; Mueller, 2018; Salehyan & Hendrix, 2014; Witmer et al., 2017), a recent and growing body of research considers the effect of environmental stressors on the incidence of interpersonal violence, especially intimate partner violence (Cools et al., 2020; Cooper et al., 2021; Epstein et al., 2020; Mares & Moffett, 2016; Miles-Novelo & Anderson, 2019).

Intimate partner violence (IPV) includes acts of completed or threatened physical, sexual, and psychological violence against a current or former partner. Globally, approximately 1 in 3 women experience IPV in their lifetime, making it the most prevalent form of violence against women (Devries et al., 2013). Although IPV is a common occurrence for women of all ages and sociodemographic backgrounds, woman who are younger, pregnant, lower income, and/or have a lower educational attainment are consistently associated with higher IPV risk (Miller-Graff, 2016). In sub-Saharan Africa, women who are in polygamous unions and those who have more children are at an even higher risk for IPV (Ahinkorah, 2021; Heath et al., 2020; Izugbara et al., 2020).

This study contributes to the literature on IPV and the environment-conflict link by employing mediation analysis to examine the direct and indirect relationships between changes or variability in ecological processes and IPV in sub-Saharan Africa. We consider the direct impact of climate variability (measured as fluctuations in precipitation, soil moisture, and temperature) on the incidence of IPV in the past 12 months, as well as the indirect effect of climate variability on IPV when mediated by household water insecurity utilizing household-level survey data. These data were obtained from the Demographic and Household Surveys (DHS) and include surveys collected between 2005 and 2016 in 15 countries in sub-Saharan Africa. We test two hypotheses.

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First, we hypothesize that increased climate variability, specifically through drier conditions, is associated with more IPV polyvictimization (i.e. the experience of different types of victimization events). Second, we hypothesize that household water insecurity (measured as water fetching time or water source type) mediates this relationship.

Previous literature

Given the documented patterns and rate of global environmental change (e.g. Warner, 2010; Brauch & Oswald Spring, 2011; Drinkwater et al., 2010; Romanello et al., 2021; IPCC, 2019b), consistently measuring the relationship between shifts in climate phenomena and human conflict has proven exceedingly difficult (Mach et al., 2019). Part of the challenge lies in the varying definitions of conflict (Galtung, 1969, 1985; Ide et al., 2016; Ide & Scheffran, 2014; Mach et al., 2019; Marcantonio, 2017; Marcantonio et al., 2018; Richmond, 2014) and environmental change (Cornwall, 2016; Gleditsch, 2012; Hendrix & Glaser, 2007; Linke et al., 2015; Ogunbode et al., 2019), different ways to model the interactions between these variables (Buhaug, 2015; Hsiang & Meng, 2014; O'Loughlin et al., 2014), and differences in the data used to measure both conflict and environmental change (Gleditsch et al., 2002; Raleigh et al., 2010; SCAD, 2016; Melander & Sundberg, 2010). For example, 'water' as a driver of conflict could be viewed through drought events (Gleick, 2014; von Uexkull, 2014), flood events (Ghimire et al., 2015; Reuveny, 2007), rainfall variability in either direction (Fjelde & von Uexkull, 2012; Linke et al., 2015; Raleigh & Kniveton, 2012), and water insecurity (Gizelis & Wooden, 2010; Link et al., 2016; Pearson et al., 2021). Other potential pathways from environmental change to conflict include food insecurity resulting from climate perturbations (Buhaug et al., 2015; Raleigh et al., 2015), climate-driven economic shocks (Kim & Conceição, 2010; Salehyan & Hendrix, 2014; Hallegatte, Green, Nicholls, & Corfee-Morlot, 2013), and climate-driven migration (Abel et al., 2019; Kelley et al., 2015; Mitchell & Pizzi, 2021; Reuveny, 2007).

Despite the extensive literature on conflict and environmental change, less research has examined the relation between climate change and IPV (Wonders, 2018), even though IPV is the most prevalent form of direct violence against women (Watts & Zimmerman, 2002). We discuss the research on the link between climate change and IPV that has been conducted world-wide, as limited research thus far has focused specifically on Africa. Global research has demonstrated the link between disasters and violence, and that disasters exacerbate pre-existing rates of violence against women (Cutter, 1996; WHO, 2005; Oxfam, 2008). The empirical literature also documents higher rates of violence against women following natural disasters, suggesting climate change may be a risk factor for IPV (Neumayer & Plümper, 2007; Wachholz, 2013). In the Philippines, Anttila-Hughes and Hsiang (2013) note an increased incidence of female infant mortality well after the immediate impacts of typhoons dissipate because resources are dedicated to the male siblings, resulting in increased mortality.

Previous research indicated that the climate-gender violence nexus may be at least in part explained by the effects of climate change on economic destabilization (Ide et al., 2021). As Carr (2013) demonstrates, livelihood is more than just material means and thus requires a more holistic perspective inclusive of economics, social structures, identity, and other factors, all of which can degrade life through polyvalent vectors. As such, examining indirect pathways that capture such destabilization or threats to livelihoods, such as water insecurity, represent important potential explanatory variables.

Women are more vulnerable to violence related to water insecurity because they are often in charge of the management of water, including transport, storage, negotiation for access to water supplies, evaluation and selection of water sources, and payment for water services (Bapat & Agarwal, 2003; Sultana, 2009). Women can also be harassed, assaulted, raped, or injured while collecting water (Geere & Cortobius, 2017; Pommells et al., 2018). In addition, water scarcity can lengthen water-fetching time, which may expose women to violence within the home due to delays or failures to complete socially expected and gender-specific "household duties" (Choudhary et al., 2020; WHO, 2005). For example, a study from India noted that women were at higher risk for marital violence during times of irrigation systems failures (Karim et al., 2012). This failure increased the travel time to fetch water, which prevented women from completing household obligations. In Nepal, lack of water access has been linked to physical and emotional forms of IPV as a response to failure to perform socially expected duties in the household (Choudhary et al., 2020).

