

Gendered Impacts of Climate Change

Evidence from Weather Shocks

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WORLD BANK GROUP

Gender Global Theme

May 2023

Abstract

Climate change is one of the defining challenges of our time. While the impacts of climate change on people's well-being can hardly be denied, it may not be as obvious that the impacts could differ by gender. However, as the COVID-19 pandemic has shown, a shock can impact men and women differently due to social norms and pre-existing gender differences. This paper reviews the economic literature linking weather shocks (such as floods, droughts, and extreme temperatures, among others) and a large range of outcomes (from endowments to economic opportunities and agency). Men and women indeed have specific vulnerabilities and exposures. Specific physiological vulnerabilities are relatively minor: boys are more vulnerable

to shocks in utero and girls and women to heat. The biggest gendered impacts are due to existing gaps and social responses to shocks. In places with strong boy preferences, families facing scarcity due to disasters are more likely to give food and other resources to boys, take their daughters out of school or marry them young, or withdraw women from agricultural work so they focus on household chores. During or after weather shocks, boys can also be taken out of schools to be put at work and men working in agriculture are often forced to migrate to find alternative sources of income. Unless climate policy acknowledges and accounts for these differences, climate change will remain an amplifier of existing gender inequalities.

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JEL: J16, O15, Q54

Keywords: climate change, gender, health, education, livelihoods, agency, vulnerability, shocks

* Broccolini, Coelho, Fruttero, Halim and Muller: The World Bank; Gninafon: Université Laval. We thank Hana Brix, Andrea Kucey, and Laura Rawlings for their guidance; Anne Kuriakose, Ezgi Canpolat, Ana Gren, Miriam Muller, Elizaveta Perova, Luca Tiberti, Julia Vaillant, and Andrea Woodhouse for their comments and insights. Horace Gninafon acknowledges financial support from the World Bank Group Africa Fellowship Program.
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1. Introduction

Climate change is a global challenge, but its effects are not evenly distributed. Extreme weather events, such as droughts, floods, hurricanes, and heavy rainfall are becoming more common and severe, causing significant social and economic consequences. Between 2000 and 2019, temperature-related excess deaths ranged from 34 per 100,000 in Latin America and the Caribbean to 139 in Eastern Europe (Zhao et al. 2021). Most reported deaths from weather, climate, and water extremes occurred in developing countries between 1970 and 2019 (WMO 2021), and poor countries are in hotspot regions of increasing temperature variability (Bathiany et al. 2018). Within countries, poor individuals tend to live in areas with greater exposure to weather and climate shocks, to work in occupations more vulnerable to them, and to have less ability to adapt. In fact, most projections indicate that climate change will push an additional 32 million to 132 million people into extreme poverty by 2030 (Jafino et al. 2020).

The impact of climate change on men and women is expected to be different. Large scale weather shocks disrupt critical services such water, sanitation, and energy supply as well as damage dwellings. These require households to spend more time on domestic activities. At the same time, households need to allocate more time to income-generating activities to compensate for the losses. Persistent gender gaps exacerbate women's exposure to shocks and limit their ability to adapt. Women's significantly lower labor force participation and wages, their high representation in the agriculture and informal sector, limited land ownership,¹ unequal access to off-farm work opportunities, restricted access to credit, higher burden of caring for family members and fulfilling domestic roles, and other restrictive social norms in many countries could increase their exposure and vulnerability and reduce their ability to mitigate the negative impacts of climate change (Deere and Doss 2006; FAO 2011; Doss et al. 2018; Eastin 2018). Additionally, some physiological reactions to the manifestations of climate change may differ across genders. The COVID-19 pandemic serves as a clear example of gendered impacts in the face of a global crisis. Men have been more vulnerable to the virus, with higher mortality rates and COVID-19 diagnoses (de Paz Nieves, Gaddis, and Muller 2021), while women have disproportionately experienced the

¹ In Africa, for example, women are responsible for 50-80 percent of agricultural production but hold title to less than 20 percent of all agricultural land (FAO 2011).

economic consequences of the pandemic in terms of employment, unpaid care work, and gender-based violence (Flor et al. 2022).

In this paper, we examine the evidence on the gender-differentiated impacts of weather shocks to understand the potential gendered effect of climate change on a range of outcomes, organized around three areas covered by the World Bank Gender Strategy 2016-23: endowments (health and education), economic opportunities (combining access to jobs and assets as well as a broader view on aspects that affect economic opportunities), and agency (gender-based violence and early marriage). While we included some relevant studies from high-income countries, our focus is mainly on causal economics studies on low- and middle-income countries where the consequences of climate shocks are more severe. We conducted a search for studies on Google Scholar using keywords such as “causal impact of climate change on gender” and “gender impact of climate change” and combined these with other keywords such as “employment”, “education”, and “agency”. We ensured the relevance of the studies by reading them and identifying other relevant studies that are cited in them. Annex Table A.1 lists and summarizes all the papers cited in this literature review. Table 1 summarizes the differentiated impacts of weather shocks on men and women. Due to their past exposure to shocks and data availability, some regions and countries, such as India and Indonesia, have higher representation. Our study adds a gender lens to previous research that examined the impacts of weather events on a range of economic outcomes without a gender focus (Dell, Jones, and Olken 2014), and extends policy work on the topic (Erman et al. 2021) by providing more studies and details.

Girls and women are particularly vulnerable to the social responses triggered by weather shocks, especially in places where they face restrictive gender norms. For example, droughts can result in reduced resources that can lead to sex-selective abortions, malnutrition, and neglect of girls due to son preference. Thus, weather shocks have been associated with girls’ higher mortality (Flatø and Kotsadam 2014; Anttila-Hughes and Hsiang 2013; Haile, Tirivayi, and Nillesen 2019; Chatterjee and Merfeld 2021), poorer health (Hoddinott and Kinsey 2000; Rocha and Soares 2015; Thiede and Gray 2020), and higher school dropouts to care for household chores or early marriage (Björkman-Nyqvist 2013; Bau et al. 2020; Dasgupta and Karandikar 2021; Dessy, Tiberti, and Zoundi 2023). In adulthood, weather shocks can force agricultural households to withdraw women from work, leading to more childbearing and household work as they are less likely to migrate to find employment to overcome losses from lower agricultural yields (Dessy et al. 2020, Afridi et

al. 2021; Chowdhury, Parida, and Agarwal 2022). It can also lead to other practices that harm their agency and physical integrity: in some places weather shocks have led to polygynous marriages, known to hamper women's health and increase violence against them (Dessy et al. 2021), and "witch hunting" (Miguel 2005). While asset ownership, such as land and livestock, can provide protection against weather shocks (de la Fuente 2007), there is strong evidence of gender bias against women in asset ownership. Men often own more land and livestock, which makes women more vulnerable to the adverse effects of weather shocks (Deere and Leon 2003; Dillon and Quiñones 2010; Lee et al. 2021). However, in contexts with milder gender bias at an early age, the adverse impact of weather shocks are less severe (Carrillo 2020). Women's specific physiological vulnerabilities, such as their body temperature regulation system, also increase their mortality risks in hotter temperatures (Achebak, Devolder, and Ballester 2019; Singh et al. 2019; Ellena et al. 2020). In addition, girls may learn less in some hot places (Dapi et al. 2010; Vu 2021).

