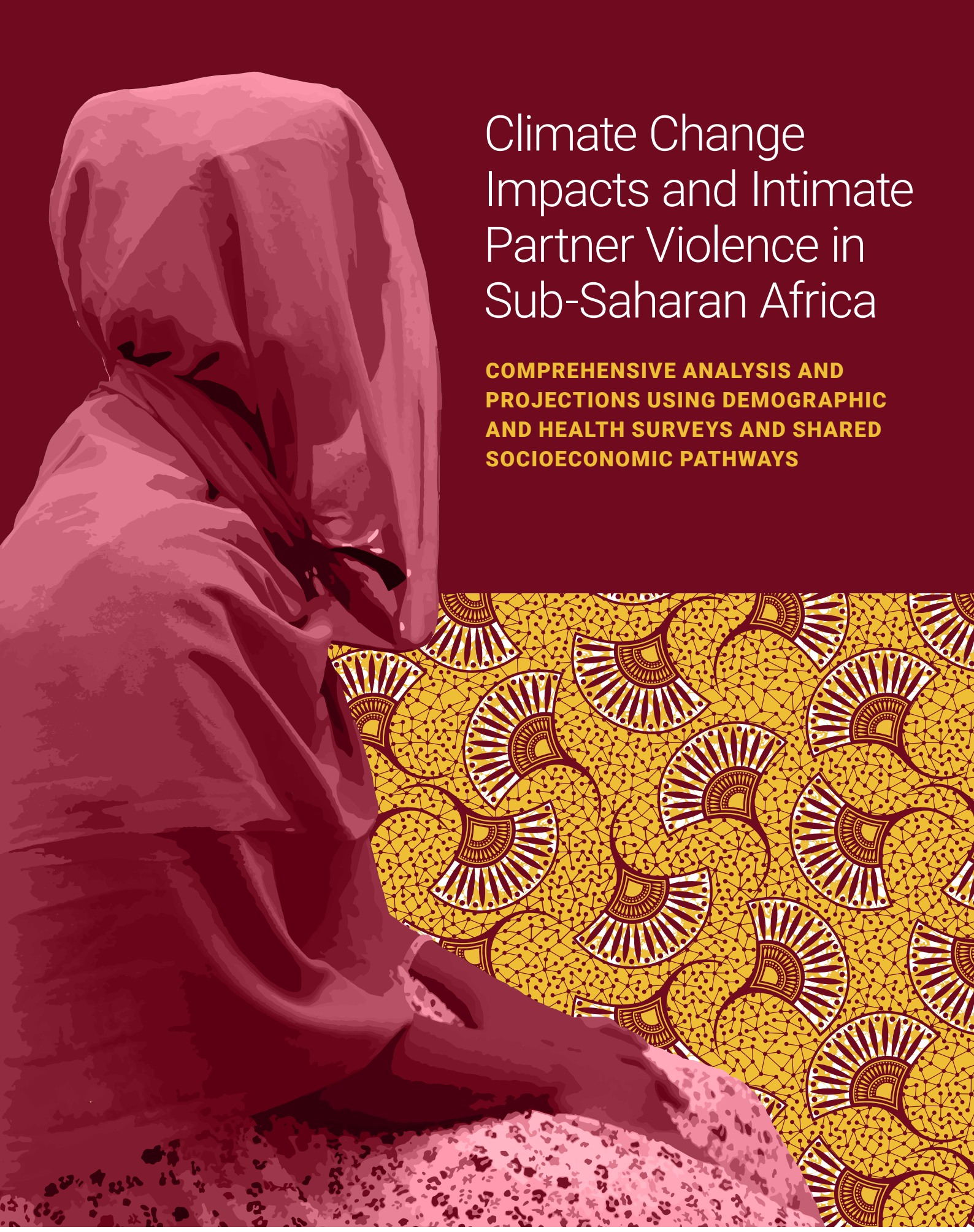

Climate Change Impacts and Intimate Partner Violence in Sub-Saharan Africa

COMPREHENSIVE ANALYSIS AND PROJECTIONS USING DEMOGRAPHIC AND HEALTH SURVEYS AND SHARED SOCIOECONOMIC PATHWAYS

UNFPA

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Foreword

It is clear that we are facing a climate emergency, which has now become a significant threat to the achievement of UNFPA's three transformative results by 2030: ending preventable maternal death, ending unmet need for family planning, and ending gender-based violence and harmful practices. If left unaddressed, climate change will continue to hinder and potentially reverse progress on these goals. We are already falling behind in achieving the Agenda 2030 goals, with only 15 per cent of them on track and some even in reversal.

Emerging evidence in the past few years has increasingly shown the direct and indirect disproportionate impacts of climate change on women and girls, especially regarding gender-based and intimate partner violence (IPV), with research demonstrating the impact of extreme heat and environmental stress in increasing the likelihood of conflict and aggressive behaviour, which has direct implications for IPV. As climate impacts deepen and onset events such as loss of livelihoods, water scarcity, hunger, food insecurity and malnutrition become more frequent, the vulnerabilities of the people who are most impacted are exacerbated, especially in female-headed households.

To gain a better understanding of the scale of climate impacts on these issues, this study used Demographic and Health Survey (DHS) datasets, one of the most reliable and representative in the region. Additionally, this study used Shared Socioeconomic Pathways, which project global socioeconomic changes up to the year 2100, to estimate the impact of climate change on IPV. The historic underreporting of IPV cases owing to associated stigma and fear gives further credence to the findings of this research as evidence and cause for a call for action.

The results of this study have shown that an increase in global temperatures corresponds to an increase in the rate of IPV, confirming the findings of recent research on the same subject with different approaches. In its most optimistic scenario of strong climate action and improved socioeconomic conditions, the findings show that the proportion of women affected by IPV in sub-Saharan Africa (SSA) will be 10 per cent lower in 2060 than the most pessimistic scenario, a business-as-usual approach with severe climate impacts. In this most pessimistic scenario, the number of women experiencing violence is projected to increase by more than 90 million from now until 2060.

These findings serve as a clear call to action. If we do not make a concerted effort to reduce inequalities, strengthen adaptation measures and lower carbon emissions, we will need to significantly scale up our efforts to protect women and girls from violence.

The study also demonstrates how increased adaptation and mitigation efforts, as well as socioeconomic development, can jointly reduce vulnerability and protect women and girls. Additionally, it highlights the critical role of education in generating both direct and indirect benefits by enhancing women's status and boosting their resilience to climate stress.

This study comes at a critical time for climate action, as we mark the 30th anniversary of the International Conference on Population and Development (ICPD30) and look forward to our Pact for the Future. For our efforts to integrate climate adaptation and resilience priorities for women and girls into the ICPD process, and bring ICPD priorities into climate change processes, the findings of this study provide insights that are timely and more significant than ever.

The study provides further evidence of the growing impact of climate change on women and girls, emphasizing the urgent need to scale up financing and actions to address these challenges. It also provides a tool that countries can utilize to strengthen the gender and SRHR components of their Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs) and other national climate policies.

At UNFPA, we must ensure that progress towards achieving our transformative results can be sustained in the face of a worsening climate crisis. Through our mandate, we are committed to contributing to the climate resilience of the individuals, communities and systems we serve. We must all act swiftly to empower women and young people to build resilient communities, to safeguard their wellbeing and protect their livelihoods in the face of an ever-changing climate.

We invite all our partners and stakeholders to join us on this journey, to fulfill the promise we made to our communities that we will not leave anyone behind.

Lydia Zigomo

Regional Director,
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Acronyms

CMIP	Coupled Model Intercomparison Project
CRU TS	Climatic Research Unit gridded Time Series
DHS	Demographic and Health Surveys
GAP	Gender Action Plan
GBV	Gender-based violence
GDP	Gross domestic product
HDI	Human Development Index
ICPD	International Conference on Population and Development
IIASA	International Institute for Applied Systems Analysis
IPV	Intimate partner violence
ISCED	International Standard Classification of Education
LAC	Latin America and the Caribbean
NAP	National Adaptation Plan
NDCs	Nationally Determined Contributions
RCP	Representative Concentration Pathway
SD	Standard deviation
SDG	Sustainable Development Goal
SEAP	Southeast Asia and Pacific
SRHR	Sexual and reproductive health and rights
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathway
UNFPA	United Nations Population Fund
WHO	World Health Organization
WMO	World Meteorological Organization

Executive Summary

Climate risks are particularly large in sub-Saharan Africa (SSA), where populations are exposed to a range of hazards and highly vulnerable to their impacts. Increasing temperatures and sea levels, changing precipitation patterns and more extreme weather threaten health and safety, food and water security, and socioeconomic development in the region. These threats negatively impact human lives, ecosystems and economies with far-reaching social implications. Some of these implications may remain invisible to the public and policymakers, including effects on intimate partner violence (IPV), which often takes place in a domestic context.

This report studies the links between climate change and IPV in SSA. Climate impacts can affect the risk of violence through multiple direct and indirect channels. Using microdata from Demographic and Health Surveys (DHS), the report provides evidence on the impacts of climatic changes and extreme weather events on violence for different population subgroups. The obtained empirical evidence is used as the basis for projections of future IPV prevalence in SSA under different plausible climate and socioeconomic development scenarios.

SSA is one of the world regions with the highest levels of IPV. Despite improvements in recent years, the levels of emotional, sexual and physical violence remain high across the region, as the evidence presented in this report shows. In some areas, more than 50 per cent of women and girls reported having been affected by IPV in the 12 months prior to the survey. Among these, more than 20 per cent of all interviewed women were exposed to less severe violence, and more than 10 per cent to severe violence. The prevalence is highest for emotional violence, which includes humiliation, insults and threats.

Regionally varying climatic impacts measured through temperature anomalies are found to significantly increase IPV against women and girls. On average, a one standard deviation temperature anomaly leads to a 3 per cent increase in the probability that a woman is affected by physical violence, according to estimates based on DHS data. Moreover, different population sub groups face differential risks. Younger and less educated women are disproportionately affected by climatic impacts and more at risk of IPV. While climatic impacts are affecting the lives of the youngest and less educated in all regions of SSA, they are strongest and most consistent in Southern and Central Africa.

Improvements in education can help mitigate climate impacts on violence in various ways. On average, the expansion of secondary education in SSA has been associated with a sizable reduction in violence, including in models that simultaneously control for changes in regional incomes. A one per cent increase in women having attained at least secondary education in a country is related to a 0.48 per cent reduction in physical forms of violence against women. Indirectly, higher personal education levels can make women and girls more resilient in times of climatic stress.

The projections show that both socioeconomic development and enhanced climate mitigation and adaptation efforts can help reduce vulnerability and protect women and girls. Using a combination of different climate and socioeconomic development scenarios, this report highlights large differences in projected IPV rates depending on future climate impacts and the resilience of societies.

Under the most favourable scenario with less severe climatic impacts and major socioeconomic improvements, the share of women affected by IPV in SSA is expected to decline from around 24 per cent in the baseline year of 2015 to 14 per cent in 2060. Under the most pessimistic scenario, this percentage hardly changes. In terms of absolute numbers, this result implies that, without immediate action, the number of women experiencing violence is expected to increase by more than 90 million from today until 2060. Simply put, the most pessimistic scenario will see IPV cases triple from 48 million in the baseline year of 2015 to 140 million by 2060. The cost of inaction would be about 1.9 billion preventable cases of IPV between both years.

Different development and emission pathways will have major impacts on IPV outcomes in the future. Socioeconomic development and climate change mitigation and adaptation efforts complement each other and could contribute jointly to reducing IPV. In particular, education acts as an important factor, creating direct and indirect benefits by strengthening women's position and increasing their resilience in times of climatic stress.

The findings of this report have important policy implications, highlighting the gendered consequences of climate change and the need for holistic solutions. More research is required to understand the drivers of IPV in different contexts and its potential future prevalence in response to different development and climate trajectories. Holistic solutions need to be developed and implemented that simultaneously support socioeconomic development and climate change mitigation/adaptation efforts, while prioritizing the groups most at risk of IPV.

Education, economic empowerment, access to health care, legal protections, and involving men as allies and advocates for gender equality are key approaches to addressing IPV. Effective interventions must be tailored to the specific needs, circumstances and vulnerabilities of affected individuals and communities, and resources should be used efficiently with a targeted approach.

The results of the analysis also underscore the importance of ensuring that national climate and relevant gender policies incorporate adaptation measures that address the impact of climate change on women and girls. A stronger integration of policies is needed not only during emergency responses where there is a heightened risk of IPV, but also in terms of general adaptation measures and efforts to enhance socioeconomic development, for example in the form of budgeted adaptation interventions and locally led solutions.

Introduction

Photo: @UNFPA

The impacts of climate change on human health, well-being and livelihoods are already being felt (Intergovernmental Panel on Climate Change, 2022). Extreme heat directly causes cardiovascular and respiratory diseases and has negative impacts for maternal health and birth outcomes (Carolan-Olah and Frankowska, 2014; Syed, O'Sullivan and Phillips, 2022; Ruan et al., 2023; Kuehn and McCormick, 2017). Natural hazards, such as storms and landslides, can cause damages to houses, severe injuries or death (Son, Liu and Bell, 2019). Apart from these direct impacts, climate change also indirectly affects health and well-being by undermining livelihood opportunities, causing food and water insecurity, and reducing access to basic services (McMichael, 2013; Sellers, Ebi and Hess, 2019). For instance, climate-induced drought events reduce water supplies, and as a consequence lead to a decline in agricultural yields, which can affect income and food availability (Warner, 2012). Water stress also makes women and girls travel longer distances to fetch water or take more time to do the household chores (e.g. laundry), which makes them more vulnerable to health impacts.

While some of the impacts of climate change are more visible, others can remain hidden or underreported, including different forms of intimate partner violence (IPV).