A recent review of the emerging body of work on water scarcity and IPV highlights several aspects of this relationship revealed by case study research (Tallman et al., 2022). In Kenya, Collins et al. (2019) found a link between water insecurity and verbal and physical forms of IPV. A more recent study by Mushavi et al. (2020) in rural Uganda highlights several aspects of violence linked to water. For example, the study noted that IPV can occur when there is insufficient water in households or physical or verbal disputes with people outside of the household while waiting in line for water. In Ethiopia, Assefa et al. (2021) find that women and girls experience various kinds of violence (e.g. rape, assault) while traveling to fetch water.

Furthermore, women are at higher risk for violence when rainfall patterns deviate from normal, particularly in regions dominated by agricultural land use, which cause loss of work and/or crop yields that reduce household income. Reductions in income may provoke actions to reallocate resources to more productive household members. Miguel (2005) noted that this reallocation in times of scarcity contributed to the murders of elderly women in rural Tanzania. Sekhri and Storeygard (2014) found in India that in times of drought, IPV became more prevalent to convince the families of women to pay more to offset drops in agricultural yields. In some cases, the husband murdered his wife to marry again and receive another dowry payment. Other work has documented that drought and drought-related income stress is associated with violence against women in the agriculturally-oriented Murray-Darling Basin of Australia (Whittenbury, 2013). Diaz and Saldarriaga (2020) examined rainfall shocks in rural Peru and found that physical IPV increased after a drought during the cropping season. The authors also found this effect was mediated by poverty-related stress and reduced female empowerment. In other land use scenarios (i.e. non-agricultural settings) drought produces others social impacts which may factor into violence against women, including reduced income and rising debt, lack of work, and separation from families (Whittenbury, 2013).

In Africa, 36.6% of ever-partnered women experience some form of IPV in their lifetime (Hindin et al., 2008). The African continent is also considered the region most vulnerable to rainfall and land surface temperature-related climate changes and has already experienced increased climate variability with more frequent and severe extreme weather events (Washington et al., 2006; IPCC, 2017; 2019a, 2019b). Agriculture in Africa is predominantly rainfed, therefore variability in climate conditions directly results in variable agricultural productivity. Alongside population increases, changes in climate and agricultural yields can result in increased food and water security, particularly in urban areas where households are predominantly net food consumers (IEP, 2020). As African nations, communities, and households are likely to endure more climate-related challenges in the near future (Hulme, Doherty, Ngara, New, & Lister, 2001; Romanello et al., 2021), it is important to understand the links between IPV and climate variability on this continent.

Recent work has investigated drought and the incidence of IPV against women in Africa (Cools et al., 2020; Epstein et al., 2020). Our study is distinct from these analyses for three key reasons. First, our study uses mediation analysis to examine how climatic variability affects IPV via water insecurity. Exploring the mechanisms through which this relationship exists is important to help design policy to target the specific aspects of climate variability that yield violence.

Second, there are differences in the variable or metric defining the climatic conditions for our statistical analysis. Other studies operationalized climatic conditions as low rainfall anomalies (i.e. drought) making it necessary that they address concerns regarding spatial correlation in rainfall due to the issues raised by Lind (2019). We operationalize climate variability, not climate anomalies, using the Standardized Precipitation Index (SPI) and the Standardized Precipitation and Evapotranspiration Index (SPEI). SPI looks at precipitation trends over multiple accumulation periods or lags. The SPEI considers both precipitation and Potential Evapotranspiration (PET) in defining climatic variability. Thus, SPEI is not just a measure of total precipitation or precipitation anomalies but characterizes climate variability and its landscape impacts by highlighting temporal deficits in soil moisture. This measure thus does not have the same concerns about spatial correlation that are present when using rainfall data only for describing the ecological contexts of an observation. However, this measure does not necessarily negate important challenges in understanding and capturing the social contexts of an observation where spatial correlation between the presence and absence of IPV might occur not for ecological reasons. The challenges of spatial correlation in assessing vulnerability and intersectional, complex social phenomena, such as violence, are many (Abrahams & Carr, 2017; Carr et al., 2015; Ide, 2017). Thus, we rely on the mediation analysis to parse and account for the complex nature of the relationship between environmental conditions and IPV.

Finally, we use non-binary measures of IPV which indicate how many of these acts of IPV women experience. This is an important contribution as it provides a measure of the prevalence of different types of IPV. Examining the influence of climate variability on different types of IPV and the frequency of these experiences is an important contribution to the literature, as both subtypes and severity may have different impacts (Paulson, 2020; Velotti et al., 2018). For example, a 2005 report by the World Health Organization (WHO) showed that there is a wide range in the reporting of physical and sexual violence across countries, households, and individuals, and that women who experience IPV are also likely to experience physical and mental health problems (Garcia-Moreno et al., 2006; Garcia-Moreno et al., 2005). Another study by Ellsberg et al. (2008) found that injury due to violence is less common than other physical and psychological effects of experiencing violence which vary by type of IPV. Therefore, these differential effects across the types of IPV are important to study and analyze (Ellsberg et al., 2008).