Boys and men also have particular vulnerabilities to weather shocks. Male fetuses are less resilient and adaptive to stress compared to female fetuses (DiPietro and Voegtline 2017; Walsh et al. 2019). Boys are more likely to dropout from school (Carrillo 2020), while men are more likely to suffer physical and mental disabilities when affected by droughts or flood in early age (Dinkelman 2017; Carrillo 2020). Extreme rainfall can also lead to increased labor for boys in agricultural activities (Trinh, Posso, and Feeny 2020) and weather shocks also can cause men working in agriculture to migrate more than women (Dillon et al. 2011; Gray and Mueller 2012; Mueller, Gray, and Kosec 2014; Bohra-Mishra et al. 2017; Anglewicz and Myroniuk 2018). Boys do not seem to benefit in terms of education and health in the long term as much as girls from better harvests (Maccini and Yang 2009; Tiwari, Jacoby, and Skoufias 2017). In general, while boys and men are negatively affected by weather shocks in most studies, their impacts tend to be relatively less severe than those on girls and women.

There are domains in which no clear gender differences are found following weather shocks. This includes direct fatalities from disasters, as well as education and cognitive and socioemotional development. Boys and girls appear to be similarly affected in their cognitive and socioemotional development following weather shocks (Shah and Steinberg 2017; Andrabi, Daniels, and Das 2021; Chang, Favara, and Novella 2022). Both boys and girls can also be taken out of school to be put at work (Bau et al. 2020; Trinh, Posso, and Feeny 2020). It is worth noting that even in domains

where either men or women tend to be more affected, some studies find no significant gender differences. For example, there were no gender differences in impacts on nutrition in Nigeria (Rabassa, Skoufias, and Jacoby 2014) and 18 Sub-Saharan African countries (Thiede and Strube 2020), as well as on school attendance in Madagascar (Marchetta, Sahn, and Tiberti 2019) and Nepal (Tiwari, Jacoby, and Skoufias 2017).

Table 1. Summary of gendered impacts of weather shocks on endowments, economic opportunities, and agency across contexts

	Higher impacts on girls and women	Similar impacts on both genders	Higher impacts on boys and men
Endowments			
Mortality	<ul style="list-style-type: none"> • Higher risk of death from heat due to body temperature regulation (Italy [Ellena et al. 2020], Spain [Achebak et al. 2019]) • Droughts led to higher girl mortality in subsequent years in places with son preference and other gender biases, sometimes due to through postnatal neglect or prenatal sex-selective abortions (India [Chatterjee and Merfeld 2021], Philippines [Anttila-Hughes and Hsiang 2013]) • Rainfall can reduce women suicide (Indonesia [Christian et al. 2019]), but too low or too high rainfall can generate depression 	<p>No clear gender differences in direct fatalities of disasters (e.g. United States [Jonkman et al. 2009], Fiji [Yeo and Blong 2010])</p>	
Other health outcomes	<ul style="list-style-type: none"> • Rainfall in early life can reduce weight and height in childhood due to diseases, but increase health, weight, and height when women are adults (Indonesia [Maccini and Yang 2009], Nepal [13]). • Droughts can reduce girl's weight-for-height (Indonesia [Thiede and Gray 2020]). • Droughts can increase the fertility of young women living in agricultural households by reducing the value of their labor (Madagascar [Dessy et al. 2020]) 	<p>No difference in nutrition due to weather shock in Nigeria [Rabassa et al. 2014]</p>	<p>Droughts can reduce height-for-age for boys (Indonesia [Thiede and Gray 2020]) and increase physical and mental disability for men (Colombia [Carrillo 2020], South Africa [Dinkelman 2017])</p>
Schooling	<ul style="list-style-type: none"> • Rainfall can lead to higher girl's schooling (Indonesia [Maccini and Yang 2009]), but also less probability to be at school and more to work in places with high child labor (India [Bau et al. 2020]). • Droughts can increase girls' dropout (Uganda [Björkman-Nyqvist 2013]), especially in patrilocal households (Malawi and Indonesia [Dessy et al. 2023]) 	<ul style="list-style-type: none"> • Sometimes the negative impact of weather shocks on schooling has no difference in school for both gender (India [Shah and Steinberg 2017], Madagascar [Marchetta et al. 2019]). • Earthquake and typhoons do not affect schooling differently across gender (Pakistan [Andrabi et al. 2021], Philippines [Deuchert and Felfe 2015]) 	<p>Rainfall can lead to more schooling decline for men (Colombia [Carrillo 2020], Vietnam [Trinh et al. 2020])</p>

	Higher impacts on girls and women	Similar impacts on both genders	Higher impacts on boys and men
Test scores and cognitive and socioemotional development	More negative impacts of weather shocks and heat for girls in Brazil [Branco and Feres 2018], Colombia [28], India [Dasgupta and Karandikar 2021], and Uganda [Björkman-Nyqvist 2013])	Similar negative impacts of weather shocks and heat for both gender in India [Shah and Steinberg 2017: Chang et al. 2022], Madagascar [Marchetta et al. 2019], and Pakistan [Andrabi et al. 2021])	
Child labor	Can increase girls' non-agricultural activities and housework (Ethiopia [Haile et al. 2019], Vietnam [Trinh et al. 2020]) and income-generating and non-income-generating work (India [Bau et al. 2020])		Weather shocks can lead boys to work more (Colombia [Carrillo 2020], Vietnam [Trinh et al. 2020])
Economic opportunities			
Employment	Weather shocks in early age or as an adult reduce women's employment and employment in more stable jobs (Colombia [Carrillo 2020], India [Afridi et al. 2021: Chowdhury et al. 2022], Vietnam [Feeny et al. 2021]), often due to increasing domestic work after shock (India [Maitra and Tagat 2019], Tanzania [Lee et al. 2021])		Weather shocks tend to raise men's employment in the non-agricultural sector. Income shocks from weather shocks and social norms lead men tend to migrate more than women (Ethiopia [Gray and Mueller 2012], Malawi [Anglewicz and Myroniuk 2018], Nigeria [Dillon et al. 2011], Pakistan [Mueller et al. 2014], Philippines [Bohra-Mishra et al. 2017], Madagascar [Marchetta et al. 2021])
Income and consumption	Rainfall can be beneficial for women: rainfall when infant raise assets when adults, likely because of better nutrition (Indonesia [Maccini and Yang 2009]), and rainfall for rice-area workers can mean higher wages (India [Mahajan 2017]). But women suffer more from droughts (India [Carpenna 2019])		
Assets	Women have much less land and livestock than men (Latin America [Deere and Leon 2003], Nigeria [Dillon and Quiñones 2010], Tanzania [Lee et al. 2021]), thus have less capacity to cope with weather shocks		
Agency			
Gender-based violence	<ul style="list-style-type: none"> • Higher violence against women following disasters and income shocks (Tanzania [Miguel 2005]) • No association between drought and IPV (SSA [Cool et al. 2020]) • Positive association between droughts and IPV, with larger positive associations among adolescent girls and unemployed women (SSA [Epstein et all 2020]) 		
Legal barriers	Higher vulnerability to shocks given higher legal challenges for women to inherit and own land in some contexts (Deere and Leon 2003; Dillon and Quiñones 2010; Lee et al. 2021)		

	Higher impacts on girls and women	Similar impacts on both genders	Higher impacts on boys and men
Marriage practices	Polygyny, harmful for women's bargaining power and vulnerability to domestic violence, are used as mitigation strategy against weather shock impacts on crop fields (through higher fertility) in some contexts (e.g. Mali [Dessy et al. 2021])		

The paper is organized as follows: Sections 2 looks at the impacts on endowments; section 3 at the impacts on economic opportunities, and section 4 at the impacts on agency. Section 5 concludes.