Extensive evidence indicates that climatic stress can impact violence both directly and indirectly (Hsiang, Burke and Miguel, 2013; Burke, Hsiang and Miguel, 2015; Levy, Sidel and Patz, 2017; Koubi, 2019). Studies have shown that extreme heat and environmental stress can be a potential trigger for aggressive behaviours and inter-group conflicts, with implications for IPV (McLean, 2007; Sanz-Barbero et al., 2018; Henke and Chi Hsu, 2020; van Daalen et al., 2022; Cohen and Nordås, 2014). Environmental stress can also cause economic hardships; food, water, and housing insecurity; sociopolitical instabilities; and increased stress levels (van Daalen et al., 2022). All these factors can lead to an increased risk of women and girls suffering physical and emotional abuse, with specific groups (persons with disabilities, refugees, migrants, persons of diverse sexual orientation and gender identity) being particularly at risk. While progress in achieving gender equality worldwide is an important step towards reducing the risk of IPV, major gaps remain (World Economic Forum, 2022).

Sub-Saharan Africa (SSA) is strongly affected by climate change impacts (Intergovernmental Panel on Climate Change, 2022; Serdeczny et al., 2017). In the most recent *State of the Climate in Africa* report, the World Meteorological Organization (WMO) reports an accelerated warming trend with an average temperature increase of approximately 0.3 °C/decade between 1991 and 2021 for the continent (World Meteorological Organization, 2021). More frequent droughts and heat events reduce water supply and put additional pressure on already scarce water resources.

Climatic trends have major consequences for local communities, which are highly

vulnerable to environmental stress due to reliance on agricultural livelihoods, protracted poverty, and limited adaptive capacities (Hoffmann et al., 2022). Women, girls and marginalized groups are disproportionately affected by climate impacts in the absence of scaled-up adaptation action strengthening their resilience (Thomas et al., 2019; Pearse, 2017; Alston and Whittenbury, 2013). The climate-related loss or change of livelihoods, as well as displacement and migration, can increase the risk of IPV (van Daalen et al., 2022; Thurston, Stöckl and Ranganathan, 2021). Women and girls exposed to IPV have their bodily autonomy and basic human rights violated, with limited opportunities to build resilience and adapt to climate change impacts.

In this context, the United Nations Population Fund (UNFPA) has committed to three transformative results by 2030: (1) ending preventable maternal deaths; (2) ending unmet need for family planning; and (3) ending gender-based violence and other harmful practices. The rapid pace of climate change over this decade will pose a serious challenge to the realization of these transformative results. To strengthen resilience to climate change for women and girls and to ensure the achievement of the transformative results, UNFPA has developed a multi-pronged programme of activities mainstreaming climate change in their programme delivery. In UNFPA's efforts to support governments in the design of evidence-based national climate policies and solutions that incorporate sexual and reproductive health and rights (SRHR) and IPV issues, a better understanding of the current and future impacts of climate change on the three transformative results is needed.

To better understand, model and project climate impacts with a focus on IPV, UNFPA, together with the University of Vienna and the International Institute for Applied Systems Analysis (IIASA), initiated a joint project to study climate change impacts in the SSA context. The project assessed the state of IPV in the region and modelled historical and future impacts of changes in climatic conditions.

Measuring and projecting intimate partner violence

Photo: @UNFPA

Due to the nature of this type of violence, IPV is often underreported due to fear, shame or stigmatization of the victims, which makes the collection of information on IPV challenging. This report relies on data from Demographic and Health Surveys (DHS), which are major representative surveys with excellent coverage in the SSA region (Figure A1 in Appendix) (Demographic and Health Surveys, 2019). First implemented in the 1980s in overlapping five-year periods, multiple DHS waves are available today, providing comprehensive data on population characteristics such as age, sex, educational attainment and area of residence, as well as information on family, marital and birth histories. Data on IPV have been collected by DHS since the early 2000s.

Based on the DHS data, a database at the individual level was constructed and combined with climatic data and further contextual information at the subnational regional level. To measure IPV, four proxy measures from the available DHS are used. These capture different forms of IPV (less severe, severe, sexual and emotional violence) where the husband or partner is the perpetrator. For all measures, a woman is counted to have experienced violence in the last 12 months when her response to the survey item was one of "often", "sometimes" or "yes, but frequency in the last 12 months missing". The remaining response categories were "never" and "yes, but not in the last 12 months".

A woman is defined to have experienced less severe violence if she has either been pushed, been shaken or had something thrown at her; been slapped, punched with fist or hit by something harmful; or been kicked or dragged by her husband or partner. Severe violence includes having the arm twisted or hair pulled, being strangled or burnt, being threatened with a knife, gun or another weapon, or being physically attacked. Sexual violence captures whether a woman has been physically forced into unwanted sex, forced into other unwanted sexual acts, or physically forced to perform sexual acts she did not want. Finally, emotional violence includes having been humiliated, threatened with harm, insulted or made to feel bad by her partner. Not all questions are asked in every survey. Accordingly, only those questions that were asked in the respective country wave are considered in the aggregation of the IPV indicators.

The measurement of the violence indicators can be affected by the sensitivity of the issue and social influences. This can bias the accurate representation of violence in a household or region. DHS ensures the protection of women providing information and the confidentiality of their answers, which may help increase their reporting. Despite this effort, the DHS data are still likely to underestimate the true prevalence of IPV in an area, which also has implications for the findings of this report. The data still prove highly useful in understanding the overall patterns in IPV and the role of different risk factors, including climatic impacts.

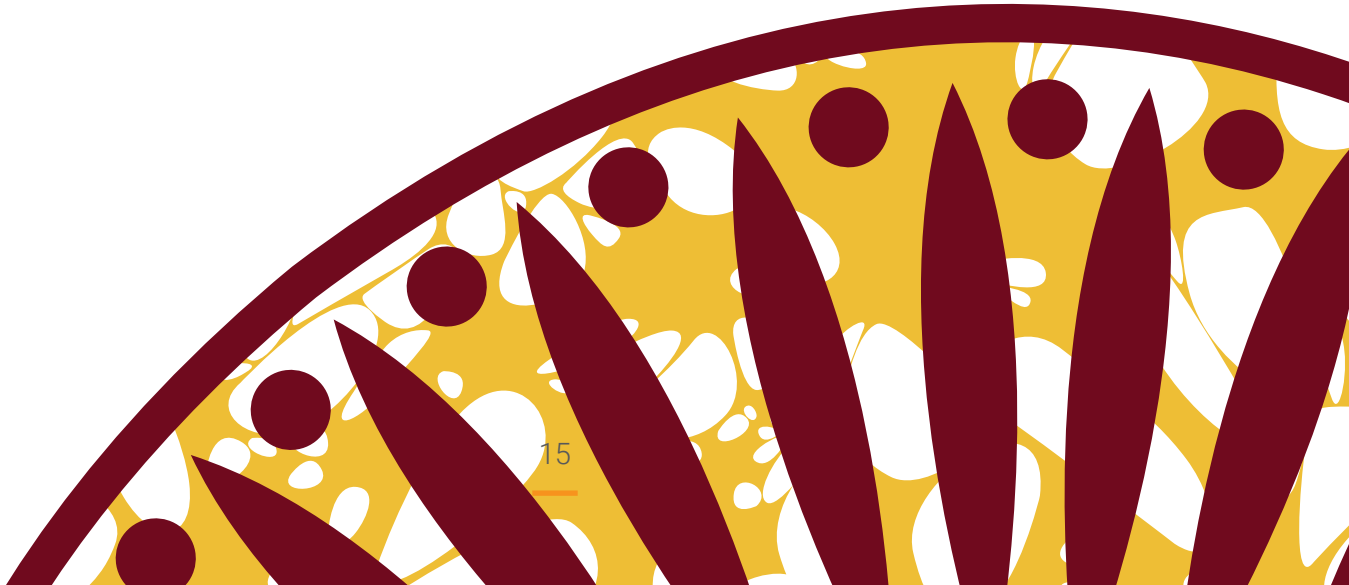
In this study, DHS-based data on IPV is combined with climatic and contextual information at a subnational DHS cluster level. The clusters indicate the household

location within a 10 km radius in rural regions and within a 5 km radius in urban regions. The climatic indicators used in our models are derived from the CRU TS (Climatic Research Unit gridded Time Series) Version 4 compiled by Harris et al. (2020) and aggregated in a 25 km radius around cluster locations. The indicators describe the monthly temperature anomalies that respondents were exposed to during the 12 months prior to the DHS interview relative to the monthly temperature and mean and variance of the previous 30 years as a reference period.

The main weather indicator considered is the average monthly temperature anomaly, which captures the standardized deviation of temperatures from the 30-year monthly mean. During the DHS observation period relevant for our work, there is a clear trend of rising temperatures and, accordingly, most months are warmer than in the reference period. To account for this, world region specific time trends and seasonality effects are controlled for in all models.

In the second part of our work, which focuses on future developments, we rely on temperature projections from the Coupled Model Intercomparison Project (CMIP) Phase 6 to predict future levels of IPV under different climate and socioeconomic scenarios (Ayugi et al., 2021; Pu et al., 2020). Combinations of different Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs) are considered to determine potential future impacts of climate change on populations (O'Neill et al., 2014; O'Neill et al., 2017; Riahi et al., 2017). SSPs are scenarios of projected socioeconomic global changes up to 2100 and have been translated in terms of future population change by age, sex and level of educational attainment (KC and Lutz, 2017). For a comparison of the population implications under the SSP with those of the United Nations Population Prospects, see Abel et al. (2016).

The different socioeconomic pathways relate to different challenges for climate adaptation and mitigation. Depending on the scenario, different amounts of greenhouse gases will be emitted, resulting in different RCP scenarios reflecting possible futures in terms of climate change. In this report, three scenario combinations are considered, reflecting an optimistic (SSP1/RCP2.6), a middle-of-the-road (SSP2/RCP4.5), and a pessimistic (SSP3/RCP7.0) scenario up to 2060 (~40 years).



OVERVIEW OF SOCIOECONOMIC AND CLIMATE SCENARIOS CONSIDERED IN THIS REPORT

Shared Socioeconomic Pathways (SSPs) are projections of global socioeconomic changes up to the year 2100. They are utilized to create various greenhouse gas emission scenarios based on different climate policies. The SSPs offer descriptions of alternative socioeconomic developments through narrative storylines that explain the relationships between the different elements. These storylines include quantitative data on factors such as national population, urbanization and gross domestic product (GDP) per capita. The SSPs are reflected in different scenarios that examine possible future paths related to socioeconomic and climate developments (O'Neill et al., 2014; O'Neill et al., 2017; Riahi et al., 2017).

The **optimistic scenario** (SSP1/RCP2.6) considered in this report assumes a world that gradually and extensively transitions towards a more sustainable trajectory, prioritizing inclusive development while respecting the projected environmental limits. The management of global resources is gradually improving, and investments in education and health are hastening the demographic shift. There is a greater emphasis on human well-being, rather than solely economic growth. This shift is propelled by a rising dedication to achieving development goals, leading to a decrease in inequality both within and between countries.

In the **middle-of-the-road scenario** (SSP2/RCP4.5), the world's social, economic and technological trends continue along historical patterns. Progress in development and income growth varies widely, with some countries achieving notable gains while others lag behind expectations. Despite efforts by global and national institutions, progress towards sustainable development goals is slow. Environmental systems continue to deteriorate, though some improvements are made, and overall, the intensity of resource and energy use decreases. Global population growth remains moderate and levels off in the latter half of the century. Income inequality endures, and efforts to reduce vulnerability to societal and environmental changes remain challenging.

The **pessimistic scenario** (SSP3/RCP7.0) describes a world in which countries are increasingly turning their attention to domestic or regional matters due to the resurgence of nationalism, concerns about competitiveness and security, and regional conflicts. As policies gradually shift towards national and regional security, countries prioritize achieving energy and food security goals within their own regions, often at the cost of broader-based development. This results in a decline in investments in education and technological development, slow economic progress, and material-intensive consumption, leading to persistent or worsening inequalities over time. While industrialized countries experience low population growth, developing nations continue to face high growth rates. Unfortunately, addressing environmental concerns remains a low priority on the international stage, leading to severe environmental degradation in some regions.

Global trends in intimate partner violence

Photo: @UNFPA

Despite efforts to reduce the global burden of GBV, its prevalence continues to be widespread. While GBV describes all kinds of acts of violence that are directed at individuals based on their gender – and both women and men can become victims of GBV – the vast majority of victims tend to be female. Of those acts of violence committed against women, according to the World Health Organization (WHO) (2021), the majority are committed by intimate partners - in which case it is named "Intimate Partner Violence (IPV)".

Worldwide, almost one third (27 per cent) of women aged 15 to 49 years report that they have been subjected to some form of physical and/or sexual violence by their intimate partner, while about 6 per cent of women worldwide are estimated to have experienced sexual violence by someone other than their partner. In absolute numbers, this amounts to a staggering 736 million women aged 15 to 49 years worldwide who have experienced intimate partner and non-partner physical and/or sexual violence during their lifetime.

WHO estimates show clear differences in IPV between different world regions (World Health Organization, 2021). The highest prevalence in lifetime exposure to IPV (37 per cent) is found in least developed countries. The prevalence in SSA (33 per cent) is slightly lower than in Southern Asia (35 per cent), but above Northern Africa (30 per cent) and Western Asia (29 per cent). The highest prevalence rates are reported in the Pacific region, including in Melanesia (51 per cent), Micronesia (41 per cent) and Polynesia (39 per cent). Regions with lower than world-average prevalence of IPV include Latin America and the Caribbean (25 per cent), as well as South-Eastern (21 per cent), Eastern (20 per cent) and Central Asia (18 per cent); Western (21 per cent), Northern (23 per cent), Eastern (20 per cent) and Southern Europe (16 per cent); North America (25 per cent); and Australia (23 per cent).

These findings have recently been confirmed by a comprehensive meta-analysis combining the results from 366 eligible studies, including reports from 2 million women worldwide (Muluneh et al., 2021). An estimated 13 per cent of all acts of GBV were reported to have taken place in the year immediately before the respective survey. The age breakdown of past-year GBV reveals a higher risk among younger women. Longitudinal evidence, although crucial for monitoring progress towards Sustainable Development Goal 5 (SDG-5) (achieve gender equality and empower all women and girls), continues to be scarce.