Conceptual model

We examine the effect of climate variability on IPV. Specifically, we use measures of variability in precipitation and temperature to analyze their association with three types of IPV – sexual, psychological, and physical. We theorize that climate variability's effects on IPV operate via its influence on household water security, which destabilizes the household, leading to domestic conflict and IPV. We test the two hypotheses shown in Figure 1. Our first hypothesis is:

H1: increased variability in climatic conditions is associated with higher incidence of IPV

We expect that increased climate variability will be associated with higher levels of IPV since this reduces the predictability

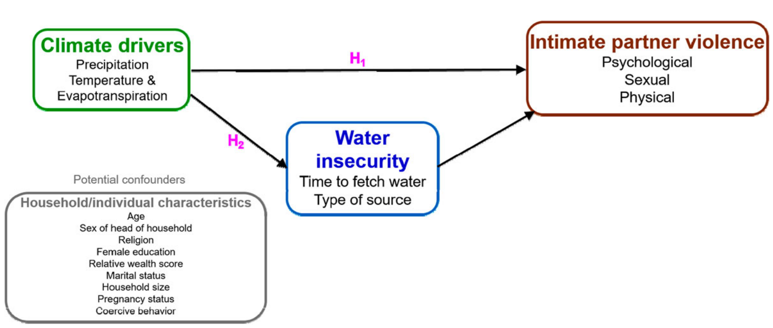

Figure 1. Conceptual diagram of study hypotheses.

of environmental conditions for meeting livelihood needs and disrupts planning efforts to meet those needs, resulting in additional stressors to everyday life. This hypothesis is in alignment with the literature on climate and conflict, outlined in the previous sections, which suggests that several types of climatic changes and associated extreme weather events (e.g. rainfall variability, temperature increases, droughts, and floods) contribute to the occurrence of social and violent conflict. Likewise, our hypothesis is supported by the literature on gender-based violence and climate change, which indicates that under drier-than-normal conditions (i.e. increased climate variability), women are at higher risk for experiencing violence. Hypothesis 1 will be tested using six multivariable regression models examining the role of climate variability on sexual, physical, and psychological IPV, controlling for demographic covariates.

H2: the relationship between climate variability and IPV is mediated by water insecurity

We hypothesize that water insecurity will mediate the link between climate variability and IPV. Drier than normal conditions are likely to increase water fetching time, a gender-specific responsibility (i.e. in most rural households, women and girls are tasked with this responsibility) and also may lead to a change in the primary water source type used by the household. In other words, nearby water sources may evaporate, or supplies may be too low, forcing households to find alternative, more distant sources of water (Pearson et al., 2015; Pearson et al., 2016). Drier conditions, thus, often increase the time burden required of women and girls to fetch water, which in turn may affect women's experience – threatened and/or completed – of IPV. Further, reliance on unimproved water sources increases rates of illness from consuming unsafe water (Bhavnani et al., 2014). The responsibility for caring for the sick household members most often falls on women in the household (Marcantonio, 2018; Marcantonio, 2019). In addition, women in households that depend on surface water sources are more likely to be affected by rainfall variability and thus may be more likely to experience IPV.

While not a comprehensive assessment of insecurity (Jepson et al., 2017a; Jepson et al., 2017b; Wutich et al., 2017), we consider two measures of water insecurity – minimum water fetching time and the type of water source. Hypothesis 2 will be tested using path analysis of climate→water insecurity→IPV, with significant mediation defined as an indirect effect of the mediator on the outcome that has a 95% confidence interval that does not include zero. Six models will be evaluated, to consider both SPI and SPEI as independent variables and each type of IPV (i.e. physical, sexual, and psychological) as dependent variables, controlling for demographic variables.

Methods

Sample and survey sampling design

Our analysis uses data from the Demographic and Health Surveys (DHS), which are nationally representative household surveys supported by USAID and the World Bank along with the Central Statistic Offices (CSO) of the countries in which they are conducted. The DHS provide information on populations in developing countries, including socioeconomic characteristics, health information, and nutrition indicators. The DHS data are collected from probability samples selected using a stratified two-stage cluster design which includes designating enumeration areas (EAs) and then drawing samples of 25–30 households from each EA. The collection of households constitutes the DHS sampling cluster that is georeferenced using the latitude/longitude coordinates for the cluster centroid, or the approximate centre of the area surveyed. The coordinates for DHS cluster centroids are displaced with a positional random error to protect privacy, 0–2 km and 0–5 km for urban and rural areas, respectively. Despite the positional random error, the spatial reference still allows for the comparison of the DHS data with climate and other data based on shared spatial location and appropriate temporal scale [see the Guide to Statistics, DHS 7 for a thorough review of the sampling methodology (Croft et al., 2018)].

We combine data from the women's questionnaire of the Standard DHS with data from the Domestic Violence module which collects information on IPV experienced by married or cohabiting women (Hindin et al., 2008). The Domestic Violence module randomly selects one eligible woman from each household to interview about experiences of domestic violence, including physical, sexual, and psychological abuse (Hindin et al., 2008). We include approximately 105,000 observations collected from 19 surveys conducted across 15 countries located in sub-Saharan Africa: Angola, Burundi, Cameroon, Democratic Republic of the Congo, Ethiopia, Ghana, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Tanzania, Uganda, and Zambia.[1] DHS survey years in this study range from 2005 to 2016, with the inclusion of multiple survey years for some countries (Malawi, Nigeria, Tanzania, and Zambia), and only one survey year for the other countries. The data are analyzed at the unit of the individual woman and geographically at the level of the DHS cluster.

Past year intimate partner violence

Women's experiences of IPV were drawn from the DHS Domestic Violence module, which asks about the lifetime and past year prevalence of physical, psychological, and sexual abuse, as well as women's lifetime experiences of coercive control.[2] Previous studies have used the DHS Domestic Violence module to examine the effects of IVP on women's contraception use and assess heightened vulnerability to violence in lower- and middle-income countries (e.g. MacQuarrie et al., 2016). To establish the necessary sequencing for analysis in the context of mediation, we included past year experiences of physical, sexual, and psychological IPV as dependent variables. Given that the presence of coercive control often pre-dates the onset of other forms of IPV, lifetime coercive control is included as a covariate (Dutton & Goodman, 2005). Coercive control was assessed based on 6 items – jealousy, accusations of unfaithfulness, control over contacts with friends, control over contacts with family, insistence on monitoring location/activities, or a lack of trust regarding the expenditure of money – each coded for presence/absence (1/0). The total score was generated by tallying items for a possible value range of 0–6 with higher values representing more experiences of lifetime coercive control.