2. Endowments

2.1. Health

There is some evidence of gender differences in mortality during hurricanes and floods, but there is no clear pattern. For example, during the 2012 hurricane Sandy, men had higher mortality rates in the United States and Canada (2:1), although mortality in men was not as high in the Caribbean (1.4:1) (Diakakis et al. 2015). Men also had higher mortality rates during the 1998 Hurricane Mitch in Central America (Bradshaw 2004) and floods killed more men than women in Portugal and Greece in 1960-2010 (Pereira et al. 2017). However, the 2005 Hurricane Katrina in the United States and the 1931 Hurricane in Fiji resulted in similar numbers of male and female fatalities (Jonkman et al. 2009; Yeo and Blong 2010). Differential mortality levels might be linked to men being more likely to engage in outdoor activities during these events.

Men and women also have some physiological differences that can affect their sensitivity to extreme heat and cold, which can impact their mortality. For example, between the 1980s and late 2010s, women were more likely to be at risk of death from cardiovascular diseases or have higher mortality risk in hot temperatures in Spain (Achebak, Devolder, and Ballester 2019) and Italy (Ellena et al. 2020), possibly due to physiological characteristics in body temperature regulation. Pregnant women are also more vulnerable to extreme heat in the United States, with exposure increasing the risk of maternal hospitalization during first trimester pregnancy for potentially life-threatening causes, especially for women residing in historically cooler countries (Kim, Lee, and Rossin-Slater 2021). In India, heat waves also posed a higher mortality risk for women and children between the 2000s and 2010s, particularly in heavily polluted areas (Singh et al. 2019).

However, in other parts of India during the 2000s, men were more at risk than women under hot and cold conditions (Ingole et al. 2022), possibly due to their engagement in outdoor activities.

Droughts have been found to have a stronger impact on the mortality rates of girls than boys in places with son preference and other gender biases, especially in poorer households. This trend has been observed in Sub-Saharan African countries, where droughts have led to higher infant mortality for girls than for boys, with 12 more deaths of infant girls per 1000 births following droughts. These impacts were only observed in areas with higher levels of son preference and lower desired fertility rates (Flatø and Kotsadam 2014). In the Philippines, child mortality due to typhoons a year after the disaster tends to be concentrated among girls and families with numerous children, with mortality rates highest in households where infant daughters face competition for resources, particularly if siblings are boys (Anttila-Hughes and Hsiang 2013). The pattern of deteriorating economic opportunities and disinvestments in human capital correlating with female infant mortality in the year following the typhoon suggests that this excess mortality is due to household decisions made while coping with post-disaster economic opportunities. In 141 countries during the 1980s and 1990s, natural disasters, including droughts, floods, earthquakes, and epidemics were found to be correlated with lower life expectancy in women than men, especially in countries with a low index of socioeconomic status for women (Neumayer and Plumper 2007). In Brazil, where gender bias at early ages is not considered a significant problem, rainfall fluctuations have had similar impacts on boys' and girls' mortality (Rocha and Soares 2015).

Droughts can have harmful consequences for women's and men's health. In Zimbabwe, they reduced women's body mass index but not men's (Hoddinott and Kinsey 2000). In Indonesia, monsoon delays resulted in a significant decrease in weight-for-height, indicating worse short-term nutrition, with girls particularly affected. However, the decline in height-for-age, indicating long-term nutrition, was much smaller, and boys were more affected (Thiede and Gray 2020). In Rwanda, only girls were negatively affected by crop failures, especially in poor households (Akresh, Verwimp, and Bundervoet 2011). In Brazil, rainfall fluctuations had a greater impact on girls' birth weight than on boys', although the impact on gestational length were similar across genders (Rocha and Soares 2015). Studies in Nigeria (Rabassa, Skoufias, and Jacoby 2014) and in 18 Sub-Saharan African countries (Thiede and Strube 2020) found no gender inequalities in health outcomes because of weather shocks.

Rainfalls are found to have long term benefits for women, partly because they lead to better harvests. In Indonesia, women who experienced a positive weather shock around the time of their birth reported better health and were taller as adults, while no difference was reported by men. The strong relationship found between birth year rainfall and adult height suggests that nutrition in infancy varies with early-life rainfall, especially for girls, as rainfall's effects on crop output—and thus household income and food availability—lead to variations in parents' abilities to provide nutrition, medical inputs, and generally the nurturing environments for infant girls (Maccini and Yang 2009). In Nepal, increased rainfall led to lower weight and height in the short term due to more diseases but had a positive effect in the medium run due to the favorable economic opportunities from better harvests during wet years. No significant differences between boys and girls were detected (Tiwari, Jacoby, and Skoufias 2017).

Due to their higher sensibility to shocks in uterus, boys may develop more disabilities due to weather shocks. In South Africa, droughts in early life led to an increase in physical and mental disabilities, particularly in men (Dinkelman 2017). Similarly, in Colombia, higher prenatal floods were associated with an increase in mental disability rates in adults aged 25-65 in 2005, with a greater impact on men (Carrillo 2020).

In addition, women in many countries often bear the responsibility of collecting water, food, and firewood, which can increase their exposure to diseases such as malaria from contaminated water sources following extreme weather shocks. This has been observed in Cambodia, South Africa, and Nigeria, as highlighted by studies conducted by Davies et al. (2015), Meyiwa et al. (2014), and Adebola (2021), respectively.

Lastly, weather shocks can also lead to increased childbearing among women as the value of their agricultural labor lowers during droughts. In Madagascar, higher fertility in young women living in agricultural households was observed even four years after a drought occurred in the agricultural season (Dessy et al. 2020). The drought did not affect marriage timing but mainly reduced the number of women's working hours and their agricultural income. The drought had no effect on the fertility of young women living in non-agricultural households or non-agrarian communities, nor did it impact fertility if it occurred during the non-agricultural season. These findings suggest that droughts, by reducing the value of women's agricultural labor, lowered the marginal cost of a child, thus increasing fertility.