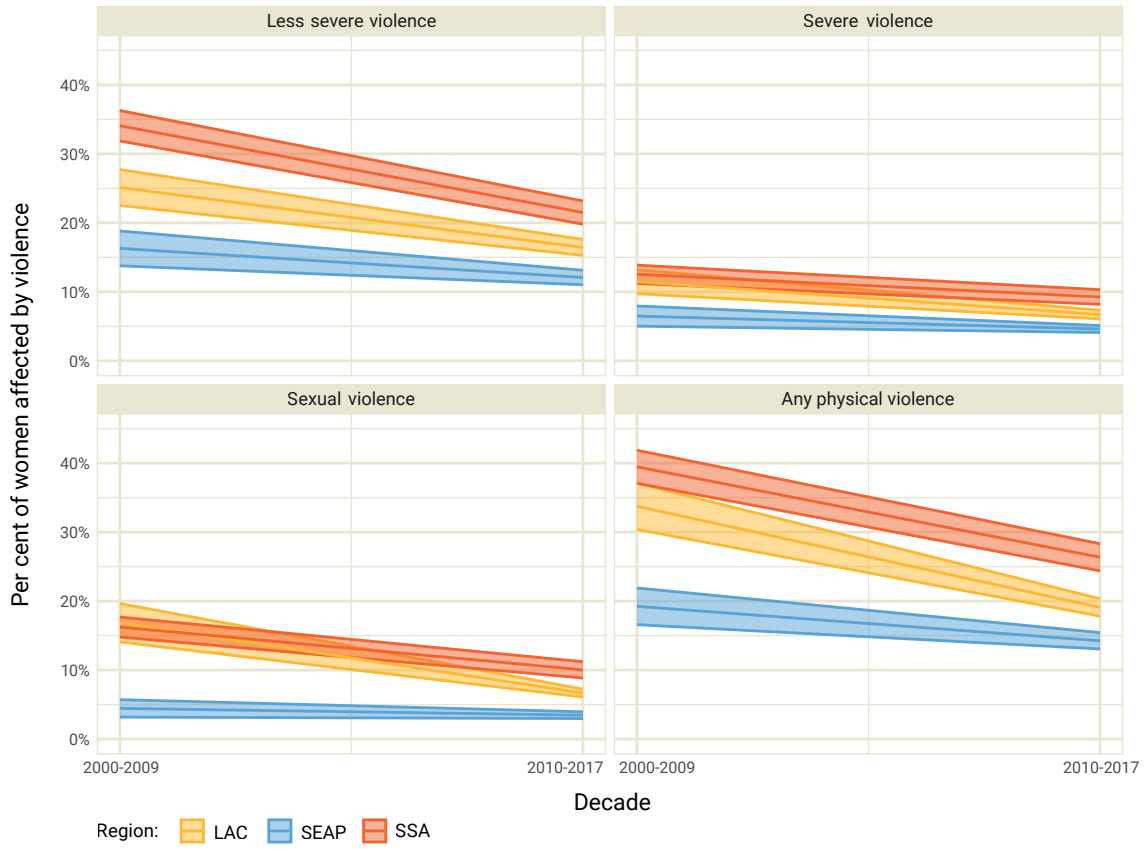


FIGURE 1: *Trends in intimate partner violence by decade and world region*

The displayed range indicates the mean ± the standard error. SSA refers to sub-Saharan Africa, LAC to Latin America and the Caribbean, and SEAP to the Southeast Asia and Pacific region. The evidence is based on DHS data derived for a number of countries worldwide. The panels show the linear trend for different physical violence categories (less severe, severe and sexual) between the decades 2000–2009 and 2010–2017. Across all indicators, a reduction in violence levels is observable, with intimate partner violence remaining very prevalent, especially in the SSA context.

These regional differences are supported by the patterns observed in the DHS that form the basis of the empirical analyses reported here. Figure 1 shows the trends in the different forms of IPV across three world regions. Across the different violence categories, the graph shows consistently higher levels of IPV in SSA compared to the Latin America and the Caribbean (LAC) and Southeast Asia and Pacific (SEAP) regions. Emotional and less severe physical violence are more common than sexual and severe violence. For all measures, we observe a declining time trend almost everywhere over the last two decades, except for LAC, where the prevalence of emotional violence has slightly increased. The physical violence indicator summarizes all accounts of physical violence (i.e. sexual, less severe and severe violence) in the data.

The state of intimate partner violence in sub-Saharan Africa and risk factors

Photo: @UNFPA

Taking a closer look at the geographical distribution of IPV in SSA reveals major regional differences. Figure 2a shows a map of the subnational regions considered in the DHS dataset. For most countries, violence levels are high, with some regional variation. In areas characterized by conflicts, such as the Lake Chad Basin or the Democratic Republic of Congo, a large number of women and girls are exposed to violence. In some regions, more than 50 per cent of the interviewed women and girls reported having been affected by physical violence in the past 12 months.

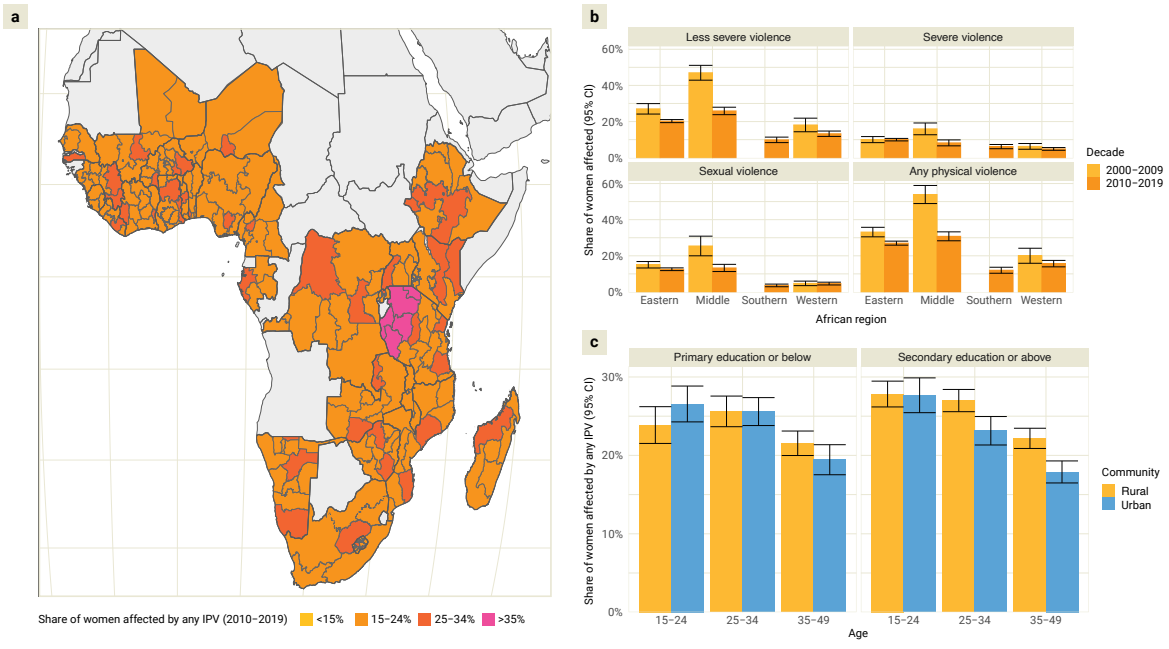


FIGURE 2: *Intimate partner violence in sub-Saharan Africa*

Panel **a** shows a map of IPV in subnational regions of SSA (average over all available DHS waves). Values reflect the average share of women who have experienced any type of physical violence in the region. Panel **b** shows temporal trends in IPV in four macro-regions in Africa between the decades 2000–2009 and 2010–2019. Panel **c** shows differences in IPV by age, educational attainment and community type. Error bars in panel b and panel c indicate 95 per cent confidence intervals. The evidence is based on DHS data derived for a large number of countries. Physical violence refers to any form of less severe, severe and sexual violence.

Figure 2b reports trends for different macro-regions in SSA and Figure 2c shows socioeconomic patterns in the level of affectedness for SSA, using the DHS data. The share of women reporting to be affected by any type of physical violence declines with age, especially in urban settings. In the age group 15 to 24 years, lower-educated women were more likely to experience violence in urban communities than in rural communities. Overall, the level of violence reported is typically higher for women with secondary education and above. These level estimates, however, could be affected by reporting bias due to young, educated women being more likely to report violence than older and less educated women.

Environmental drivers of intimate partner violence

Photo: @UNFPA

Climate change can have a range of implications for sustainable development in general, as well as for gender equality and IPV in particular. IPV represents one of the consequences affecting women and girls in particular, often in a domestic context. The effects of climate change on IPV can be both direct and indirect.

There is robust evidence on the direct impact of climate change on conflict, in the form of both interpersonal and collective social violence (Hsiang, Burke and Miguel, 2013; Burke, Hsiang and Miguel, 2015; Levy, Sidel and Patz, 2017; Koubi, 2019). Psychological studies have suggested a direct, causal relation between above-average temperatures and violence, describing uncomfortable temperatures as a potential driver for aggressive behaviours (Anderson, 1989; Anderson et al., 2000). This includes the impact of extreme temperatures or heat waves on GBV, sexual aggression and intimate partner violence (McLean, 2007; Sanz-Barbero et al., 2018; Henke and Chi Hsu, 2020; van Daalen et al., 2022). At the same time, climate disruptions have been shown to be positively associated with inter-group conflicts. As a consequence of global warming, the risk of GBV is likely to increase because of its widespread use as an instrument to cause fear and terror within populations and to destroy communities (Cohen and Nordås, 2014).

Climate change impacts can also influence IPV indirectly, for example by reducing household income, food security and labour-market opportunities. A recent review by Desai and Zhang (2021) suggests that a combination of decreased agricultural yield, decreased income and patriarchal norms is responsible for an increase in violence against women following climate change impacts. Evidence from South Africa suggests that water scarcity, which exposes women and girls to risks of abduction and rape while fetching water, can increase women's risk of GBV (Meyiwa et al., 2014). Similar results have been obtained by Karim et al. (2012), pointing at patriarchal norms, which stipulate that women are expected to fetch more water in response to warmer temperatures.

The disruptive effects of disasters on women's social support systems have been identified as an additional indirect channel through which IPV can increase in the aftermath of a disaster event (Sorensen et al., 2018). Another indirect effect of climate shock related to IPV is early marriage. The vast majority of studies investigating this relationship find a strongly positive association. For example, McLeod, Barr and Rall (2019) find that both IPV and child marriage tend to increase during times of hardship following disasters and can negatively affect women's ability to build resilience to climate change (Le Masson et al., 2019). Evidence from Bangladesh (Tsaneva, 2020) and SSA (Hoogeveen, Van Der Klaauw and Van Lomwel, 2011; Corno, Hildebrandt and Voena, 2020) suggests that droughts can increase the probability of early marriage for girls through disrupting livelihoods and reducing female educational and economic opportunities.

In addition to economic stress, dowry practices have been shown to be an important factor (Tsaneva, 2020). This

evidence is not supported by data from India, highlighting the importance of considering contextual influences, such as the directionality of marriage transfers, when examining this relationship (Corno, Hildebrandt and Voena, 2020). While dowry practices were found to lead to lower risk of child marriage in response to drought in India, the opposite was observed in SSA, where bride prices are the prevailing norm. A major protective effect against practices of early marriage in response to extreme weather, according to Vietnamese data, comes from parental education, in particular that of fathers (Trinh and Zhang, 2021).

Climate change impacts in sub-Saharan Africa

Photo: @UNFPA

Climate change has major impacts on the African continent (World Meteorological Organization, 2021; James and Washington, 2013; Müller et al., 2014), which has witnessed significant warming over recent decades, with increased frequency, intensity and duration of temperature-related extreme events and heatwaves (Intergovernmental Panel on Climate Change, 2018; Rohat et al., 2019). Increased levels of aridity and drought have been observed in some regions of the continent, particularly in Southern Africa and parts of Eastern Africa. At the same time, there has been an increase in the intensity of heavy precipitation in Western and Eastern Africa, leading to flooding and major displacements (International Displacement Monitoring Centre, 2021). Further risks arise from more gradual environmental change processes, such as glacial retreat and sea level rise.

Figure 3 shows the projected effect of different scenario pathways on the mean temperature in the different macro-regions in SSA. With the exception of the most optimistic scenario (SSP1, RCP2.6), temperature increases are expected across all regions. These warming trends are expected to lead to a multitude of challenges, including disruptions to ecosystems, agricultural systems and water resources, exacerbating existing vulnerabilities and threatening food security, biodiversity, and the overall well-being of communities across SSA.

FIGURE 3: *Surface temperature in African regions until 2100 as projected by FGOALS-g3 in CMIP6 (Ayugi et al., 2021; Pu et al., 2020)*

The figure shows considerable variation in temperature projections throughout Africa, depending on the socioeconomic and carbon pathway realized.

Socioeconomic, agricultural, demographic and political factors are influential in determining the impacts of climate change on populations. Several countries in Africa are highly vulnerable due to high levels of poverty, low adaptive capacities, structural inequalities, protracted conflicts, and political instability. Climate risks are closely related to, and can be exacerbated by, the occurrence of other sociopolitical and health crises (Barnett and Adger, 2007; Leichenko, O'Brien and Soleck, 2010). The coronavirus pandemic, for example, had a significant impact on the continent, contributing to a further increase in

vulnerability in many countries (Leichenko, O'Brien and Soleck, 2010; Phillips et al., 2020).

Food insecurity, fueled by changing climatic conditions, land use and management, and population dynamics, can cause major displacement and migration (Stavi et al., 2021; Misselhorn, 2005).

In 2020, an estimated 282 million people in Africa (21 per cent of the population) were undernourished, and 798.8 million were moderately or severely food insecure (59.6 per cent of the population). Compared to 2015, these numbers increased by almost 30 per cent. (Food and Agriculture Organization of the United Nations, 2021).