Psychological IPV was assessed using 3 items – humiliated, insulted, or threatened – coded for presence/absence (1/0). Then, the total amount of psychological IPV experienced was constructed as the sum of total number of types endorsed (Range 0–3). Physical IPV was assessed using 7 items, including questions about being hit, slapped, strangled, burned, kicked or dragged, having one's arm twisted, having one's hair pulled, or being attacked with a weapon. A variable was then constructed indicating the total number of types endorsed (Range 0–7). Sexual IPV was assessed using 3 items, including questions about being forced to have sex, being forced into sexual acts when not wanted, and being coerced into sexual acts when not wanted. A variable was constructed indicating the total number of types endorsed (Range 0–3). Previous work has found that the DHS survey is likely to be highly sensitive (i.e. correct identification of positive cases) but is unlikely to be very specific (i.e. presence of false negatives), depending upon the specific survey conditions (Elsberg, Harrison, Echelmeyer, & Krimmel, 2001). Therefore, it is anticipated that these measures are biased towards zero, so any statistical significance found is likely to understate the true effect. All three measures of IPV were not collected on all survey respondents, so the number of women in each analysis varied from 96,002–52,315.

Climate variability data – the standardized precipitation index and standardized precipitation evapotranspiration index

We compiled time series precipitation data for a 37-year period for the African continent from the Climate Hazards Center's Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset (Funk et al., 2015).[3] The CHIRPs dataset combines satellite imagery with weather station data to create raster rainfall estimates in millimeters at 0.05-decimal-degree resolution from 1981 onward (Funk et al., 2015). Rainfall estimates were extracted for a 10-kilometer buffer around each georeferenced DHS cluster location for the 24 months preceding each cluster's unique survey start date (i.e. the month and year data was recorded for each individual cluster). The average monthly precipitation was calculated for each cluster and surrounding buffer zone. Minimum and maximum monthly temperature data for the same time period were compiled from the Terrestrial Hydrology Research Group (Princeton University, version 3) (Perez-Heydrich et al., 2013; Sheffield et al., 2006) and the samaaafe methodology was used to extract average minimum and maximum temperature for DHS cluster locations (Burgert et al., 2013).

The derived precipitation and temperature data were then used to calculate two widely-used drought indices: the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI). The SPI measures the number of standard deviations that the observed cumulative precipitation departs from the long-term mean and can be compared across markedly different climates. While traditionally called a drought index, different SPI time-periods highlight different agroclimatic processes (Keyantash, 2018). For shorter time periods, SPI is closely related to soil moisture whereas for longer periods it is more related to groundwater availability. SPI uses only precipitation in its calculation and enables us to compare regions around the world with vastly different climates. Positive SPI values indicate wetter conditions while negative values indicate drier conditions (Vicente-Serrano et al., 2010).

The SPEI, an extension of the SPI, most closely represents a proxy for soil moisture and incorporates both precipitation and potential evapotranspiration (PET) in its calculation (Bunting et al., 2019). The SPEI differs from the SPI in that it is designed to consider both precipitation and PET in determining drought (Bunting et al., 2019). Thus, unlike the SPI, the SPEI captures the main impact of increased temperatures on water demand and is generally more useful for capturing climate change and variability (Vicente-Serrano et al., 2010). Additionally, because the SPEI is calculated based on the accumulated difference between precipitation and PET, it can comprehensively reflect the change in surface water balance (Pei, Fang, Wang, & Yang, 2020), which can impact water availability and access. Like SPI, negative values of the SPEI indicate drier conditions while positive values indicate wetter conditions.

Water insecurity – time to fetch water and type of water source

The DHS survey contains two variables related to water insecurity. One variable indicates self-reported time, in minutes, to fetch water. While self-reported time to fetch water has been shown to be unreliable in relation to objective measures such as distance to source (Pearson, 2016), it has been used in other research as a direct form of water access issues (Rosinger et al., 2020). Households spending 60+ minutes fetching water have significantly higher odds of borrowing water from others due to unmet needs, compared to households with water in the home (0 min fetch time) (Rosinger et al., 2020). While absolute values of minutes spent fetching water may have measurement error, relative rank of minutes may be a useful indicator of water insecurity issues. In the DHS, this variable includes time to travel to the water source, wait in a queue, and return home and is reported in minutes. This question in the DHS pertains to the primary water source for domestic purposes.

We also evaluated type of water source, collected in the DHS as a nominal variable. To represent water insecurity, we ranked these types to generate a proxy measure as an ordinal variable ranging from 1 to 7, where higher values indicate higher water insecurity and lower values indicate lower risks and higher reliability. Specifically, a value of 1 indicates a piped source on property, 2 a groundwater source not on property, 3 a protected well, 4 an unprotected well, 5 a surface water source, 6 rainwater, and 7 small vendor or bottled water. These ranks are based on information about types of water sources evaluated for the water quality risk (Bain et al., 2014; Pearson et al., 2016), accessibility (Howard & Bartram, 2003; WHO/UNICEF, 2012), cost (Soares et al., 2002), and reliability (Pearson et al., 2016). For example, a piped source on the property will tend to have low water quality risk, high

Table 1. Variable Descriptions.