2.2. Education

Schooling

The impact of weather shocks on female dropouts during childhood and adolescence depends on several factors, including gender bias and child labor. In Indonesia, positive rainfall shocks increased female schooling completion but had no effect on male (Maccini and Yang 2009). In Uganda, decreased rainfall had no effect on boys' and young girls' schooling, but it permanently increased primary school dropouts among girls (Björkman-Nyqvist 2013). In Malawi and Indonesia, where both matrilineal and patrilineal post-marriage residence customs² exist, patrilineal households tend to prioritize sons' education over daughters' during droughts if schooling requires fees, while matrilineal households do not (Dessy, Tiberti, and Zoundi 2023). In Colombia, where there is no known gender bias at early ages, higher prenatal floods led to a decline in years of schooling for both genders, but especially for men (Carrillo 2020). In Madagascar, both girls and boys experienced similar adverse effects on school attendance due to droughts and cyclones (Marchetta, Sahn, and Tiberti 2019).

In settings where households lack formal mechanisms to cope with income shocks, such as climate shocks, families may face different opportunity costs for enrolling or promoting their children's education. For example, extreme rainfall in Vietnam increased the likelihood of boys engaging in agricultural activities more than girls (Trinh, Posso, and Feeny 2020). In addition, income stress caused by these climate events is positively associated with changes in the number of hours of domestic work for girls. This evidence is consistent with findings from Ethiopia, where girls were less likely to engage in agricultural activities than boys during a drought, suggesting that climate shocks have increased girls' engagement in non-agricultural activities relative to boys (Haile, Tirivayi, and Nillesen 2019).

In Indian districts with high prevalence of child labor, extreme rainfall during early life significantly increased girls' likelihood of working and decreased their likelihood of attending school, while outcomes for oldest sons remain relatively protected from the shock (Bau et al. 2020). This effect persisted across generations, with children of household heads who were

² These marriage customs prescribe whether daughters [matrilocal] or sons [patrilocal] co-reside with their parents after marriage, eventually becoming their source of old-age support

exposed to extreme rainfall early in life being more likely to work and less likely to attend school. In India, gender norms that favor higher labor participation of females led to worse schooling outcomes after rainfall shocks (Dasgupta and Karandikar 2021), while in districts where norms did not favor higher female labor force participation, rainfall shocks affected scores of male and female children to a similar extent. In contrast, where norms favored female work, female children were more affected by rainfall shocks and had a higher likelihood of dropping out of school — which improved considerably under a positive rainfall shock. Thus, the trade-off between schooling and productive work is stronger in settings that are more gender-equal in the labor market norms. Yet, another study in India found that rainfall shocks had different effects in schooling depending on the age of the children but did not detect any difference between males and female (Shah and Steinberg 2017). Similarly, for a study in Indonesia that found that monsoon delays increased child labor among children aged 10-14 years, but no evidence of a gender difference (Korkeala 2012). These findings suggest that the impact of climate shocks on child labor may not always favor one gender over the other, and that the impact may depend on various factors such as the type of work and the cultural context.

Test scores and cognitive and socioemotional development

Overall, research suggests that weather events have similar impact on boys' and girls' test scores and cognitive and socioemotional skills. However, there are some variations depending on the specific weather and context. For instance, exposure to droughts in utero in India was found to reduce socioemotional skills for both boys and girls at age 15, but it primarily reduced cognitive skills in boys at age 5 and age 15 (Chang, Favara, and Novella 2022). In contrast, positive rainfall shocks in India had a positive effect on math and reading scores if they occurred before age 2, with no gender differences (Shah and Steinberg 2017). In India, droughts negatively affected girls in reading and math compared to boys of the same age (Dasgupta and Karandikar 2021). Similarly, the impacts of droughts and cyclones in Madagascar (Marchetta, Sahn, and Tiberti 2019) and an earthquake in Pakistan (Andrabi, Daniels, and Das 2021) had negative impacts on test scores for boys and girls. In Kenya, early-life exposure to droughts negatively affected cognitive development for young adolescents, regardless of gender (Nübler et al. 2021). However, in some contexts, weather shocks had a larger impact on girls. For example, higher prenatal floods were associated with a larger increase in illiteracy rates, for women compared to men (Carrillo 2020), and, in Uganda, lower rainfall reduced girls' test scores but not boys' (Björkman-Nyqvist 2013).

In Brazil, droughts affected the school performance of girls more than boys in rural northeast municipalities (Branco and Feres 2018). Typhoon Mike in the Philippines had a greater impact on girls' highest-grade completion 2 and 4 years after the disaster, but the impact was similar to boys' 12 and 15 years after (Deuchert and Felfe 2015).

Whether heat affects student learning differently for boys and girls remains unclear. A study conducted in 58 countries found that hot school days reduced learning (Park et al. 2021), but few studies examine gender differences and even fewer find statistically significant gender differences. In the United States, no heterogeneity by gender was found (Park, Goodman, and Behrer 2020), while in Vietnam, the negative effect of heat on student learning was more pronounced among girls than boys, possibly due to nutrition intake and heat compensation (Vu 2021). In Cameroon, the more adverse effect of heat on learning in girls than boys was hypothesized to be associated with boys' ability to compensate and prevent heat, influenced by social norms (Dapi et al. 2010).

3. Impacts on economic opportunities

Employment

Exposure to droughts, extreme rainfalls, and floods in early life can have negative impacts on women's employment, especially in households where parents have lower levels of education. In Colombia, higher prenatal floods were associated with a greater reduction in the likelihood of women working compared to men (Carrillo 2020). Similarly, in India, droughts between 2010-14 resulted in a greater reduction in the likelihood of employment and workdays for women compared to men. Men increased their workdays in non-farm work, while women did not, likely due to higher burden of domestic work for women and restrictions imposed by rigid social norms that limit women's ability to find work outside their place of living (Afridi et al. 2021). Floods in 15 major states in India between 1983 and 2011 also led to a decrease in women's rural agricultural employment, while men's employment in the non-agricultural sector increased. This disparity may be due to cultural norms and women's lower levels of education (Chowdhury, Parida, and Agarwal 2022). In India, women and men also tend to respond differently to rainfall shocks. During adverse rainfall shocks, women are more likely to be casual wage earners, while men are more likely to do regular wage work (Maitra and Tagat 2019). However, during positive rainfall shocks, men are more likely to shift their time to casual wage work, while women are more likely to do housework.

In some cases, climate shocks have resulted in an increase in women's agricultural work. A study on 31 African countries found that climate shocks can reduce the number of hours worked by individuals in the agriculture sector. However, the impact on men and women can differ depending on the type of shock and the sector of activity. For instance, droughts had a similar effect on men's and women's work hours, regardless of their sector of activity. But heat waves and floods increased the number of hours women worked in the agricultural sector compared to men, and led to the opposite effect in the non-agriculture sector (Nico and Azzarri 2022). In Tanzania, during the maize-growing season, men reduced family labor under heat stress, but women increased their family labor when they were the only head of the household (Lee et al. 2021).

Women's reliance on agricultural work can lead them to choose different crops. In Uganda, where men and women cultivate separate plots of land, during a drought women diversify to more risky, commercial crops and away from subsistence farming while men allocate more time to off-farm labor employment, indicating that women may be more vulnerable to the impacts of climate change and may adapt differently than men (Agamile et al. 2021).