The poorest parts of the population face the highest climate risks due to their limited abilities and resources to cope with and adapt to environmental changes and hazards. According to recent studies, it is estimated that without immediate action, by 2030 up to 118 million extremely poor people (i.e. those living on less than US$1.25/day) may be exposed to drought, floods and extreme heat in SSA, causing humanitarian emergencies (Shepherd et al., 2013).

Demographic dynamics play an important role in exposure and vulnerability to climate risks (Muttarak, Lutz and Jiang, 2015). Whereas population growth has declined in most regions of the world, Africa has seen steady increases in its population over the past decades. The high levels of population growth result from a combination of declining mortality and high fertility rates (Lutz and Qiang, 2002). If the African population continues to grow at the current rate, it is expected to double in size by 2050 (United Nations, 2019). The growing population means that more people will be exposed to hazards in the future, which is mirrored in the increasing number of people affected by disasters in the region (Centre for Research on the Epidemiology of Disasters, 2022). At the same time, the demographic trends have important implications for societal progress and the provision of public infrastructure and services, such as housing, transportation and health care (Muttarak, 2021).

Together with rapid population growth, environmental degradation can fuel conflicts in the area. For example, increased rivalry for resources between farmers and pastoralists has led to disputes across the Sahel region, contributing to instances of violence in recent years (Brottem, 2016; United Nations Environment Programme, 2011). Institutional arrangements and social norms can prevent the outbreak or escalation of violent conflict. These mechanisms can take the form of regulations governing access to limited resources or facilitating effective mediation (Adano et al., 2012). The presence of well-designed collective institutions can not only help mitigate environmental scarcity, but can also enhance collaboration among diverse social groups.

Estimating climatic impacts on intimate partner violence

Photo: @UNFPA

In the first step of our empirical analysis, the effects of changes in environmental conditions and extreme climatic events on IPV are estimated using the DHS micro-level data. For this, statistical models are used to estimate the impacts of temperature anomalies on the probability that a woman is affected by IPV. All models control for stable characteristics of the region that may affect and bias the estimation through the use of region fixed effects. In addition, United Nations intermediate region-specific time trends and seasonality effects are controlled for. The model results are shown in Table 1.

TABLE 1: *Regression models estimating climatic impacts on violence over time*

DEPENDENT VARIABLE: AFFECTED BY VIOLENCE					
	Any physical	**Less severe**	**Severe**	**Sexual**	**Emotional**
Temperature anomaly	0.0279*** (0.0060)	0.0185*** (0.0054)	0.0156*** (0.0037)	0.0155*** (0.0043)	0.0250*** (0.0060)
Observations	265,858	265,970	265,881	265,912	268,514
R^{2} [a]	0.05876	0.04811	0.05031	0.0492	0.0494
Within R^{2} [b]	0.00032	0.00017	0.00025	0.0002	0.00028

Note: Linear regression coefficients with clustered standard errors in parentheses. Standard errors are clustered at the DHS cluster level. All models control for region and seasonal fixed effects, as well as United Nations intermediate region-specific time trends. [a] The R^2 shows the proportion of the variation in the dependent variable that is explained by the explanatory variables considered. [b] The within R^2 describes the proportion of the variance in the dependent variable over time that can be explained through changes in the explanatory variables. P-values: *p<0.1; **p<0.05; ***p<0.01

The baseline estimates suggest that temperature anomalies increase IPV, in particular less severe and emotional violence.

According to the estimates, a one standard deviation (SD) increase in temperature anomaly leads to an increase of 2.79 per cent in the probability for women to be affected by any form of physical violence, including less severe, severe and sexual violence. In additional models, we find that the effects decline in income and Human Development Index (HDI) level, indicating that the positive effect on violence is stronger in areas with relatively low levels of income and development.

Differential social vulnerability to climatic impacts

Photo: @UNFPA

Not all population groups are equally affected by climatic impacts, but they have a differential vulnerability (Muttarak, Lutz and Jiang, 2015). Table 2 shows the results of extended models distinguishing among the effects of temperature anomalies on different age and education groups. Further distinguishing by population sub-groups, the models show that the increase in violence due to temperature anomalies is most pronounced in the age groups 15 to 24 years and 25 to 34 years, while the effect declines for older groups (with the exception of less severe forms of violence). In terms of education, women without or with only primary education are most likely to become victims of violence in response to temperature anomalies.

TABLE 2: *Estimating climatic impacts on violence among different population groups*

ANY PHYSICAL VIOLENCE						
	Overall	**Age 15–24**	**Age 25–34**	**Age 35–49**	**Primary education (ISCED 0–1)**	**Secondary education (ISCED >1)**
Temperature anomaly	0.0279*** (0.0060)	0.0282** (0.0107)	0.0284*** (0.0085)	0.0244** (0.0089)	0.0385*** (0.0081)	0.0111 (0.0087)
Observations	265858	66492	108862	90504	156540	109307
R^{2} [a]	0.05876	0.06124	0.06238	0.06339	0.06244	0.06148
Within R^{2} [b]	0.00032	0.00031	0.00032	0.00027	0.00053	0.0005

LESS SEVERE VIOLENCE						
	Overall	**Age 15–24**	**Age 25–34**	**Age 35–49**	**Primary education (ISCED 0–1)**	**Secondary education (ISCED >1)**
Temperature anomaly	0.0185*** (0.0054)	0.0128 (0.0098)	0.0190* (0.0079)	0.0198* (0.0077)	0.0292*** (0.0072)	0.0032 (0.0083)
Observations	265,970	66,516	108,907	90,547	156,582	109,377
R^{2} [a]	0.04811	0.05358	0.05046	0.05379	0.04985	0.05258
Within R^{2} [b]	0.00017	0.0007	0.00017	0.00021	0.00036	0.00006

SEVERE VIOLENCE

	Overall	Age 15–24	Age 25–34	Age 35–49	Primary education (ISCED 0–1)	Secondary education (ISCED >1)
Temperature anomaly	0.0156*** (0.0037)	0.0200** (0.0063)	0.0169** (0.0056)	0.0115* (0.0057)	0.0201*** (0.0051)	0.0059 (0.0052)
Observations	265881	66486	108872	90523	156539	109331
R^{2} [a]	0.05031	0.04087	0.05849	0.05792	0.06609	0.03426
Within R^{2} [b]	0.00025	0.00041	0.00027	0.00014	0.00035	0.00004

SEXUAL VIOLENCE

	Overall	Age 15–24	Age 25–34	Age 35–49	Primary education (ISCED 0–1)	Secondary education (ISCED >1)
Temperature anomaly	0.0155*** (0.0043)	0.0244** (0.0085)	0.0143* (0.0061)	0.0087 (0.0063)	0.0163** (0.0060)	0.0125* (0.0058)
Observations	265912	66495	108897	90520	156557	109345
R^{2} [a]	0.0492	0.04561	0.05281	0.05342	0.05516	0.04653
Within R^{2} [b]	0.0002	0.00042	0.00016	0.0007	0.00019	0.00014

Note: Regression coefficients from linear fixed effects models with clustered standard errors in parentheses. Standard errors are clustered at the DHS cluster level. All models control for region and seasonal fixed effects, as well as United Nations intermediate region-specific time trends. [a] The R^{2} shows the proportion of the variation in the dependent variable that is explained by the explanatory variables considered. [b] The within R^{2} describes the proportion of the variance in the dependent variable over time that can be explained through changes in the explanatory variables. P-values: *p<0.1; **p<0.05; ***p<0.01

Regional differences in climatic impacts on violence

Photo: @UNFPA

As a next step, the statistical models are further expanded, considering differences by age, education and United Nations intermediate region (West, South, Middle and East) within SSA. The results are shown as a coefficient plot in Figure 4, which depicts the effects of a one standard temperature anomaly on the probability of a woman in a region experiencing IPV. These coefficient estimates also form the basis for our projections of IPV under climate change in the following sections.

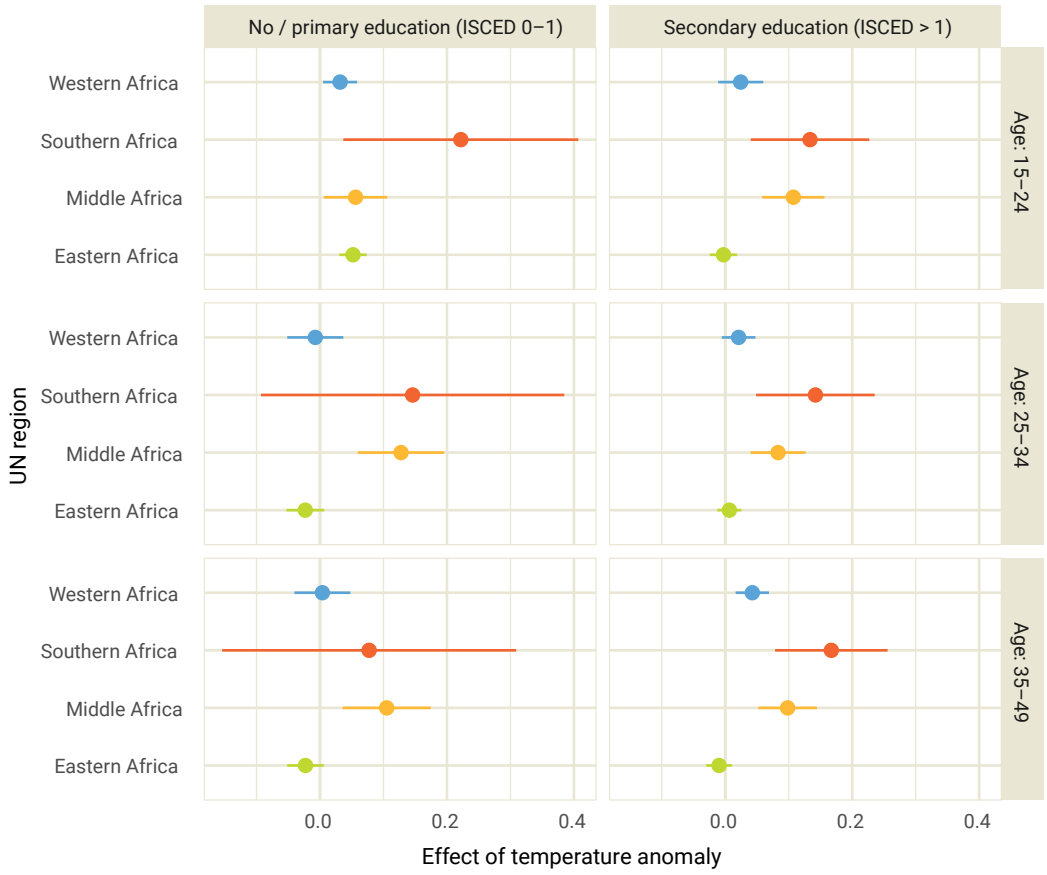


FIGURE 4: *Effects of temperature anomalies on physical violence by women's age, education and region of residence within sub-Saharan Africa*

The effects are displayed in terms of standard deviation changes with a one standard deviation change in the climatic factor. The evidence is based on DHS data from 2000 to 2017. Physical violence refers to any form of less severe, severe and sexual violence in the last available DHS wave.

While the overall pattern of mostly low-educated, younger women suffering from violence is confirmed, there is also a strong regional variation in the effects of temperature anomalies on violence across SSA. Climatic impacts are found to be strongest in Southern and Middle Africa, and weaker in Western and Eastern Africa, where they are only significant for the lowest education and age group. Differences in the precision of the point estimates, as indicated by the confidence intervals, also reflect differences in underlying sample sizes. In our projections, we assume that differences in the effects between regions across Africa remain stable over time.

Improved education and its direct and indirect impacts on violence

Photo: @UNFPA

Education can both directly and indirectly help in mitigating climate impacts on violence. Indirectly, this happens by making women more resilient in times of climatic stress. A direct impact can result from education-induced changes in societal perceptions and norms, leading to a general decline in violence, irrespective of climate change.

In order to capture such societal effects, the impacts of compositional changes in education at the regional level on the prevalence of IPV are analysed in Table 3, which shows the effects of the educational expansion in 242 subnational regions within SSA.

The findings show that if the share of highly educated women (International Standard Classification of Education or ISCED > 1) of reproductive age (15 to 49 years) within a region doubles, then the incidence of IPV is halved. These effects also remain robust when the models additionally control for changes in regional income, indicating that education is the key factor in inducing societal change.

TABLE 3: *Estimating compositional effects on violence*

PHYSICAL VIOLENCE			
	(1)	(2)	(3)
Temperature anomaly	0.03	0.03	0.03
	(0.02)	(0.02)	(0.02)
Secondary education	-0.48**	-0.39	-0.02
	(0.18)	(0.34)	(0.72)
Secondary education²		-0.09	-0.89
		(0.27)	(1.48)
Secondary education³			0.51
			(0.97)
Num. obs.	242	242	242
R^{2} [a]	0.87	0.87	0.87
Adj. R^{2} [b]	0.77	0.77	0.77

Note: Linear fixed effects regression coefficients with clustered standard errors in parentheses. The unit of observation are subnational regions (provinces and districts) in SSA observed over time. Standard errors are clustered at the subnational regional level. All models control for subnational region and seasonal fixed effects, as well as United Nations intermediate region-specific time trends. [a] The R^2 shows the proportion of the variation in the dependent variable that is explained by the explanatory variables considered. [b] The adjusted R^2 additionally corrects the R^2 by the number of explanatory variables considered. P-values: *p<0.1; **p<0.05; ***p<0.01

The estimation of these effects allows us to account for the impacts of aggregate changes in education over time on IPV. These findings have important implications for the projections, as populations change in terms of their composition and characteristics, including their education. In order to assess future climate change impacts, it is important to take such changes into account, including in the age and education structure of populations, as these may determine future vulnerability to climatic stress.

Photo: @UNFPA

Projecting future impacts of climate change and socioeconomic development

Photo: @UNFPA

In order to assess the future IPV burden in SSA, the empirical evidence gathered so far based on DHS data is combined with available climate and socioeconomic projections. These projections are taken from the Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs), respectively. The linkages between these two types of projections are explained in section 2 ("Measuring and projecting intimate partner violence"), as well as in the Appendix. Figure 5a shows differences in the projected number of women affected by violence during the 2015–2060 period. The colours indicate different possible combinations of SSPs and RCPs following Jones and O'Neill (2016).