Variable	Description
SPI12	Indicates the variability of the cumulative rainfall over this 12-month period compared to the long-term trends in rainfall.
SPEI12	Indicates the combined variation in rainfall and evapotranspiration which is affected by temperature compared to long-term trends in both over this 12-month period
SPI24	Indicates the variability of the cumulative rainfall over this 24-month period compared to the long-term trends in rainfall.
SPEI24	Indicates the combined variation in rainfall and evapotranspiration which is affected by temperature compared to long-term trends in both over this 24-month period
Total Sexual Violence	Total number of types endorsed, of 3: Total number of times reported being forced to have sex, being forced into sexual acts when not wanted, and being coerced into sexual acts when not wanted
Total Physical Violence	Total number of times reported being pushed, hit, slapped, strangled or burned, kicked or dragged, having one's arm twisted or hair pulled, or being attacked with a weapon
Total Psychological Violence	Total number of times reported being humiliated, insulted, threatened
Fetch Time	Minimum time spent fetching water
Source Type	1 = piped source on property; 2 = groundwater source not on property; 3 = protected well; 4 = unprotected well; 5 = surface water source; 6 = rainwater; 7 = small vendor, bottled water
Age	Age of respondent
Currently Pregnant	Indicator = 1 if currently pregnant
Muslim	Indicator = 1 if religion is Muslim (omitted is Other)
No Religion	Indicator = 1 if religion is No Religion (omitted is Other)
Catholic	Indicator = 1 if religion is Catholic (omitted is Other)
Spiritual	Indicator = 1 if religion is Spiritual (omitted is Other)
Widowed, Divorced, Separated	Indicator = 1 if individual is widowed, divorced, or separated (omitted is currently married)
Number of Household Members	Total number of members in household
Sex of Household Head	Indicator = 1 if head of household is male
Wealth Index Score	Wealth Index factor score
Education Level	Count variable = 0 if no education, = 1 if primary education only, = 2 if secondary education only, = 3 if higher education only
Coercive Acts Experienced Previously	Sum of jealousy, accusations of unfaithfulness, control over contacts with friends, control over contacts with family, insistence on monitoring location/activities, and a lack of trust regarding the expenditure of money

accessibility, low cost, and high reliability. Therefore, someone with a piped source on the property will tend to have high water security, in terms of these domains. Rainwater, however, will have more variable water quality risk, medium accessibility, high cost, and low reliability. Therefore, a household that relies on rainwater will be considered more water insecure than a household with a piped source on the property.

Demographic characteristics

Information on respondent age, sex of household head, number of household members, religion, relative wealth score, marital status, highest education of the respondent, and pregnancy status were obtained from the Standard DHS household questionnaire. These variables are considered potential confounders. All variable descriptions are provided in Table 1 and summary statistics are reported in Table 2.

Results

Hypothesis 1

Tables 3 and 4 present the results estimated to test our first hypothesis: drier than normal conditions are associated with higher levels of IPV. Table 3 presents results showing the linkages between climate and IPV where climate change is operationalized using SPI24 (a 24-month window or period). These results provide support for our hypothesis but suggest that the link between SPI24 and IPV depends upon the type of IPV reported. Column 1 of Table 3 indicates no statistical link between sexual violence and climate conditions. However, in columns 2 and 3 we find a link between climate variability and physical and psychological violence; drier conditions increase the incidence of both types of IPV.

If we examine the direct linkages between SPEI24 and IPV (Table 4), the results are similar for physical and psychological violence – drier conditions increase the incidence of both. Recall that the model using SPEI versus SPI shows the impact of both precipitation and temperature on the outcome condition. Recall that unlike SPI, SPEI includes both PET and precipitation amount into its calculation, therefore depicting conditions such as soil moisture and surface water availability. Interestingly, the results derived using SPEI indicate that wetter conditions increase the incidence of sexual violence.

Hypothesis 2

Tables 5 and 6 present the results of the path analysis to test if the impact of climate variability on IPV is mediated by water

Table 2. Summary Stats.

Variable	Mean	Std Dev	Min	Max	Obs
SPI24	0.1291	0.7750	−3.175	2.483	105,438
SPEI24	0.0736	0.8138	−2.386	2.320	105,326
Total Sexual Violence	0.2077	0.6121	0	3	51,594
Total Physical Violence	0.5250	1.2388	0	7	83,121
Total Psychological Violence	0.4375	0.8329	0	3	94,918
Fetch Time	23.228	36.2324	0	360	105,438
Source Type	3.1492	1.5303	1	7	105,438
Age	30.7612	8.3975	15	49	105,438
Currently Pregnant	0.1267	0.3326	0	1	105,438
Muslim	0.2219	0.4155	0	1	105,438
No Religion	0.0226	0.1485	0	1	105,438
Catholic	0.6391	0.4803	0	1	105,438
Spiritual	0.0094	0.0967	0	1	105,438
Widowed, Divorced, Separated	0.1099	0.3128	0	1	105,438
Number of Household Members	5.3778	2.6448	1	48	105,438
Sex of Household Head	0.7753	0.4174	0	1	105,438
Wealth Index Score	−0.0518	1.9919	−16.010	23.838	105,438
Education Level	1.0652	0.8467	0	3	105,432
Coercive Acts Experienced Previously	0.8099	0.3924	0	1	105,438

Table 3. Impact of SPI24 on Total Intimate Partner Violence In Previous Year.