Climate-related shocks may also have delayed effects on employment outcomes through the accumulation of human capital. In Vietnam, exposure to extreme rainfall during in-utero development and up to age 4 reduced the probability of having formal employment for women, with education and the age at which children experience the shock influencing the outcome. Exposure to shocks at ages one and two had the largest gender differentiated impact on formal sector employment outcomes in adulthood (Feeny et al. 2021). This suggests that the impacts of climate-related shocks on employment outcomes may be complex and long-lasting, and that interventions to mitigate these impacts may need to consider the specific vulnerabilities and needs of different groups.

Migration can be one mechanism for households to cope with income shocks resulting from weather shocks in the agricultural sector, with men likely to migrate more than women due to social norms in many countries. For instance, heat, typhoons, and rainfall increased men's outmigration relative to women's in the Philippines (Bohra-Mishra et al. 2017). In Malawi, exposure to multiple shocks such as damage to houses due to fire, flood, or other unexpected events increased men's migration relative to women's in 2010 (Anglewicz and Myroniuk 2018). Droughts have been found to increase rural-urban migration and international migration in Mali (Defrance,

Delesalle, and Gubert 2020), while in Ethiopia they have been found to increase men migration to find employment and to reduce the likelihood of women to get married (Gray and Mueller 2012). Similarly, they have been found to increase men's likelihood to migrate but to deter migration of young women in Madagascar (Marchetta et al. 2021). In Nigeria, temperature increases have been found to lead to more men's migration (Dillon et al. 2011).

Climate shocks can limit migration in contexts where households face budget constraints that hinder their ability to move to areas with better job opportunities. For example, in Tanzania, rising temperatures did not affect women's migration, but reduced men's migration (Hirvonen 2016). In Côte d'Ivoire and seven West African migrant-sending countries (Benin, Burkina Faso, Guinea-Bissau, Mali, Niger, Senegal, and Togo), women's labor has been found to be a critical coping strategy for migrant households facing negative political or climate shocks such as drought, floods, landslides, and armed conflict (Elmallakh and Wodon 2021). In Pakistan, positive rainfall shocks generally do not affect the mobility of men and women, but high temperatures are more likely to encourage men to migrate to find employment than women in response to adverse income shocks caused by heat stress (Mueller, Gray, and Kosec 2014). Finally, in Nepal, the 2015 earthquakes reduced the number of international migration work permits issued to men but not women living in the affected districts (Shakya, Basnet, and Paudel 2022).

Assets, income, and consumption

Asset ownership is crucial in providing protection against shocks, as it can offer alternative coping mechanisms in the absence of insurance markets. Assets such as land and livestock can provide income-enhancing productivity and can be used to counterbalance short term effects, for example by sacrificing livestock for consumption or selling them to purchase grains (de la Fuente 2007), even though they are not always used to for this purpose.³ The use of assets to cope with shocks depends on their distribution before the event and the ability of households to find other income sources.

³ For example, during the droughts of the 1980s in Burkina Faso, less than a third of the crop income shortfall was compensated through livestock sales, which was a relatively small amount given the widespread famine caused by the drought (Fafchamps et al. 1998). The relatively small consumption smoothing observed may be explained by households intentionally reducing consumption to conserve livestock, which contradicts simple optimal saving theories (Kazianga and Udry 2006).

In Indonesia, experiencing a positive shock in infancy resulted in women living in households with higher socioeconomic status as an adult while it had no significant impact on men. The positive impact of rainfall on agricultural output leads to higher household incomes and better health for infant girls. Eventual benefits for adult women's socioeconomic status appear to be mediated strongly by improved schooling attainment (Maccini and Yang 2009). In South Africa, weather variability leading to crop failure disproportionately impacted female-headed households, which tend to rely on a single income earner, resulting in lower per capita consumption compared to male-headed households (Tibesigwa et al. 2015). On the other hand, temperature increase had no effect on food security regardless of the gender of the head of the household (Tibesigwa and Visser 2016). In India, extreme rainfall increased the wages of both men and women. However, relative wages of women in rice-growing areas were affected differently by droughts and extreme rainfall. Droughts increased relative women's wages, while extreme rainfall reduced them, possibly due to the increased demands of their work in these conditions (Mahajan 2017). Female-headed households in India also experienced reduced fat consumption, including cooking oils and meat consumption, during drought periods compared to male-headed families (Carpena 2019).

There is strong evidence of gender bias against women in assets ownership, which limits their ability to adapt to climate shocks. For example, in Tanzania, female-only households have on average half the land area and almost five times less livestock ownership compared to dual-adult households (Lee et al. 2021). In Nigeria, men own more livestock and land, and this gender asset inequality is passed down over generations, with initial endowments of men having a greater positive impact on future livestock holding compared to women (Dillon and Quiñones 2010). In Latin America, gender inequality in land ownership is often attributed to male preferences in inheritance, marriage, and land distribution, as well as difficulties for women in obtaining credit and labor in order to purchase land (Deere and Leon 2003).

Gender inequality in asset holdings can result in gender differences in the ability to cope with climate shocks. In Bangladesh, floods increased joint land accumulation by husbands and wives. However, droughts worsened gender inequalities in land accumulation, favoring husbands. This is because households must invest more in irrigation during the drought, and when women's land, if of poor quality, may be the first to be given up (Quisumbing, Kumar, and Behrman 2018). Conversely, no differences in non-land assets were observed due to floods or droughts. In Uganda, both droughts and floods increased land accumulation by men more than women (Quisumbing,

Kumar, and Behrman 2018). In a different study conducted in Bangladesh, droughts increased women's asset accumulation, but not for men (Rakib and Matz 2016).

Women may be more vulnerable to climate shocks in some contexts due to legal challenges they face in inheriting and owning land, leading to less investment in their land and greater vulnerability to climate shocks. In Malawi, for instance, women managing land in districts where women traditionally have more secure property rights (under a matrilineal system⁴) are less vulnerable to temperature shocks in terms of their household consumption (Asfaw and Maggio 2018).

In terms of household work burden and related bargaining, floods decreased the gap between men and women in terms of the time spent on wage labor, child and elder care, and household chores in Pakistan. This could be attributed to the provision of more labor market opportunities for women through flood recovery programs (Akter 2021).

4. Agency

Weather-related economic shocks tend to have a disproportionately negative impact on women's agency due to various factors, including their lower decision-making power in the household, limited representation in policy making, and higher exposure to gender-based violence.

Drops in income due to weather events can increase the likelihood of violence, especially against women. For instance, severe droughts and floods in Tanzania led to a drop in consumption, increased hunger, and murders of elderly women through “witch” hunting, usually by their relatives (Miguel 2005). In Indonesia, incidents of domestic violence in a year correlated with the rainfall levels in December, a crucial month in the Indonesian rice-planting season, likely because it influences household income (Eastin and Dupuy 2021). In Peru, the prevalence of physical intimate partner violence increased by 65 percent after the occurrence of events of drought, but not flood, during the cropping season. This effect is mediated by increased poverty-related stress and reduced female empowerment caused by rainfall shocks (Diaz and Saldarriaga 2020).