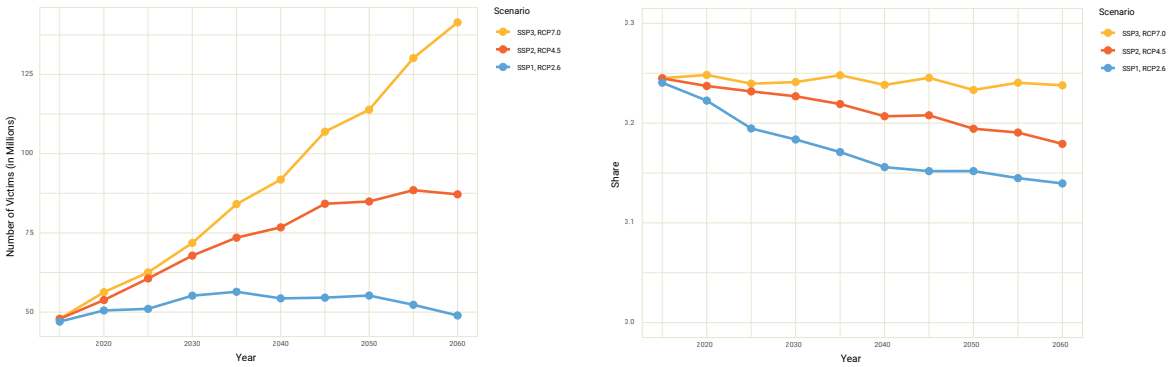


FIGURE 5: *Projections of future gender-based violence*

Panel **a** shows the projected number of women (in millions) affected by violence in three different scenarios. Panel **b** shows the share of women affected by violence relative to the projected total population in SSA for the period 2015–2060. Projections are based on three scenarios reflecting combinations of different SSPs and RCPs. While SSP1 reflects an optimistic scenario with inclusive socioeconomic development and successful climate adaptation and mitigation (corresponding to RCP 2.6), SSP3 shows a pessimistic scenario with limited development and major challenges in adaptation and mitigation (corresponding to RCP 7.0). SSP2 shows a middle-of-the-road scenario reflecting a continuation of current development and climate mitigation trends (corresponding to RCP4.5).

Results suggest that, following the most pessimistic socioeconomic pathway (SSP3), which is characterized by regional rivalry rather than cooperation at the global level and simultaneously leads to the highest emissions pathway (RCP7.0), the absolute number of victims of violence in SSA is expected to almost triple from around 48 million in the baseline year of 2015 to 140 million by 2060.

Following the slightly less pessimistic middle-of-the-road SSP2 scenario, which is likely to follow an intermediate concentration pathway (RCP4.5), the IPV burden is still going to almost double in

absolute terms, whereas according to SSP1, the pathway describing a sustainable transition with global cooperation, slow population growth thanks to progress in the demographic transition, and strong improvements in educational attainment across the Global South, the projected annual number of victims of violence is going to stabilize. This is of course also a consequence of lower carbon emissions (RCP2.6) leading to fewer meteorological anomalies. In sum, over the entire 2015–2060 period the difference between sustainable development under SSP1 + RCP2.6 and regional rivalry under SSP3 + RCP7.0 amounts to more than 1.9 billion avoidable IPV cases.

These absolute numbers are of course driven to a large extent by the increase in the total population that SSA is going to experience under all SSPs, albeit to varying degrees. Given the severe delay of the demographic transition and subsequent deceleration in educational expansion under SSP3, a much larger female population is going to be exposed to the risk of violence compared to SSP2 and SSP1. Therefore, rather than the total number of victims, Figure 5b shows differences in the projected share of women affected by violence during the 2015–2060 period. While we project relative stabilization under SSP3 + RCP7.0, shares of women affected actually start to decline under SSP1 + RCP2.6 and SSP2 + RCP4.5.

An interesting follow-up question regards the extent to which different demographic factors co-determine these projection results. Due to the delay in the demographic transition under SSP3, the population of SSA is not just going to be more numerous, but also younger and less educated on average compared to SSP2 and even more so SSP1. SSA will experience quite considerable aging in all three SSPs, but this effect is going to be far less pronounced in SSP3. From the viewpoint of an individual woman, the extent of aging at the societal level does not matter, as every individual woman will have to go through every age group, facing declining risks of violence as she gets older. From a societal perspective, however, the proportion of women that are of vulnerable ages at any point in time does make a difference. As shown in Figure A2 of the Appendix, while under SSP3, the proportion of women aged 15 to 24 years in the total female population of reproductive age (15 to 49 years) declines only from 41 per cent to 36 per cent between 2015 and 2060; under SSP2, it reaches 31 per cent and under SSP1, 26 per cent. Vice versa, the share of women in the relatively less vulnerable age groups (25 to 34 and 35 to 49 years) compared to the younger groups (15 to 24 years) increases more rapidly under SSP2 and SSP1.

More importantly with respect to the future incidence of violence, though, the share of women with at least lower secondary education increases dramatically under SSP1 and SSP2. As shown in Figure A3 of the Appendix, starting from a proportion of slightly less than 35 per cent of women of reproductive age with higher education in 2015, this proportion increases to 76 per cent under SSP2 and almost universal higher education (ISCED > 1) under SSP1 by 2060. Instead, under SSP3, we will see only a modest increase to 40 per cent, leaving the vast majority of women in SSA vulnerable to violence.

The complementary role of climate change mitigation and adaptation

Photo: @UNFPA

The overall change in future IPV prevalence as implied by our projections can be broken down into two parts: on the one hand, there is increased radiative forcing, as described by the RCPs (i.e. climate change), which leads to mitigation challenges; on the other hand, there are the socioeconomic developments described by the SSPs that affect the capacity to adapt to the changes brought about by climate change. Following this reasoning, in this final substantive chapter, we present the breakdown of our overall projection results into individual components. The solid lines in the three panels of Figure 6 correspond to the three lines shown in Figure 5 above. The alternative line types and symbol shapes correspond to different "Versions" of projections resulting from disregarding different effect components, leading to the overall results one at a time.

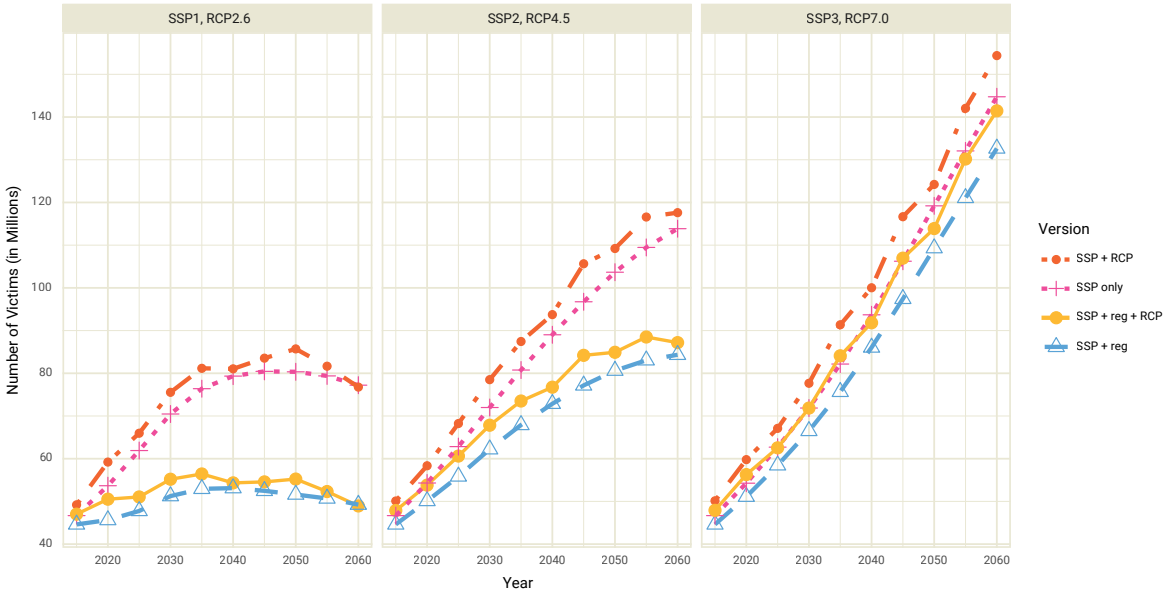


FIGURE 6: *Projected number of women (in millions) affected by violence in three different scenarios in sub-Saharan Africa for the period 2015–2060*

Projections are based on three scenarios reflecting combinations of different SSPs and RCPs. While SSP1 reflects an optimistic scenario with inclusive socioeconomic development and successful climate adaptation and mitigation (corresponding to RCP 2.6), SSP3 shows a pessimistic scenario with limited development and major challenges in adaptation and mitigation (corresponding to RCP 7.0). SSP2 shows a middle-of-the-road scenario reflecting a continuation of current development and climate mitigation trends (corresponding to RCP4.5). Versions are ordered by degree of severity in terms of the expected future violence burden, ranging from just the combined socioeconomic effects ("SSP + reg" without climate effects), which yields the lowest IPV burden under all SSPs, to the SSPs without the IPV-reducing effect from structural change or climate effects ("SSP only"), and finally, SSPs and RCPs without the effects from societal development at

the regional level ("SSP + RCP"), leading to the highest projected future number of violence victims.

Starting out with the worst scenario (SSP3 + RCP7.0) in the rightmost panel and using the full results ("SSP + reg + RCP") as our baseline, if we trusted the "SSP + reg" version we would not account for almost 9 million annual victims of violence across SSA by 2060 attributable to the effect of temperature anomalies. If on top of that we had to forgo the violence-reducing effect from compositional change in the SSA population, while continuing to ignore the likely effect from increasing temperature anomalies (i.e. "SSP only"), projected victim numbers would rise by 9.1 per cent compared to "SSP + reg". If on top of that we accounted for the violence effect of increasing temperature anomalies under RCP7.0 (i.e. "SSP + RCP"), this projected figure would increase by yet another 6.6 per cent, reaching a total of 154 million expected victims of violence by 2060 in the worst case. However, even under the most pessimistic of socioeconomic scenarios (SSP3) there are going to be improvements in the overall age and education structure of the population, with implications for IPV. Taking these into consideration leads us back to the solid baseline, according to which the predicted number of victims will be lower by slightly more than 9 per cent compared to the worst-case version just described.

When looking at the other two panels corresponding to SSP1 + RCP2.6 and SSP2 + RCP4.5, we find the main difference with SSP3 + RCP7.0 to rest in the more favourable population compositions resulting from these scenarios. Ignoring the compositional effect here would result in a 58 per cent increase in the projected number of women becoming victims of violence under SSP1 + RCP2.6. This difference is almost as big as the one observed between the baseline scenarios in the two panels on the left (SSP1 + RCP2.6 vs. SSP2 + RCP4.5). Including the effect of climate change does of course increase the risk of violence in all SSPs; however, the difference is not as striking as the one considering different socioeconomic conditions.

Recommendations

- **Increased investment in research and evidence generation.** It is critical to increase investment in research and evidence generation to support better understanding of the drivers of IPV in different contexts, and the role of development and climate pathways for the risk of violence in the future. Projections of possible future scenarios will help policy makers to plan and implement more informed and targeted policies to reduce IPV.
- **Development and population-responsive climate action.** Ensure new and existing policies in sub-Saharan Africa are implemented in a manner that supports both socio-economic development and climate change mitigation/adaptation efforts, addressing different parts of the nexus and contributing to reduced IPV cases. Development and population policies in sub-Saharan Africa should integrate climate change to help address future impacts on communities. Adaptation measures should anticipate and meet the gendered needs of those impacted, displaced and at risk, including through humanitarian response and the strengthening of assistance and social protection programmes.
- **Targeted measures to identify and prioritize groups at risk.** IPV cannot be addressed through a one-size-fits-all approach, hence the need for policy makers to identify and prioritize the groups most at risk, including younger women aged 15 to 24 with low levels of education. Targeted interventions tailored to the specific needs, circumstances and vulnerabilities of the individuals and communities affected can help address the root causes of IPV and encourage long-term behaviour change.
- **Leverage the transformative role of education to strengthen resilience and adaptive capacity.** Education is crucial for reducing cases of IPV by reducing vulnerabilities and increasing resilience and adaptive capacity, especially during climate disasters, and for strengthening women's position in society and inclusion in decision-making processes. Information campaigns and awareness-raising programmes about healthy relationships, consent and rights can help women and girls recognize the signs of IPV and develop the needed skills and knowledge to protect themselves and promote positive changes in societal norms towards violence.
- **Economic empowerment of women and girls.** Since addressing linkages between climate change and violence requires a multi-faceted approach, economic empowerment of women and girls can help reduce their vulnerability to IPV, ensuring financial independence and an enhanced sense of security. Education and vocational training, microfinance, green skills and other forms of support can be considered to help build economic resilience.
- **Access to quality health care that includes SRHR.** Access to health care is crucial for young women and girls who are experiencing IPV, including integrating SRHR into climate-resilient health, protection and education systems, and strengthening risk reduction, emergency response and data systems. Providing medical and psychological support, as well as legal and other information services, will be crucial.