	Total Sexual Violence	Total Physical Violence	Total Psychological Violence
SPI24	.0061638	−.0345014***	−.0188893***
	[.0052819]	[.0074054]	[.0049731]
Age	−.003819***	−.0050357***	−.0006029
	[0.0004437]	[.00067]	[.000434]
Currently Pregnant	.0039459	−.0370446**	−.0037624
	[.0107596]	[.0149099]	[.0100555]
Muslim	−.1945968***	−.6267765***	−.2832654***
	[.0157633]	[.0344218]	[.0159996]
No Religion	.0032724	−.1021187**	−.0450403*
	[.02826]	[.0521802]	[.0245716]
Catholic	.0051345	−.1814877***	−.0395916***
	[.0132985]	[.0328028]	[.0135764]
Spiritual	−.1258498***	−.2423975***	−.0043783
	[.0331605]	[.0675808]	[.0404857]
Widowed, Divorced,	.0663718***	.3641024***	.2083159***
Separated	[.0184868]	[.0283732]	[.0160332]
Number of	.0063191***	.0047705**	.0100455**
Household Members	[.0016771]	[.0021716]	[.0014905]
Sex of Household	.0207354*	.0285043	.0383033***
Head	[.0119208]	[.0175078]	[.0102054]
Wealth Index Score	−.0038202***	−.0041416	−.0075091***
	[.0013797]	[.0028108]	[.0019086]
Education Level	−.0239483***	−.0511719***	−.0233048***
	[.0044004]	[.0073553]	[.0047396]
Coercive Acts	.1677479***	.4709559***	.404856***
Experienced	[.0093489]	[.010892]	[.0067215]
Observations	52,390	84,200	96,002
Log psuedolikelihood	−788793.84	−969526.34	−1022325.8

Notes: * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level.

insecurity. Table 5 presents the results of the mediation analysis where fetch time is the measure of water insecurity. The results of the mediation analysis contained in Table 6 uses water source type as the measure of water insecurity (mediator). Looking first at the A path in Table 5, we find a negative relationship which indicates that drier conditions increase the amount of time an individual spends obtaining water. The negative relationship is consistent across all specifications. This negative coefficient is also consistent with prior research showing that if there are more drought-like conditions, then individuals will report spending more time fetching water. We find a similar negative relationship for the A path in Table 6, indicating that if conditions are drier, household water insecurity is higher.

We also find in both Tables 5 and 6 a consistent positive relationship between the two measures of water insecurity and IPV. This indicates that the more water insecure a household is, the more likely that women experience IPV. This positive and significant relationship is present for all three types of IPV – sexual, physical, and psychological violence. Since both the A and B paths are statistically significant in all specifications, except the impact of SPEI24 on physical violence, we conclude that these two variables are significant in 11 of our 12 specifications.

Finally, the columns for the C path and C' path in Table 5 allow us to compare the results without fetch time included as a mediating variable (C path) with the results where fetch time is included as a mediating variable (C' path). A comparison of these columns indicates that fetch time does mediate the relationship between climate and IPV because the magnitude of the coefficients is statistically different. That said, the results indicate that climate variability is still linked directly to IPV and similar to the direction of the effect indicated by the results in Tables 3 and 4. Drier conditions increase the incidence of physical and psychological forms of IPV and decreases the incidence of sexual violence. The strength of this association changes when fetch time is included as a mediator. For sexual and psychological violence, the link with climate variability is stronger when fetch time is included as a mediator. For physical violence, the link with climate variability is weaker when fetch time is included as a mediator. This result is further confirmed in the final table where the indirect effects are presented. We find a consistent negative effect for all three types of IPV, with the indirect effect being significant at the 5% level for sexual violence, the 10% level for physical violence, and the 1% level for psychological violence.

The results in Table 6, where water source type is the mediating variable, are marginally different to those in Table 5. The C and C' path columns indicate that water insecurity (source type) is a mediator of the relationship between IPV and climate variability. However, the results are not as consistently statistically significant as they were in Table 5 when fetch time is used as the measure of water insecurity. Specifically, the indirect effect is no longer statistically significant when examining the relationship between SPEI24 and physical violence. The indirect effect is also only statistically significant at the 10% level when considering the relationship between SPEI24 and sexual violence. This result could be due to the fact that water source type may not vary as much as fetch time in people's responses to changing environmental conditions, which could affect the ability to obtain a strong enough signal to see a statistically significant effect. It could also indicate that even within water source types, there is high variability in experiences of water insecurity for those who use them.

Table 4. Impact of SPEI24 on Total Intimate Partner Violence in Previous Year.

	Total Sexual Violence	Total Physical Violence	Total Psychological Violence
SPEI24	.0185468***	−.0218157***	−.0132389***
	[.0048747]	[.0071776]	[.0048924]
Age	−.0038493***	−.005097***	−.0006327
	[.0004435]	[.0006703]	[.0004339]
Currently Pregnant	.0046702	−.0363133**	−.0039968
	[.0107693]	[.0149284]	[.0100567]
Muslim	−.1931384***	−.6207868***	−.2817323***
	[.0157645]	[.034352]	[.0159796]
No Religion	.0081894	−.0976558*	−.045025*
	[.0282493]	[.0522596]	[.0245878]
Catholic	.0095946	−.1739471***	−.0389599***
	[.0131086]	[.0327427]	[.0135559]
Spiritual	−.1223651***	−.2373203***	−.0034122
	[.0330588]	[.0676678]	[.0404772]
Widowed, Divorced, Separated	.0661959***	.3639671***	.2084177***
	[.0185005]	[.0284105]	[.0160552]
Number of Household Members	.0063022***	.0048707**	.010059***
	[.0016787]	[.0021736]	[.0014921]
Sex of Household Head	.0203717	.0290501*	.0378835***
	[.0119351]	[.0175272]	[.010217]
Wealth Index Score	−.0037782***	−.0040146	−.0075472***
	[.0013769]	[.0028125]	[.0019091]
Education Level	−.0231038***	−.0524014***	−.0233363***
	[.0043547]	[.0073595]	[.0047416]
Coercive Acts Experienced	.1615194 ***	.4702121***	.4033548***
	[.009317]	[.0109257]	[.0067297]
Observations	52,315	84,115	95,905
Log psuedolikelihood	−790322.6	−970564	−1022426.1

Notes: * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level.