Analyses of the relationship between droughts and physical Intimate Partner Violence (IPV) in Sub-Saharan African have yielded contradictory findings. One study found no evidence of a strong

⁴ In these districts women usually inherit land and men move to their wives' villages to cultivate land, as men do not have access to land belonging to their own matrilineage

association between drought and IPV, arguing that possible explanation are that rainfall shocks do not affect spouses' power, or that the slow onset of the droughts allows for a calmer response to the crisis (Cools et al. 2020). Another study found that drought was associated with measures of IPV towards women, with larger positive associations among adolescent girls and unemployed women. There was heterogeneity in these associations across countries (Epstein et al. 2020). A more recent study found little association between drought and emotional, physical, and sexual violence on any continent, yet found associations between drought and increases in controlling behaviors in Latin America and the Caribbean, and Asia. It also found that extreme drought has a protective effect against controlling behaviors in Sub-Saharan Africa. The authors explain this finding with the coping strategies specific to each gender. Drought in Africa may result in men spending more time away from their partners to travel further distances to obtain water or to pursue off-farm labor opportunities to a greater degree than in Asia or Latin America and the Caribbean (Cooper et al. 2021). A mixed-method systematic review concludes that a potential increase of gender-based violence during or after extreme events relates to factors such as economic instability, food insecurity, and mental stress, but also highlights the poor quality of most quantitative studies on the topic (van Daaleen et al. 2022).

In many countries, high temperatures correlate negatively with women's rights, including their right to inherit on the same basis as men, their ownership and control of property, and their ability to engage in any occupation without a man's consent, reflecting their lower decision-making power in their household because of pre-existing restrictive social norms (lowering women's propensity to work in the formal sector and joining civil society organizations), especially in countries that are poorer, more dependent on agriculture and have less democratic political institutions (Eastin 2018).

Finally, in some contexts, marriage practices such as polygyny (a marriage practice whereby a man can have multiple wives simultaneously), known for negatively impacting women's bargaining power, health (Bove and Vallengia, 2009; Bove et al. 2014) and increase violence against women (Ebrahim and Atteraya 2020), are used as mitigation strategies against weather shocks. In Mali, households living in communities where polygynous marriages are more prevalent cope better with droughts and reduce the negative effects on crop yields — as polygyny raises fertility such that having a large family that can work enables households to leverage diversification of crop production and income sources and can create mutual insurance

opportunities between polygynous and monogamous households living in the same village — (Dessy et al. 2021).

5. Conclusion

Climate change is the defining challenge of our time, and its impacts are far-reaching and complex. As we design policies to address this challenge, it is essential that we understand the ways in which climate change affects different groups in society. There is growing evidence that climate change has a gendered impact, with women and girls disproportionately affected by extreme weather events and other climate-related phenomena. Understanding these impacts is essential if we are to design policies that are effective, equitable, and sustainable.

The largest differences in the gendered impacts of climate change come from the social responses to weather shocks. In many parts of the world, girls and women are more likely to be discriminated against from an early age, leading to reduced opportunities for education and employment. Women are more likely to withdraw from agricultural work and struggle to find alternative sources of income after weather shocks. Boys may also be taken out of school to work, while men may be forced to migrate in search of new employment opportunities. These social responses to weather shocks could ultimately result in widening the gender gaps.

To design policies that effectively address the gendered impacts of climate change, we need a better understanding of the social mechanisms through which men and women are affected. This requires investment in research that looks at the intersection of climate change, gender, and social inequality. It also requires policies that are designed with a gender perspective, taking into account the unique challenges faced by men and women in different contexts. For this, there is a critical need for improved collection and analysis of gender-disaggregated data. As the COVID-19 pandemic has shown, pervasive gaps in sex-disaggregated data caused knowledge of the gender impacts of the pandemic to be incomplete (World Bank 2021). The lack of gender-disaggregated data makes it difficult to fully understand and address the ways in which men and women are affected differently by climate change. By improving the systematic collection and analysis of gender-disaggregated data, policymakers and researchers can gain a more nuanced understanding of the gendered impacts of climate change, which can inform the development of more effective and equitable policies and interventions.

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7. Annex 1. Table A.1. Summary of studies cited in the review

Paper	Countries	Climate Shock	Gendered Findings	Affected Outcome
Achebak, Devolder, and Ballester 2019	Spain	Heat	Women are more likely to die than men for heat-related cardiovascular diseases, across all age groups.	Endowments: Health
Afridi et al. 2021	India	Rainfall	Drought reduces labor force participation and employment more for women than for men, due to lack of diversification to the non-farm sector.	Economic opportunities: Labor
Agamile et al. 2021	Uganda	Rainfall	Weather shocks provide an opportunity for women to enter the commercial crop market by allocating land from subsistence to income generating crops. This is because men are more likely to opt for off-farm labor opportunities.	Economic opportunities: Labor (Land allocation)
Akresh, Verwimp, and Bundervoet 2011	Rwanda	Crop Failure	During crop failure, households shield boys from harm by reallocating scarce resources towards them and therefore only girls suffer the negative effect.	Endowments: Health
Akter 2021	Pakistan	Flood	Flood is correlated to a significant shift in the gender division of labor for both paid and unpaid work: (a) increase in men's and women's time use as hired labor; (b) decrease in women's time use in care work; and (c) increase in men's time use in domestic work.	Economic opportunities: Labor
Andrabi, Daniels, and Das 2021	Pakistan	Earthquake	In earthquake affected areas, there are no differential gender effects on enrollment rates in primary and secondary school or test scores.	Endowments: Education
Anglewicz and Myroniuk 2018	Malawi	Rainfall	Men are more likely to move after environmental or economic shocks, while women are more likely to move after household shocks (for example, illness or breakup).	Economic opportunities: Labor
Anttila-Hughes and Hsiang 2013	Philippines	Typhoons	Infant mortality rate rises the year after the typhoon and mortality is highest in households where infant daughters face competition from other children over resources, particularly if those siblings are male.	Endowments Health
Asfaw and Maggio 2018	Malawi	Heat	High temperature shocks disrupt household's food consumption, and caloric intake but also non-food consumption, when plots in the household are solely managed by women.	Endowments Health Economic opportunities: Asset ownership
Bau et al. 2020	India	Rainfall	In the presence of rainfall positive shocks, a larger early-life investment in human capital reduces schooling (and increases child work) in districts with a high prevalence of child labor, in particular for girls. The effect persists across generations.	Endowments: Education
Björkman-Nyqvist 2013	Uganda	Rainfall	A negative rainfall shock reduces female enrollment in primary school for older girls, while not affecting boys or younger girls. It also has an adverse effect on the test scores of older female students but not on boys'	Endowments Education
Bohra-Mishra et al. 2017	Philippines	Heat, typhoons, and rainfall	Men are more likely to migrate following climate changes especially heat and typhoons, following a decline in agricultural productivity.	Economic opportunities Labor
Bradshaw 2004	Nicaragua; Honduras; El Salvador	Hurricane	Mortality rates are higher among men. Only female heads of household working in agriculture continued to do so after the hurricane while women in	Endowments Health