- **Strengthening social and legal protection.** Victims of IPV need access to supportive networks, including family, friends and community organizations. It is important that these networks are able to provide safe spaces, emotional support and practical assistance. Pursuing legal protection and assistance for victims, and leveraging and enacting laws that criminalize IPV can help to deter perpetrators and enable victims to navigate the justice system, ensure protection of their rights.
- **Male engagement in prevention of IPV.** Male engagement can be a good approach to prevent cases of IPV against women and girls, especially taking on the role of allies and advocates for gender equality, and enabling them to challenge harmful gender norms and stereotypes that increases the risk of IPV. Men can also work to promote healthy relationships based on respect, trust and open communication, as well as being positive role models for other men and boys, who encourage their peers to reject violent and abusive behaviour towards women and girls.
- **Reflection on the international climate negotiations process.** These findings come at a critical time as we approach the review of the UNFCCC Lima Work Programme and its Gender Action Plan, as we progress on the goals of the Paris Agreement. It is important that the gender and climate negotiations reflect the intersection with IPV and ensure strong integration into the various national Gender Action Plans (GAPs) on climate change.
- **Integration of IPV measures into national climate policies.** The results of the analysis underscore the importance of ensuring that international climate processes such as the Global Goal on Adaptation (GGA) and national climate policies, including the Nationally Determined Contributions (NDC), National Adaptation Plans (NAPs) and the GAPs, as well as relevant national gender policies, incorporate adaptation measures that address the impact of climate change on women and girls. This is not only during emergency responses where there is a heightened risk of IPV, but also in the overall adaptation and socio-economic development planning.
- **Localization and women-led organizations:** Women in affected communities can be relied upon to discern needs and support responses. It is important to provide robust support for such local organizations, with adequate financial and other technical support needed for successful work. It is critical that climate emergency and disaster risk reduction actors conduct gender analyses, social norms mapping and needs assessments across sectors. Additional measures could include IPV risk prevention across sectors, including in preparedness planning – for example, ensuring that food distribution centre times and procedures are designed and implemented to reduce IPV risk.

Appendix: Research design and methods

Photo: @UNFPA

In order to study the impacts of climatic changes and extreme events, we construct an extensive dataset from the DHS, climatic data and further contextual variables. Using pooled DHS microdata from all available countries and DHS waves in SSA, we explore individual women's outcomes and challenges at the micro-level. The results of our models are stratified by age and education to explore differences in effects for different population groups. Finally, we present projections of the likely future incidence of IPV in SSA, relying on commonly used scenario assumptions.

Data

Due to violence often occurring in hidden places and victims being stigmatized, the collection of data on IPV is challenging. This study relies on data from DHS, major representative surveys with an excellent coverage in the SSA region (Demographic and Health Surveys, 2019). First implemented in the 1980s in overlapping five-year periods, multiple DHS survey waves are available today, providing comprehensive data on population characteristics, such as age, sex, educational attainment and area of residence, as well as information on family, marital and birth histories. Data collection on IPV commenced in 2000 with the inclusion of specific modules that are included in some DHS waves. Based on the DHS data, a longitudinal database was constructed and combined with climatic data and further contextual information at a subnational level.

To provide a sufficiently large sample size for empirical analyses, the DHS draws samples from smaller population segments with unequal probability. Sampling weights are used to further improve the precision concerning underrepresented households. Response rates are very high in most of Africa, ensuring a high degree of external validity (Vaessen, Thiam and Lê, 2005), while standardized DHS data collection procedures ensure comparability across countries and over time. The sample includes women of reproductive age (aged 15 to 49 years), which in the following analyses are weighted using post-stratification weights for the subsample that responded to the questions in the domestic violence modules.

The DHS-based violence data are combined with climatic and contextual information at the DHS cluster and subnational regional level. The climatic indicators used in our models are derived from the CRU TS (Climatic Research Unit gridded Time Series) Version 4 presented by Harris et al. (2020). They describe the temperature conditions and anomalies that respondents were exposed to in their community during the 12 months prior to the DHS interview relative to the average conditions of the previous 30 years as a reference period.

Measuring intimate partner violence

To measure IPV, we construct four proxy measures from the available DHS surveys that capture different forms of IPV (less severe, severe, sexual and emotional violence) where the husband or partner is the perpetrator. For all measures, a woman is counted to have experienced IPV in the last 12 months when her response to the survey item was one of "often", "sometimes" or "yes, but frequency in the last 12 months missing". The remaining response categories were "never" and "yes, but not in the last 12 months". Accordingly, the exact timing of the occurrence within the previous 12 months cannot be determined based on the available data. This necessitates a relatively high level of temporal aggregation and precludes modelling the sequence of events in detail.

A woman is defined to have experienced less severe violence if she has either been pushed, been shaken or had something thrown at her; been slapped, punched with fist or hit by something harmful; or been kicked or dragged by her husband or partner. Severe violence includes having the arm twisted or hair pulled, being strangled or burnt, being threatened with a knife, gun or another weapon, or being physically attacked. Sexual violence captures whether a woman has been physically forced into unwanted sex, forced into other unwanted sexual acts, or physically forced to perform sexual acts she did not want. Finally, emotional violence includes having been humiliated, threatened with harm, insulted or made to feel bad by her partner. Not all questions are asked in every survey. Accordingly, only those questions that were asked in the respective country wave are considered in the aggregation of the IPV indicators.

The measurement of the violence indicators can be affected by the sensitivity of the issue and social influences. This can bias the accurate representation of violence in a household or region. DHS ensures the protection of women providing information and the confidentiality of their answers, which may help increase their reporting. Despite this effort, the DHS data are still likely to underestimate the true prevalence of IPV in an area, which also has implications for the findings of this report. The data still prove highly useful in understanding the overall patterns in IPV and the role of different risk factors, including climatic impacts.

Climate and contextual variables

The climatic indicators used in our models describe temperature anomalies that respondents were exposed to during the 12 months prior to the DHS interview relative to the average conditions of the previous 30 years as a reference period. The temperature anomalies are calculated by subtracting the long-run temperature mean over the past 30 years from the observed monthly temperature and dividing the result by the long-run temperature standard deviation.

Since interviews in a region can take place at different dates of a DHS wave, for aggregation at the cluster level we chose the date of the first interview in the respective region. During the DHS observation period relevant for our empirical work, there is a clear trend of rising temperatures and, accordingly, positive temperature anomalies relative to the reference period.

In the second part of our work, which focuses on future developments, we rely on temperature projections from the Coupled Model Intercomparison Project (CMIP) Phase 6 to predict future levels of IPV under different climate scenarios. Based on the evaluation of surface temperature over East Africa from several CMIP6 models by Ayugi et al. (2021), we choose the FGOALS-g3 of Pu et al. (2020) for this application. Future anomalies are calculated in accordance with the definition used for the historical time series.

Regional economic and social conditions are captured using the GDP per capita and the HDI based on the grids produced by Kummu, Taka and Guillaume (2018). GDP per capita reflects 2011 US dollars and is corrected for differences in purchasing power. For each region-year and cluster-year combination, we calculate the means of GDP per capita and HDI, weighted by the fraction of each respective grid cell that intersects with the clusters or regions. Since the grids are only available for 1990–2015, the values are averaged over this time period in order to characterize the overall socioeconomic conditions at the interview locations.

Estimation approach

In our estimation, we follow different steps. First, we estimate baseline models using the DHS microdata. As outcomes, we consider whether an interviewed women reported having been affected by less severe, severe, sexual and emotional violence in the past 12 months. The first three indicators are summarized in one aggregate indicator, capturing whether a woman experienced any form of physical violence. The binary violence outcomes are regressed on the temperature anomaly measure using fixed effects regression models. The models take the following form:

$$y_{irct} = \alpha_r + C_{rct}\beta + \delta_{rt} + \gamma_s + \varepsilon$$

where y_{irct} is the IPV experienced by individual i living in DHS cluster r in country c at time t and C_{rct} are the observed intensity of temperature anomalies in the DHS cluster r over time. α_r is a subnational region-specific intercept capturing time-invariant factors, δ_{rt} controls for decadal time trends separated for West, East, Middle and Southern Africa, and γ_s controls for seasonality effects of the different meteorological seasons.

The latter three model components allow us to control for unobserved heterogeneity, time trends and seasonality effects. Unobserved heterogeneity at the country level can for instance be caused by relatively constant political, institutional or cultural characteristics. Time trends can be driven by relatively slow-moving processes, like the demographic transition and macro-economic development. Our estimates abstract from these factors and rely on the exogenous variation in climatic conditions over time to identify effects on the outcomes of interest.

Furthermore, to capture the heterogeneous effects of temperature anomalies by women's age, education, and region of residence, we estimate further models with interactions between the temperature anomaly, age of the respondent, education, and four macro-regions within Africa. Based on the interaction terms, we calculate the effects for each age and education subgroup, which we also use as the basis for our projections.

Projections

To translate the empirical results on IPV in SSA into projections of the future incidence of IPV under different socioeconomic (SSPs) and greenhouse gas emission scenarios (RCPs), we rely on the average marginal effects derived from the micro-level models. Those effects were calculated separately for different combinations of age, education and the four macro-regions of SSA (Western, Southern, Middle, Eastern Africa) and were subsequently combined with available national-level population projections by age, sex and level of educational attainment following KC and Lutz (2017).

This is accomplished by using today's incidence of violence observed in a respective country as a baseline and projecting future changes using the historically estimated effects. The more anomalous weather conditions become in a given climate scenario relative to the baseline, the stronger they are going to impact the living conditions of women in SSA. To account also for changing population compositions at the sub-national regional level, we combine the individual-level effects estimated in the main model (formula 1 above) with estimates derived from a regional model that regresses the regional share of women affected by IPV on the size and educational composition of the population.

References

Abel, Guy J., Bilal Barakat, Samir Kc, and Wolfgang Lutz. 2016. "Meeting the sustainable development goals leads to lower world population growth." *Proceedings of the National Academy of Sciences of the United States of America* 113 (50): 14294–99. https://doi.org/10.1073/pnas.1611386113.

Adano, Wario R, Ton Dietz, Karen Witsenburg, and Fred Zaal. 2012. "Climate change, violent conflict and local institutions in kenya's drylands." *Journal of Peace Research* 49 (1): 65–80. https://doi.org/10.1177/0022343311427344.

Alston, Margaret, and Kerri Whittenbury. 2013. "Research, action and policy: Addressing the gendered impacts of climate change." *Research, Action and Policy: Addressing the Gendered Impacts of Climate Change*, 1–281. https://doi.org/10.1007/978-94-007-5518-5.

Anderson, Craig A. 1989. "Temperature and aggression: Ubiquitous effects of heat on occurrence of human violence." *Psychological Bulletin* 106 (1): 74–96.

Anderson, Craig A., Kathryn B. Anderson, Nancy Dorr, Kristina M. DeNeve, and Mindy Flanagan. 2000. "Temperature and aggression." *Advances in Experimental Social Psychology* 32 (January):63–133. https://doi.org/10.1016/S0065-2601(00)80004-0.

Ayugi, Brian, Hamida Ngoma, Hassen Babaousmail, Rizwan Karim, Vedaste Iyakaremye, Kenny T.C. Lim Kam Sian, and Victor Ongoma. 2021. "Evaluation and projection of mean surface temperature using cmip6 models over East Africa." *Journal of African Earth Sciences* 181 (September):104226. https://doi.org/10.1016/J.JAFREARSCI.2021.104226.

Barnett, Jon, and W. Neil Adger. 2007. "Climate change, human security and violent conflict." *Political Geography* 26 (6): 639–55. https://doi.org/10.1016/j.polgeo.2007.03.003.

Brottem, Leif V. 2016. "Environmental change and farmer-herder conflict in agro-pastoral West Africa." *Human Ecology* 44 (5): 547–63. https://doi.org/10.1007/s10745-016-9846-5.

Burke, Marshall, Solomon M Hsiang, and Edward Miguel. 2015. "Climate and conflict." *Annual Review of Economics* 7:577–617. https://doi.org/10.1080/03071849008445480.

Carolan-Olah, Mary, and Dorota Frankowska. 2014. "High environmental temperature and preterm birth: A review of the evidence." *Midwifery* 30 (1): 50–59. https://doi.org/10.1016/j.midw.2013.01.011.

Centre for Research on the Epidemiology of Disasters (2022). EM-DAT: The emergency events database. Centre for Research on the Epidemiology of Disasters (CRED). Available at https://www.emdat.be/.

Cohen, Dara Kay, and Ragnhild Nordås. 2014. "Sexual violence in armed conflict: Introducing the svac dataset, 1989–2009." *Journal of Peace Research* 51 (3): 418–28. https://doi.org/10.1177/0022343314523028.

Corno, Lucia, Nicole Hildebrandt, and Alessandra Voena. 2020. "Age of marriage, weather shocks, and the direction of marriage payments." *Econometrica* 88 (3): 879–915. https://doi.org/10.3982/ECTA15505.

Demographic and Health Surveys (DHS) (2019). *The DHS Program. Demographic and Health Surveys*. Available at https://dhsprogram.com/.

Desai, Zalak, and Ying Zhang. 2021. "Climate change and women's health: A scoping review." *GeoHealth* 5 (9): e2021GH000386. https://doi.org/10.1029/2021GH000386.

Food and Agriculture Organization of the United Nations (FAO) (2021). *The state of food security and nutrition in the world*. Available at https://www.fao.org/publications/home/fao-flagship-publications/the-state-of-food-security-and-nutrition-in-the-world/2021/en.

Harris, Ian, Timothy J. Osborn, Phil Jones, and David Lister. 2020. "Version 4 of the cru ts monthly high-resolution gridded multivariate climate dataset." *Scientific Data* 7 (1): 1–18. https://doi.org/10.1038/s41597-020-0453-3.

Henke, Alexander, and Lin chi Hsu. 2020. "The gender wage gap, weather, and intimate partner violence." *Review of Economics of the Household* 18 (2): 413–29. https://doi.org/10.1007/s11150-020-09483-1.

Hoffmann, R, C Wiederkehr, A Dimitrova, and K Hermans. 2022. "Agricultural livelihoods, adaptation, and environmental migration in sub-Saharan drylands: a meta-analytical review." *Environmental Research Letters* 17 (8). https://doi.org/10.1088/1748-9326/ac7d65.

Hoogeveen, Johannes, Bas Van Der Klaauw, and Gijsbert Van Lomwel. 2011. "On the timing of marriage, cattle, and shocks." *Economic Development and Cultural Change* 60 (1): 121–54. https://doi.org/10.1086/661215.

Hsiang, Solomon M., Marshall Burke, and Edward Miguel. 2013. "Quantifying the influence of climate on human conflict." *Science* 341 (6151): 1235367. https://doi.org/10.1126/science.1235367.