Discussion

Building on previous work (Cools et al., 2020; Epstein et al., 2020), we also find linkages between climate variability and IPV. Drier conditions are associated with higher past year incidence of psychological and physical IPV but lower past year incidence of sexual IPV. It is important to note, however, that the effect of climate variability on IPV via water insecurity was the same across IPV subtypes, suggesting that while climate conditions themselves may have disparate effects on IPV, climate-related water insecurity is associated with higher rates of all three types of IPV. Moreover, the strength of the associations in the model did vary by IPV subtype. These results emphasize the findings of previous work on examining IPV subtypes (Paulson, 2020; Velotti et al., 2018). Further, the presence of inconsistent mediation related to sexual IPV, whereby the direct effect and indirect effect produced different directions of effect, is consistent with other research demonstrating IPV subtypes often produce differential effects, sometimes in unexpected patterns (Miller-Graff & Graham-Bermann, 2016; Vyas & Watts, 2009). Such findings underscore the importance of further inquiry into other explanatory processes at play and the value of our mediation analysis method to parse these complex pathways.

Overall, SPEI produces more consistent results than SPI as the measure of climate variability, a finding consistent within the literature (e.g. Tefera et al., 2019). This is interesting because the use of SPEI goes beyond previous studies that either use just a measure of rainfall or only SPI. We, like previous studies, show that SPEI combines the multitemporal (window) timescales, as

Table 5. Indirect Effects using Minimum Fetch Time as Measure of Water Insecurity.

	Joint significance?	A path B(SE) Climate → Water Insecurity	B path B(SE) Water Insecurity → IPV	C path B(SE) Climate → IPV	C′ path B(SE) Climate → IPV	Indirect effect
DV: Sexual violence						
IV: SPI24		−1.209979***	.0003422***	.0061638	.0060143 [.0053312]	−.0004141**
		[.3766018]	[.0000974]	[.0052819]		[.0001703]
IV: SPEI24		−1.223133***	.0003307***	.0185468***	.0183867***	−.0004045**
		[.3419974]	[.000096]	[.0048747]	[.0049205]	[.0001598]
DV: Physical violence						
IV: SPI24		−1.02973***	.0003815**	−.0345014***	−.0356709***	−.0003928*
		[.2770454]	[.0001893]	[.0074054]	[.007488]	[.0002216]
IV: SPEI24		−1.091525***	.0004112**	−.0218157***	−.0227044***	−.0004489*
		[.2617019]	[.000189]	[.0071776]	[.0072568]	[.000231]
DV: Psychological violence						
IV: SPI24		−1.347214***	.0003226***	−.0188893***	−.0170345***	−.0004347***
		[.2602602]	[.0001093]	[.0049731]	[.0049869]	[.0001698]
IV: SPEI24		−1.532968***	.0003149***	−.0132389***	−.0113913**	−.0004828***
		[.2504846]	[.0001083]	[.0048924]	[−.1658518]	[.0001849]

Notes: * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level.

Table 6. Indirect Effects using Source Type as Measure of Water Insecurity.

	Joint significance?	A path B(SE) Climate → Water Insecurity	B path B(SE) Water Insecurity → IPV	C path B(SE) Climate → IPV	C′ path B(SE) Climate → IPV	Indirect effect
DV: Sexual violence						
IV: SPI24		−.0712179***	.0064644***	.0061638	.0064984	−.0004604**
		[.0137382]	[.0022634]	[.0052819]	[.0052959]	[.0001877]
IV: SPEI24		−.0349058***	.0061696***	.0185468***	.0189253***	−.0002154*
		[.0127857]	[.0022468]	[.0048747]	[.0048868]	[.0001142]
DV: Physical violence						
IV: SPI24		−.0194526**	.0151077***	−.0345014***	−.0342538***	−.0002939*
		[.0096142]	[.0043655]	[.0074054]	[.007436]	[.0001719]
IV: SPEI24		−.0019471	.0151041***	−.0218157***	−.0215872***	−.0000294
		[.0094235]	[.0043737]	[.0071776]	[.0072072]	[.000143]
DV: Psychological violence						
IV: SPI24		−.0574295***	.0111565***	−.0188893***	−.0177224***	−.0006407***
		[.0092124]	[.0026205]	[.0049731]	[.0049864]	[.0001882]
IV: SPEI24		−.0349239***	.0111311***	−.0132389***	−.012034**	−.0003887***
		[.0090572]	[.0026248]	[.0048924]	[.0049053]	[.0001401]

Notes: * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level.

does SPI, with information on potential evapotranspiration, making it more useful in research examining the human impacts of climate change (Vicente-Serrano et al., 2010). The usefulness of SPEI is strengthened through its real-world modelling of multivariate environmental patterns. In an effort to characterize climate variability and its impacts developing models and methods that depict the multitemporal impacts is critical. Numerous publications (e.g. Homdee et al., 2016; Tefera et al., 2019) have looked at the relationship between SPI and SPEI from a statistical perceptive, meaning beyond the ecological and/or environmental context. Such studies indicate that the correlations between SPI and SPEI were closer at shorter time scales (1–6 months) than decrease at longer timescales (9–24 months) (Tefera et al., 2019). This could be due to data difference, for instance SPEI involves the calculation of PET, or it might relate to environmental differences that result from a longer climate window.

In a literature review on published work on conflict and water across the African continent, Mach et al., 2022 highlighted that 82% of reviewed work found a significant link between various measures of water and conflict. Further such work found that the magnitude and direction of such linkages varied across scale, time, and scale due to various reasons (Mach et al., 2022). These findings are not surprising, yet support the results of our analysis, as recent theories on the climate/conflict relationship have emerged highlighting climate change as a "threat multiplier" (Huntjens & Nachbar, 2015). This threat multiplier effect highlights that climate solely may not result is various forms of conflict but when combined with other threats or social factors can amplify a situation. Overall, the shift from studying a single causal mechanism to multiple interacting factors – characterized in the literature as direct versus indirect effects – highlights the complexity of the issue and the contention that social factors can play a crucial role in conflict outcomes (Gizelis & Wooden, 2010; Raleigh, 2014; Raleigh et al., 2015; Tir & Stinnett, 2012; Witmer et al., 2017). These sources of causal complexity stress the importance of understanding nuanced relationships between climate, conflict, and socio-ecological contexts (Devlin & Hendrix, 2014; O'Loughlin et al., 2014; Witmer et al., 2017), especially as they vary across time and space.