			male headed household reduced their participation in rural work increasing domestic work. Migration increases more for men than for women	Economic opportunities Labor
Branco and Feres 2018	Brazil	Rainfall	Drought shocks in rural areas are associated to lower scores and higher probability of child work, especially for girls. Moreover, drought tends to be more harmful for girls than for boys in schools with water storage device	Endowments Education
Carpena 2019	India	Drought	Consequences of a drought are more severe for female-headed households in fat consumption, while there are not significant differences in the reduction of other groups of food compared to men.	Endowments Health
Carrillo 2020	Colombia	Rainfall	Male fetuses are more vulnerable to detrimental influences in utero of adverse rainfall shocks, suggesting a higher biological vulnerability. This leads to higher infant mortality rates and mental disability rates and a greater reduction in years of schooling and literacy rates for men than for women. In contrast, larger effects on employment for females than for males are found.	Endowments: Health, Education Economic opportunities: Labor
Chang, Favara, and Novella 2022	India	Rainfall	The effect of rainfall shocks in-utero on cognitive and non-cognitive skills development (math and vocabulary test scores) over the first 15 years of life is negative. However, there are no significant gender differences	Endowments: Education
Chatterjee and Merfeld 2021	India	Rainfall	A positive agricultural shock reduced female child mortality. before the introduction of Mahatma Gandhi National Rural Employment Guarantee Scheme (NREGS). NREGS mitigates the relationship between income shocks and the health of surviving girls.	Endowments Health
Chowdhury, Parida, and Agarwal 2022	India	Rainfall	Flood damage affects female agricultural employment more negatively than males' in the long run. Women also suffer disproportionately in obtaining employment in the non-agricultural sector in the aftermath of the shock. Gender norms discourage women from migrating or engaging in economic activities.	Economic opportunities: Labor
Dapi et al 2010	Cameroon	Heat	For girls in secondary school, the impact of heat on health status is higher than for boys, most likely due to menstruation, body composition, longer hair, and tighter uniforms.	Endowments: Health
Dasgupta and Karandikar 2021	India	Rainfall	While all children experience a worsening of learning outcomes under positive rainfall shocks, girls in rice-dominant districts are especially affected.	Endowments: Education
Davies et al. 2015	Cambodia	Rainfall and typhoons	Women can be more exposed to water-borne diseases in the face of extreme weather events (risk of malaria for collecting water, physical and mental health) in congested spaces like evacuation centers.	Endowments Health
Defrance et al. 2020	Mali	Rainfall	Climate events increase international migration as well as migration from rural areas and for both men and women, regardless of their age. The effect differs according to the level of agricultural diversification in the area and the household's capacity to cope with the shock	Economic opportunities: Labor
Dessy, Tiberti, and Zoundi 2023	Malawi and Indonesia	Droughts	Patrilocal households (where sons co-reside with their parents after marriage, eventually becoming their source of old-age support), but not matrilineal ones (where daughters co-reside with their parents after marriage), sacrifice their daughters' schooling in favor of sons' when they experience droughts and schooling requires payment of fees (Dessy, Tiberti, and Zoundi 2023)	Endowments: Education
Dessy et al. 2020	Madagascar	Drought	Droughts increase the fertility of young women living in agricultural households, while it does not affect marriage time.	Endowments Health

Deuchert and Felfe 2015	Philippines	Typhoon	Climate shock does not affect children's health, but it has a higher negative effect on girls' education than for boys'	Endowments: Education
Diakakis et al. 2015	Bahamas; Cuba; Jamaica; Puerto Rico; the Dominican Republic; Haiti; United States; Canada	Hurricane	Men recorded higher percentage among the victims, while female mortality rate is higher in the Caribbean than in continental North America	Endowments: Health
Dillon et al. 2011	Nigeria	Temperature shocks	Men are more likely to migrate to mitigate both <i>ex ante</i> and <i>ex post</i> agricultural risk, especially in the presence of more frequent hot shocks	Economic opportunities: Labor
Dinkelman 2017	South Africa	Rainfall	Early childhood drought exposure in later-life disability rates (both physical and mental) is larger for men than for women.	Endowments: Health
Eastin 2018	All developing countries using IMF 2017 classification	Temperature and rainfall shocks	Climate shocks impact magnifies pre-existing constraints on women's ability to achieve economic independence reducing both women's social rights (women's equal rights to inheritance, to own property, to marry whom they choose etc.) and economic rights (rights to equal pay; to equality in hiring practices etc.).	Voice and Agency Women economic and social rights
Eastin and Dupuy 2021	Indonesia	Rainfall	Climate shocks elevate the incidence of domestic violence and abuse via their impact on agriculture and agrarian livelihoods which disproportionately diminishes women's bargaining power in the household.	Voice and Agency: Gender based violence
Ellena et al. 2020	Italy	Temperature shocks	Women are systematically more at risk than men under heat stress condition. The discrepancy is due to differences in response to thermal stress due to physiological characteristics and socio-demographic characteristics.	Endowments: Health
Elmallakh and Wodon 2021	8 West African countries	Rainfall, fires, landslides, etc.	FLFP and women's employment increase and the gender gap shrink in migrant households that are negatively affected. In context where female labor is considered a "reserve labor" climate shocks can change the labor division between women and men disrupting long-standing gender roles.	Economic opportunities: Labor
Feeny et al. 2021	Vietnam	Rainfall	Greater exposure to rainfall shocks in early life reduces the probability of formal sector employment in adulthood only for women. education is the most important pathway through which early-life exposure to rainfall shocks impacts on the gender gap in future formal sector employment.	Economic opportunities Labor
Flatø and Kotsadam 2014	29 Sub-Saharan African countries	Rainfall	Droughts cause significantly higher female infant mortality than male infant mortality. The difference is only present in communities with low levels of female employment, where you would expect strong preferences for sons.	Endowments: Health
Gray and Mueller 2012	Ethiopia	Rainfall	Droughts increase long-distance and labor-related migration for men. However, women's short-distance and marriage-related mobility reduce, reflecting a decreased ability to finance wedding expenses and new household formation.	Economic opportunities: Labor
Haile, Tirivayi, and Nillesen 2019	Ethiopia	Drought	Droughts have a negative effect on the highest grade completed for girls. While drought affects health status equally for boys and girls.	Endowments: Health, Education
Hirvonen 2016	Tanzania	Temperature shocks	Adverse temperature shocks reduce long-term migration among men due to liquidity constraints and migration costs. However, they do not affect female's	Economic opportunities: Labor