Intergovernmental Panel on Climate Change (IPCC) (2018). *Special report on global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat.*

Intergovernmental Panel on Climate Change (IPCC) (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. contribution of working group ii to the sixth assessment report of the intergovernmental panel on climate change* in, Pörtner, H.-O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., and Rama, B. Eds. Cambridge University Press.

International Displacement Monitoring Centre (IDMC) (2021). *Global report on internal displacement 2021*. Available at https://www.internal-displacement.org/global-report/grid2021/.

James, Rachel, and Richard Washington. 2013. "Changes in African temperature and precipitation associated with degrees of global warming." *Climatic Change* 117 (4): 859–72. https://doi.org/10.1007/S10584-012-0581-7.

Jones, B., and B. C. O'Neill. 2016. "Spatially explicit global population scenarios consistent with the shared socioeconomic pathways." *Environmental Research Letters* 11 (8). https://doi.org/10.1088/1748-9326/11/8/084003.

Karim, K. M.Rabiul, Maria Emmelin, Bernadette P. Resurreccion, and Sarah Wamala. 2012. "Water development projects and marital violence: experiences from rural Bangladesh." *Health Care for Women International* 33 (3): 200–216. https://doi.org/10.1080/07399332.2011.603861.

KC, Samir, and Wolfgang Lutz. 2017. "The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100." *Global Environmental Change* 42 (January):181–92. https://doi.org/10.1016/j.gloenvcha.2014.06.004.

Koubi, Vally. 2019. "Climate change and conflict." *Annual Review of Political Science* 22 (May):343–60. https://doi.org/10.1146/ANNUREV-POLISCI-050317-070830.

Kuehn, Leeann, and Sabrina McCormick. 2017. "Heat exposure and maternal health in the face of climate change." *International Journal of Environmental Research and Public Health* 14 (8): 853. https://doi.org/10.3390/ijerph14080853.

Kummu, Matti, Maija Taka, and Joseph H.A. Guillaume. 2018. "Gridded global datasets for gross domestic product and human development index over 1990–2015." *Scientific Data 2018 5:1* 5 (1): 1–15. https://doi.org/10.1038/sdata.2018.4.

Le Masson, Virginie, Colette Benoudji, Sandra Sotelo Reyes, and Giselle Bernard. 2019. "How violence against women and girls undermines resilience to climate risks in Chad." *Disasters* 43 Suppl 3 (Suppl 3): S245–70. https://doi.org/10.1111/DISA.12343.

Leichenko, Robin M., Karen L. O'Brien, and William D. Soleck. 2010. "Climate change and the global financial crisis: A case of double exposure." *Annals of the Association of American Geographers* 100 (4): 963–72. https://doi.org/10.1080/00045608.2010.497340.

Levy, Barry S., Victor W. Sidel, and Jonathan A. Patz. 2017. "Climate change and collective violence." *Annual Review of Public Health* 38:241–57. https://doi.org/10.1146/annurev-publhealth-031816-044232.

Lutz, Wolfgang, and Ren Qiang. 2002. "Determinants of human population growth." *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 357 (1425): 1197–1210. https://doi.org/10.1098/RSTB.2002.1121.

McLean, Iain. 2007. "Climatic effects on incidence of sexual assault." *Journal of Forensic and Legal Medicine* 14 (1): 16–19. https://doi.org/10.1016/J.JCFM.2005.12.001.

McLeod, Christie, Heather Barr, and Katherina Rall. 2019. "Does climate change increase the risk of child marriage? a look at what we know--and what we don't--with lessons from Bangladesh

& Mozambique." *Columbia Journal of Gender and Law* 38 (1): 96–145. https://doi.org/10.7916/CJGL.V38I1.4604.

McMichael, Anthony J. 2013. "Globalization, climate change, and human health." *The New England Journal of Medicine* 368 (14): 1335–43. https://doi.org/10.1056/NEJMRA1109341.

Meyiwa, Thenjiwe, Thandokazi Maseti, Sizani Ngubane, Tebello Letsekha, and Carina Rozani. 2014. "Women in selected rural municipalities: Resilience and agency against vulnerabilities to climate change." *Agenda* 28 (3): 102–14. https://doi.org/10.1080/10130950.2014.955686.

Misselhorn, Alison A. 2005. "What drives food insecurity in Southern Africa? a meta-analysis of household economy studies." *Global Environmental Change* 15 (1): 33–43. https://doi.org/10.1016/j.gloenvcha.2004.11.003.

Müller, Christoph, Katharina Waha, Alberte Bondeau, and Jens Heinke. 2014. "hotspots of climate change impacts in sub-Saharan Africa and implications for adaptation and development." *Global Change Biology* 20 (8): 2505–17. https://doi.org/10.1111/GCB.12586.

Muluneh, Muluken Dessalegn, Lyn Francis, Kingsley Agho, and Virginia Stulz. 2021. "A systematic review and meta-analysis of associated factors of gender-based violence against women in sub-Saharan Africa." *International Journal of Environmental Research and Public Health* 18 (9): 4407. https://doi.org/10.3390/ijerph18094407.

Muttarak, R. (2021). Demographic perspectives in research on global environmental change. *Population Studies*, vol. 75, pp. 77–104.

Muttarak, Raya. 2021. "Demographic perspectives in research on global environmental change." *Population Studies* 75 (S1): 77–104. https://doi.org/10.1080/00324728.2021.1988684.

Muttarak, Raya, Wolfgang Lutz, and Leiwen Jiang. 2015. "Introduction: What can demographers contribute to the study of vulnerability?" *Vienna Yearbook of Population Research* 13:1–13. https://doi.org/10.1553/populationyearbook2015s001.

O'Neill, Brian C., Elmar Kriegler, Keywan Riahi, Kristie L. Ebi, Stephane Hallegatte, Timothy R. Carter, Ritu Mathur, and Detlef P. van Vuuren. 2014. "A new scenario framework for climate change research: The concept of shared socioeconomic pathways." *Climatic Change* 122 (3): 387–400. https://doi.org/10.1007/s10584-013-0905-2.

O'Neill, Brian C., Elmar Kriegler, Kristie L. Ebi, Eric Kemp-Benedict, Keywan Riahi, Dale S. Rothman, Bas J. van Ruijven, et al. 2017. "The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century." *Global Environmental Change* 42:169–80. https://doi.org/10.1016/j.gloenvcha.2015.01.004.

Pearse, Rebecca. 2017. "Gender and climate change." *Wiley Interdisciplinary Reviews: Climate Change* 8 (2): e451. https://doi.org/10.1002/WCC.451.

Phillips, Carly A., Astrid Caldas, Rachel Cleetus, Kristina A. Dahl, Juan Declet-Barreto, Rachel Licker, L. Delta Merner, et al. 2020. "Compound climate risks in the COVID-19 pandemic." *Nature Climate Change* 10 (7): 586–88. https://doi.org/10.1038/s41558-020-0804-2.

Pu, Ye, Hongbo Liu, Ruojing Yan, Hao Yang, Kun Xia, Yiyuan Li, Li Dong, et al. 2020. "CAS FGOALS-G3 model datasets for the CMIP6 scenario model intercomparison project (ScenarioMIP)." *Advances in Atmospheric Sciences 2020 37:10* 37 (10): 1081–92. https://doi.org/10.1007/S00376-020-2032-0.

Riahi, Keywan, Detlef P. van Vuuren, Elmar Kriegler, Jae Edmonds, Brian C. O'Neill, Shinichiro Fujimori, Nico Bauer, et al. 2017. "The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: An overview." *Global Environmental Change* 42:153–68. https://doi.org/10.1016/j.gloenvcha.2016.05.009.

Rohat, Guillaume, Johannes Flacke, Alessandro Dosio, Hy Dao, and Martin Maarseveen. 2019. "Projections of human exposure to dangerous heat in African cities under multiple socioeconomic and climate scenarios." *Earth's Future* 7 (5): 528–46. https://doi.org/10.1029/2018EF001020.

Ruan, Tiechao, Yan Yue, Wenting Lu, Ruixi Zhou, Tao Xiong, Yin Jiang, Junjie Ying, et al. 2023. "Association between low ambient temperature during pregnancy and adverse birth outcomes: A systematic review and meta-analysis." *Chinese Medical Journal* 10 (February):1097. https://doi.org/10.1097/CM9.0000000000002361.

Sanz-Barbero, Belén, Cristina Linares, Carmen Vives-Cases, José Luis González, Juan José López-Ossorio, and Julio Díaz. 2018. "Heat wave and the risk of intimate partner violence." *Science of The Total Environment* 644 (December):413–19. https://doi.org/10.1016/J.SCITOTENV.2018.06.368.

Sellers, Samuel, Kristie L. Ebi, and Jeremy Hess. 2019. "Climate change, human health, and social stability: Addressing interlinkages." *Environmental Health Perspectives* 127 (4): 45002. https://doi.org/10.1289/EHP4534.

Serdeczny, Olivia, Sophie Adams, Florent Baarsch, Dim Coumou, Alexander Robinson, William Hare, Michiel Schaeffer, Mahé Perrette, and Julia Reinhardt. 2017. "Climate change impacts in sub-Saharan Africa: from physical changes to their social repercussions." *Regional Environmental Change* 17 (6): 1585–1600. https://doi.org/10.1007/s10113-015-0910-2.

Shepherd, Andrew, Tom Mitchell, Kirsty Lewis, Amanda Lenhardt, Lindsey Jones, Lucy Scott, and Robert Muir-Wood. 2013. "The geography of poverty, disasters and climate extremes in 2030." https://odi.org/en/publications/the-geography-of-poverty-disasters-and-climate-extremes-in-2030/.

Son, Ji Young, Jia Coco Liu, and Michelle L. Bell. 2019. "Temperature-related mortality: A systematic review and investigation of effect modifiers." *Environmental Research Letters* 14 (7): 73004. https://doi.org/10.1088/1748-9326/ab1cdb.

Sorensen, Cecilia, Virginia Murray, Jay Lemery, and John Balbus. 2018. "Climate change and women's health: Impacts and policy directions." *PLOS Medicine* 15 (7): e1002603. https://doi.org/10.1371/journal.pmed.1002603.

Stavi, Ilan, Anastasia Paschalidou, Apostolos P. Kyriazopoulos, Rares Halbac-Cotoara-Zamfir, Si Mokrane Siad, Malgorzata Suska-Malawska, Dragisa Savic, et al. 2021. "Multidimensional food security nexus in drylands under the slow onset effects of climate change." *Land* 10 (12): 1350. https://doi.org/10.3390/land10121350.

Syed, Sarah, Tracey L. O'Sullivan, and Karen P. Phillips. 2022. "Extreme heat and pregnancy outcomes: A scoping review of the epidemiological evidence." *International Journal of Environmental Research and Public Health* 19 (4): 2412. https://doi.org/10.3390/ijerph19042412.

Thomas, Kimberley, R. Dean Hardy, Heather Lazrus, Michael Mendez, Ben Orlove, Isabel Rivera-Collazo, J. Timmons Roberts, Marcy Rockman, Benjamin P. Warner, and Robert Winthrop. 2019. "Explaining differential vulnerability to climate change: A social science review." *Wiley Interdisciplinary Reviews: Climate Change* 10 (2): e565. https://doi.org/10.1002/WCC.565.

Thurston, Alyssa Mari, Heidi Stöckl, and Meghna Ranganathan. 2021. "Natural hazards, disasters and violence against women and girls: A global mixed-methods systematic review." *BMJ Global Health* 6 (4): e004377. https://doi.org/10.1136/bmjgh-2020-004377.

Trinh, Trong-Anh, and Quanda Zhang. 2021. "Adverse shocks, household expenditure and child marriage: Evidence from India and Vietnam." *Empirical Economics* 61 (3): 1617–39. https://doi.org/10.1007/s00181-020-01907-2.

Tsaneva, Magda. 2020. "The effect of weather variability on child marriage in Bangladesh." *Journal of International Development* 32 (8): 1346–59. https://doi.org/10.1002/JID.3507.

United Nations (UN). 2019. World population prospects 2019. *Department of Economic and Social Affairs. World Population Prospects 2019.*

United Nations Environment Program (UNEP). 2011. "Livelihood security: climate change, migration and conflict in the Sahel." Nairobi. https://wedocs.unep.org/handle/20.500.11822/8032;jsessionid=A1647F87A7FF30A0E06F2EF28B2CA8F5.

Vaessen, Martin, Mamadou Thiam, and Thanh Lê. 2005. "The demographic and health surveys." In *Household Sample Surveys in Developing and Transition Countries*. New York: United Nations.

van Daalen, Kim Robin, Sarah Savić Kallesøe, Fiona Davey, Sara Dada, Laura Jung, Lucy Singh, Rita Issa, et al. 2022. "Extreme events and gender-based violence: A mixed-methods systematic review." *The Lancet Planetary Health* 6 (6): e504–23. https://doi.org/10.1016/S2542-5196(22)00088-2.

Warner, Koko, Kees Van Der Geest, Sönke Kreft, Saleemul Huq, Sven Harmeling, Koen Kusters, and Alex De Sherbinin. 2012. "Evidence from the frontlines of climate change: Loss and damage to communities despite coping and adaptation." *Loss and Damage in Vulnerable Countries Initiative. Policy Report. Report No. 9.* Bonn. https://i.unu.edu/media/ourworld.unu.edu-en/article/8283/LossDamage_Vol1.pdf.

World Economic Forum (2022). *Global gender gap report 2022*. Available at https://www.weforum.org/publications/global-gender-gap-report-2022/.

World Health Organization (2021). *Violence against women prevalence estimates, 2018: Global, regional and national prevalence estimates for intimate partner violence against women and global and regional prevalence estimates for non-partner sexual violence against women.*

World Meteorological Organization (2021). *State of the climate in Africa 2020*. Available at https://library.wmo.int/records/item/57682-state-of-the-climate-in-africa-2020.