This study builds upon prior work offering several novel contributions. First, different from previous research investigating the climate-IPV nexus, we conduct a mediation analysis that enables us to examine both the direct and indirect effects of climate variability on IPV, utilizing water insecurity as the mediating variable. This allows us to test empirically whether climate variability has a direct impact on IPV or if the relationship is better explained by the effect of climate variability on water insecurity. Second, when examining the relationship between climate change and IPV across multiple countries in sub-Saharan Africa we utilize a more comprehensive measure of climate variability and environmental change, the Standardized Precipitation Evapotranspiration Index (SPEI). SPEI is commonly used in studies on climate impact and resulting environmental change because it captures rainfall variability as well as soil moisture content through its inclusion of potential evapotranspiration (PET) in its formulation (Vicente-Serrano et al., 2010). Accounting for soil moisture content, particularly in the study region, is important because soil moisture is crucial to the viability and productivity of crops, as opposed to total rainfall which does not fully capture the distribution of rainfall over time which can substantially limit crop growth (Bachmair et al., 2016; Vergopolan et al., 2021). Finally, we use multiple, non-binary measures of IPV to further our understanding about which types of IPV and how the incidence of IPV are expected to change with our measures of climate variability. Combined, these efforts provide nuanced information with policy relevance about the linkages between climatic conditions, water security and IPV. While policy makers are unlikely to completely undo or stop climate change, our research suggests that an impact can be made with regards to conflict within the household by helping address issues of water insecurity.

While our research improves upon the literature, we recognize there are still limitations of our analysis. First, both of our measures of water insecurity were measured at one point in time in the DHS survey. As such, these measures do not capture the dynamic nature of water insecurity, source intermittency, decision-making in response to environmental changes including changing sources or migrating (Stoler et al., 2021), the complex and relational dimensions of water insecurity (Jepson et al., 2017a; Jepson et al., 2017b; Wutich et al., 2017), or variation in needs and physical capacity to fetch water (Geere & Cortobius, 2017). Despite these limitations, these two measures are well-established and have the advantage of simplicity, and cross-cultural comparability in the DHS dataset. Second, with regards to the assessment of IPV, the current study represents a significant advance on the literature by including multiple types of IPV as well as assessing IPV dimensionally rather than categorically (i.e. presence vs. absence). The DHS survey, however, is not optimally sensitive and future research should consider examining IPV using more detailed and highly sensitive metrics. In addition, some domains of IPV that may be highly relevant in the context of climate change and water insecurity, such as economic abuse, were not included in the current study but are important areas for future research. Third, we did not explore the potential for food insecurity to mediate the effects of climate variability on IPV, due to lack of availability of these data in the DHS survey for the years and sites included. Future work could evaluate the role of food insecurity in climate-violence research as this has also been shown to be linked with water insecurity (Brewis et al., 2019). Finally, PET is modelled using the Thornthwaite equation. This is common in the literature, but still may be a limitation of our analysis.

Our approach opens several areas of expansion for future research. First, researchers can integrate climatic extremes with long-term climate regime data to determine the effects of varying levels of exposure and risk. Such an analysis would highlight how climate change is, in two ways, altering household dynamics both in the short and long term. Epstein et al. (2020), using precipitation data and extreme value theory, looking at the top 10% of climate regimes, began to develop this information but households are impacted at multiple temporal scales. Second, future research should explore other types of interpersonal violence. For example, is water insecurity causing stress that makes all types of violence more likely, or is there something special about how it affects the family? And if so, what are the precise pathways? Third, future work should conduct a similar analysis in other countries. This is important given the cultural context of IPV, gender roles and the variability in climate and water resources globally. Conducting this analysis in other countries would also provide opportunities to examine extreme precipitation events, versus the current application to Africa which is more affected by drought.

Finally, case-based research could investigate communities where IPV is linked to climate and conflict. Recent studies highlight a dearth of work on this topic in regions of the world including Latin America, North America, and Southeast Asia (Tallman et al., 2022), which is not necessarily surprising given the relative newness of research on this topic (Tallman et al., 2022; Tandon et al., 2022). Case-based research could also assess the efficacy of proposed solutions to IPV related to water scarcity. Recent work on IPV suggests several solutions that are worthy of evaluation (Logie et al., 2022). Participants of the Logie et al. (2022) study suggested that enhanced lighting in water collection areas and on pathways to fetch water may mitigate IPV. They also suggested that having men fetch water at night or having men accompany women to fetch water could reduce IPV. Participants also suggested that increasing the number or the location of water fetch points so they are closer to communities might also reduce the incidence of IPV.

Conclusion

Global climate conditions are projected to become more variable and as a result, interpersonal violence will likely increase. Women are disproportionately affected by intimate partner violence and are likely to be most exposed because of a changing climate. This study examined whether variability in climatic conditions increases the incidence of different types of IPV. While we found linkages between several types of IPV and climatic variability, the finding that water insecurity mediates this relationship suggests important nuances that merit additional investigation over space and time. Future research should also consider other potential mediators of the relationship between climate variability and IPV, including income change and livelihood threats.

Notes

1. Not all questions are asked for every country. The sexual abuse questions were not asked in Cameroon, Ghana, and Mozambique. The physical abuse questions were not asked in Cameroon.
2. https://projects.iq.harvard.edu/violenceagainstwomen/publications/domestic-violence-module-demographic-and-health-surveys
3. https://www.chc.ucsb.edu/data/chirps; https://www.chc.ucsb.edu/data;

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