			decisions due the fact that they are largely motivated by marriage and family rather than work.	
Hoddinott and Kinsey 2000	Zimbabwe	Rainfall	Adult women's body mass, but not men's, is adversely affected by drought. The effect is larger for women residing in poor households and daughters, lacking resources (like ownership of livestock) to cope with the shock.	Endowments: Health
Ingole et al. 2022	India	Temperature shocks	Total mortality rates attributable to ambient temperature are higher for men than for women.	Endowments: Health
Jonkman et al. 2009	United States	Hurricane	There are no significant gender differences in the number of fatalities.	Endowments: Health
Kim, Lee, and Rossin-Slater 2021	United States	Temperature shocks	Extreme heat has adverse impacts on women's health during pregnancy, especially for women residing in historically cooler counties, suggesting a lower adaptation capability, and black mothers.	Endowments: Health
Korkeala 2012	Indonesia	monsoon delays	The probability of continuing from primary to secondary school is reduced when a delayed onset coincides with the transition year and child labor increase but there are no gender differences	Endowments: Education
Lee et al. 2021	Tanzania	Temperature shocks	Heat stress reduces total male agricultural labor but does not statistically affect female. However, heat stress significantly increases female agricultural labor supply in female-only household. Females face greater constraints than males in terms of access to human capital, productive resources and financial assets which may in turn weaken their adaptive capacity	Economic opportunities: Labor
Maccini and Yang 2009	Indonesia	Rainfall	Higher early-life rainfall has significant impact on schooling years, health status and height of girls and not of boys. This suggesting that a positive shock is associated with a higher households' expenditure in education, higher quality of nutrition and access to medication for girls and is consistent with gender bias in allocation of resources.	Endowments: Health, Education
Maitra and Tagat 2019	India	Rainfall	A positive rainfall shock prompts men in agricultural households to reallocate time toward welfare program (NREGS) work whereas rainfall shortages result in men allocating more time in agriculture. Women, in contrast, shift time into NREGS activities in response to rainfall shortages and spend less time attending educational institution increase the time they allocate to domestic duties.	Endowments: Education Economic opportunities: Labor
Mahajan 2017	India	Rainfall	The effect of a rainfall shock on the gender wage gap depends upon the gender roles underlying the technology of production. In particular, female-to-male wage ratio is significantly positively associated with a rainfall shock in regions where rainfed rice is cultivated, due to a possible association of demand for female labor.	Economic opportunities: Labor
Marchetta, Sahn, and Tiberti 2019	Madagascar	Rainfall	Negative rainfall shocks and cyclones negatively affect cognitive test scores for all children and the probability of attending school and encourage girls more than boys to enter the workforce.	Endowments: Education
Marchetta, Sahn, Tiberti and Dufour 2021	Madagascar	Rainfall	The occurrence of a climate change deters migration of young women due to liquidity constraints but not young men.	Economic opportunities: Labor
Meyiwa et al. 2014	South Africa	Individual perception of climate changes	Climate change add to women's care burden and expose those who work in the fields to heat stress. As a result of the household division of labor, rural	Endowments: Health

			girls confront particular challenges as they need to search further from home for water and are exposed to the risk of gender violence.	Voice and Agency: Gender Based Violence
Miguel 2005	Tanzania	Rainfall	Extreme rainfall is associated with a large increase in the murder of “witches”, elderly women often killed by relatives. As violence increase during crisis, income shocks rather than cultural norms is a key factor driving the result.	Voice and Agency: Gender Based Violence
Mueller, Gray, and Kosec 2014	Pakistan	Rainfall and temperature shocks	Flooding shocks, associated with large relief efforts, have modest impacts on migration, Heat stress, however -which has attracted relatively little relief-increases the long-term migration of men, driven by a negative effect on farm and non-farm income but not of women.	Economic opportunities: Labor
Neumayer and Plumper 2007	World	Disasters such as volcanos, hurricanes, extreme rainfall, etc.	Natural disasters on average kill more women than men directly, and indirectly via related post disaster events.	Endowments: Health
Nico and Azzarri 2022	31 African countries	Temperature shocks and rainfall	Both droughts and heat waves reduce the number of hours worked in agriculture, however the reduction is lower for women.	Economic opportunities: Labor
Nübler et al. 2021	Kenya	Rainfall	Early life rainfall shocks reduce both achievement and cognitive test score for both boys and girls.	Endowments: Education
Park et al 2020	United States	Temperature shocks	Cumulative heat exposure inhibits cognitive skill development as measured by reduced test scores with no gender differences.	Endowments: Education
Pereira et al. 2017	Portugal; Greece	Hurricane	Gender distribution of fatalities shows a higher vulnerability of men than women, linked to their more active stance in the face of risk for several reasons, including performing labor duties, rescuing or assisting, retrieving property and livestock.	Endowments: Health
Quisumbing, Kumar, and Behrman 2018	Bangladesh and Uganda	Rainfall	In Bangladesh, flood and drought shocks have a negligible gendered impact on land and asset ownership, possibly owing to effective emergency assistance and the low level of women’s ownership and control of agricultural assets. Drought shocks have a negative and significant impact on wife’s non- land assets in Uganda, appearing that households affected are coping by disposing of wife’s non- land assets	Economic opportunities: Asset ownership
Rabassa, Skoufias, and Jacoby 2014	Nigeria	Rainfall	Rainfall shocks have a statistically significant impact on child health but there are no gender differences.	Endowments: Health
Rakib and Matz 2016	Bangladesh	Rainfall	Shocks that occur due to climatic variability reduce the asset base of men more strongly than of women, as men own more frequently assets involved in the agricultural activities (land, tools, vehicles).	Economic opportunities: Asset ownership
Rocha and Soares 2015	Brazil	Rainfall	Rainfall fluctuations during the gestational period have similar impact among girls and boys in terms of infant mortality, weight at birth and length of gestational period.	Endowments: Health
Shah and Steinberg 2017	India	Rainfall	Positive productivity shocks lead to lower school enrollment and test scores for school-aged children and to an increase in human capital investment in early life. However, there are no significant differences among boys and girls	Endowments: Education

Shakya, Basnet, and Paudel 2022	Nepal	Eartqakesu	Number of work permits issued to individuals for international migration decreased significantly only for men. These results are not explained by changes in agriculture productivity, labor productivity, and aid disbursement.	Economic opportunities: Labor
Thiede and Gray 2020	Indonesia	Temperature shocks and rainfall	Adverse effect of temperature and precipitation shocks on height for age are negative and statistically significant among boys (but not girls), while the effects on weight for height are stronger among girls.	Endowments: Health
Thiede and Strube 2020	18 Sub-Saharan African countries	Temperature shocks and rainfall	Climatic variability affects many underlying determinants of child malnutrition and weight but there no gender differences are found.	Endowments: Health
Tibesigwa and Visser 2016	South Africa	Temperature shocks and rainfall	Male headed households are more food secure compared to female-headed ones, with the latter depending more on agriculture. The gender gap is larger in rural areas.	Endowments: Health
Tibesigwa et al. 2015	South Africa	Rainfall, wind, haile storm	While weather-related crop failure affects both male-headed and de jure female-headed households in equal proportion, the de facto female-headed households are less affected. This depends on the fact that on average their food security does not depend on agricultural activities as much as on remittances.	Endowments: Health
Tiwari, Jacoby, and Skoufias 2017	Nepal	Rainfall	Positive rainfall shock has an immediate disease environment effect on both boys and girls that is only transitory. On the other hand, the income increase has a lagged effect translating into a higher average height of children. There are no gender differences.	Endowments: Health
Trinh, Posso, and Feeny; 2020	Vietnam	Rainfall	Above-average rainfall is associated with an increase in the likelihood that children enter work. Boys experience an increase in the probability of entering agricultural work while girls are more likely to undertake chores	Endowments: Education
Yeo and Blong 2010	Fiji	Hurricane	Higher proportion of the male fatalities is due to the larger number of men driving and working as professional rescuers.	Endowments: Health