Further materials

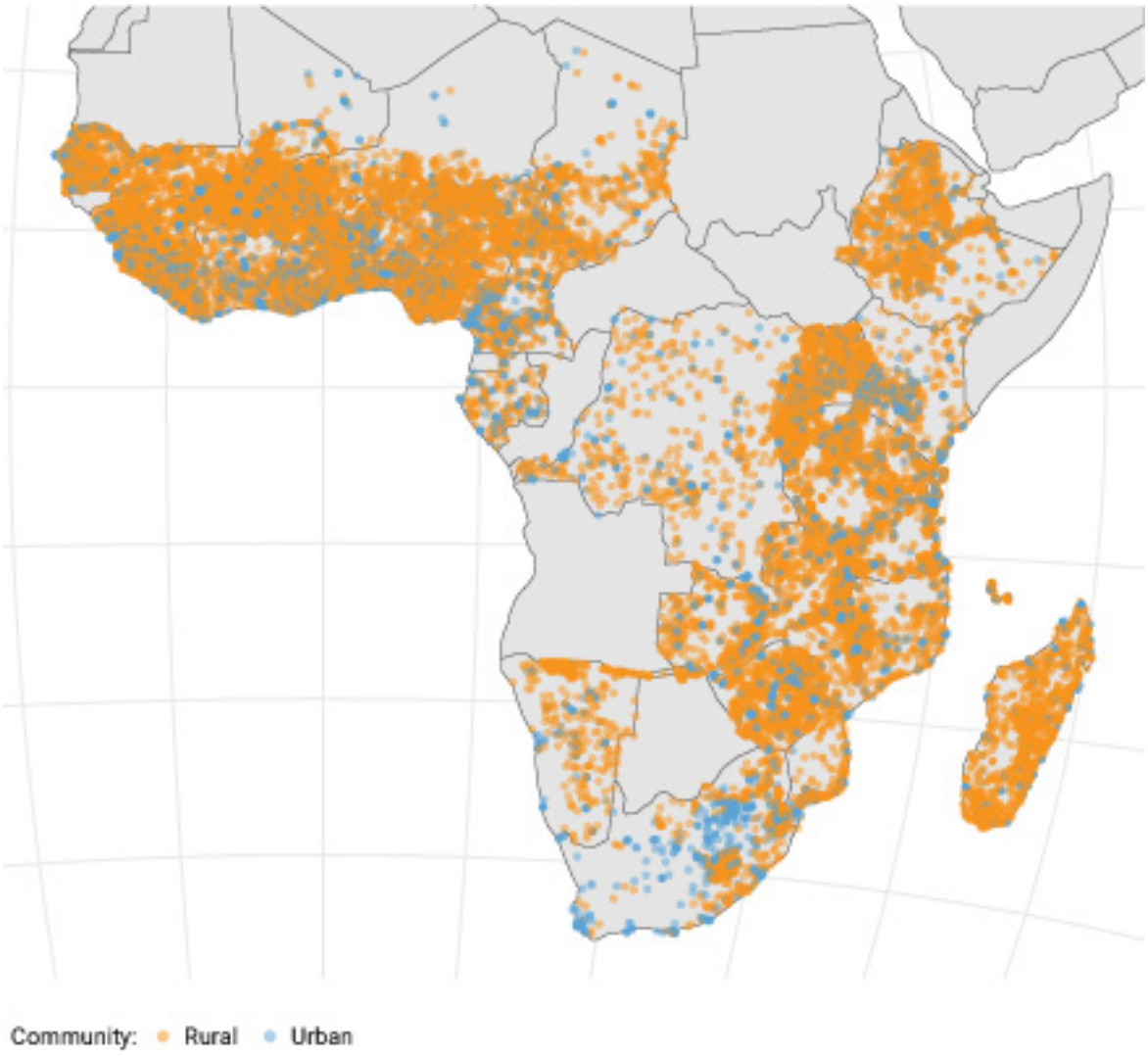


FIGURE A1: *Map of cluster centroids in sub-Saharan Africa by settlement type. The location of rural clusters (turquoise) is shifted by up to 10km, the location of urban clusters (red) up to 5km.*

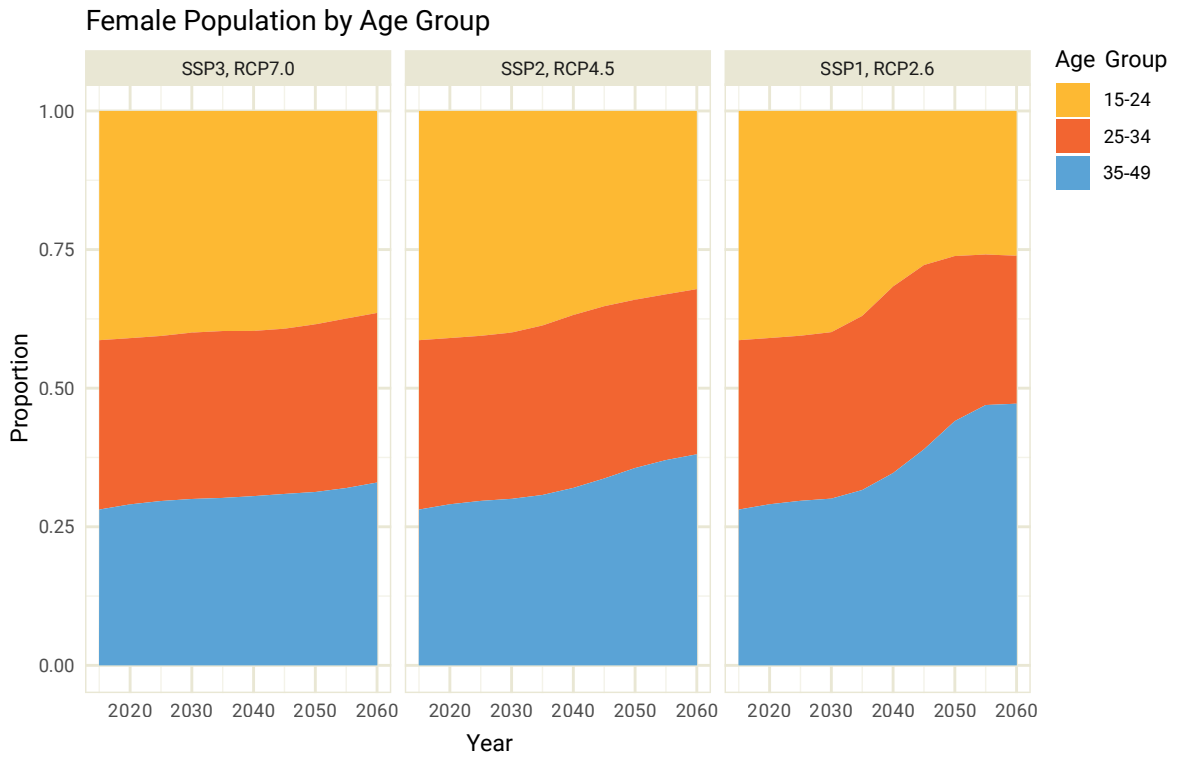


FIGURE A2: *Proportion of women in sub-Saharan Africa by age group (15 to 24, 25 to 34, 35 to 49 years) under three different socioeconomic scenarios (SSP1, SSP2, SSP3), 2015–2060*

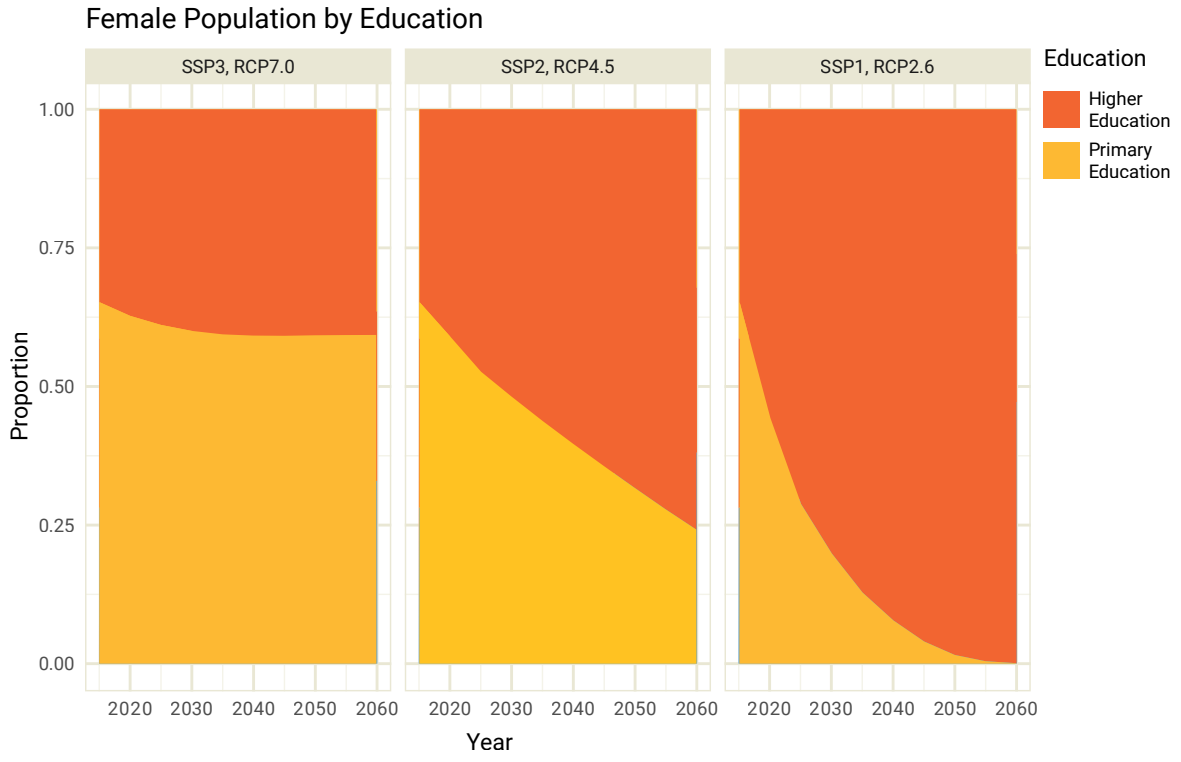
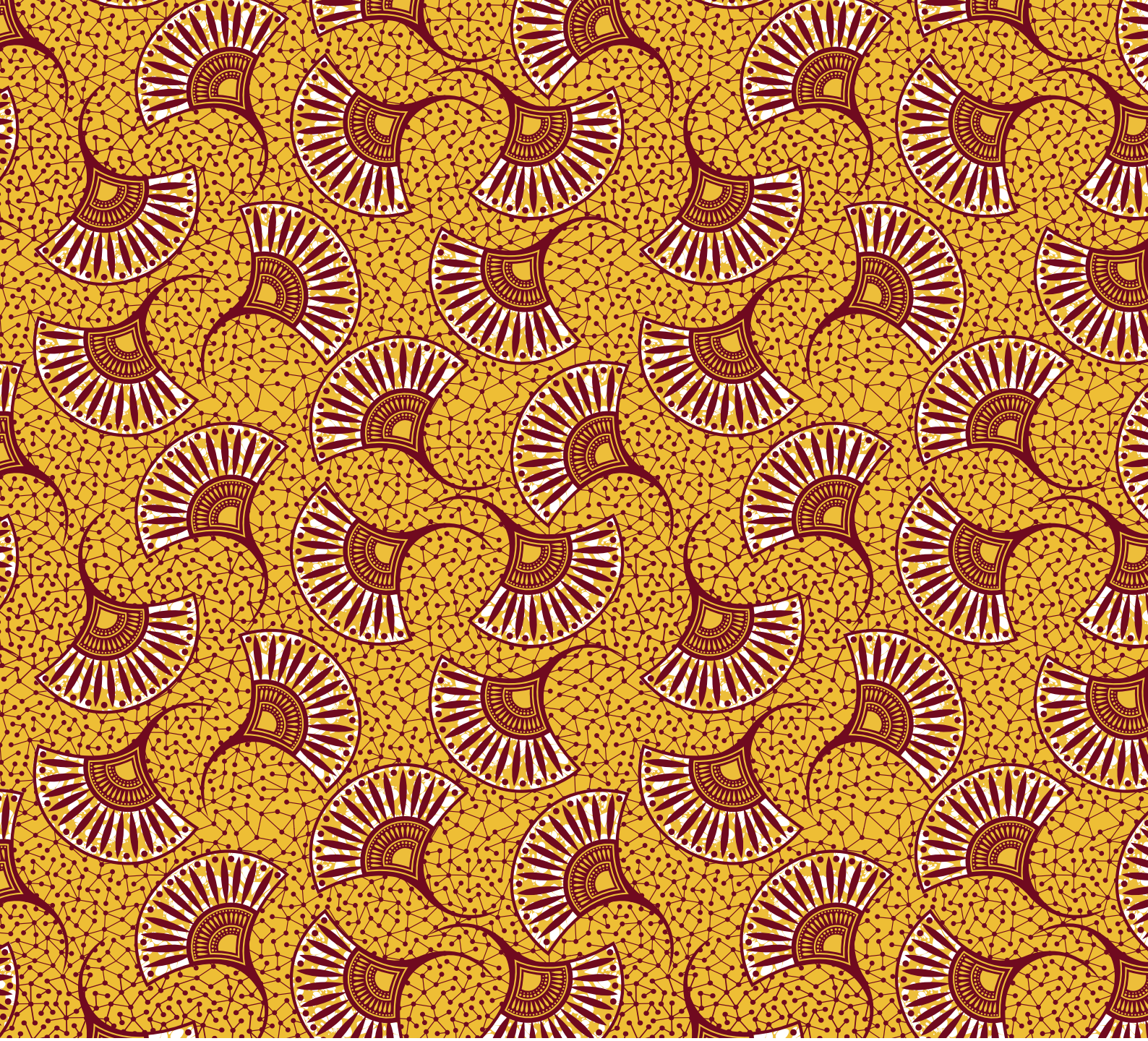


FIGURE A3: *Proportion of women in sub-Saharan Africa by level of education under three different socioeconomic scenarios (SSP1, SSP2, SSP3), 2015–2060*



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