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Mapping the Nexus Between Women, Ethnic Groups and Environmental Vulnerability

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Abstract

Environmental disruptions are intensifying social inequalities, disproportionately affecting women, Indigenous Peoples, and Afro-descendant communities. This systematic review synthesizes causal evidence on how these dynamics intersect with health, human capital, and adaptive capacity. Findings reveal that extreme climatic conditions exacerbate vulnerabilities, leading to heightened health risks—such as pregnancy complications and intergenerational effects—and undermining educational attainment and income generation. Structural barriers further constrain the ability of marginalized groups to recover from economic losses and access adaptation strategies. Evidence underscores the importance of empowering women in decision-making and safeguarding Indigenous land rights as pathways to resilience, while highlighting persistent gaps in understanding the economic impacts on Indigenous and Afro-descendant populations. Although traditional ecological knowledge shows promise for ecosystem stewardship, its integration into formal mitigation frameworks remains underexplored. Addressing these knowledge gaps is critical for designing equitable policies that strengthen public services, promote inclusive adaptation, and advance sustainable development.

JEL Codes: J16 Economics of Gender; J15 Economics of Minorities, Races, Indigenous Peoples, and Immigrants; Q540 Climate; Natural Disasters and Their Management; Global Warming Q560 Environment and Development; Environment and Trade; Sustainability; Environmental Accounts and Accounting; Environmental Equity; Population Growth; Q510 Valuation of Environmental Effects

Key Words: Gender Equality, Women, Ethnicity, Inequality, Minorities, Race Environment, Climate Change, Environmental Equity.

Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
ARDL	Panel Autoregressive Distributed Lag model
BMI	Body Mass Index
CC	Command and Control
CF	Control Function approach
CFM	Community Forest Management
CIWB	Carbon Intensity of Well-being
CO2	Carbon Dioxide
DiD	Difference-in-Differences
ET	Energy Transition
FAO	Food and Agriculture Organization
FD	First Differences
FE	Fixed Effects
GDP	Gross domestic product
GHG	Greenhouse Gas
GII	Gender Inequality Index
HAP	Heat Action Plan
HAZ	Height-for-Age Z-Scores
HFA	Height-for-Age
IDB	Inter-American Development Bank
IK	Indigenous Knowledge
IKLK	Indigenous and Local Knowledge
IoT	Internet of Things

IPCC	Intergovernmental Panel on Climate Change
IV	Instrumental Variables
KAP	Knowledge, Attitudes, and Practices
LAC	Latin America and the Caribbean
LEAP	Livelihood Empowerment Against Poverty
NDVI	Normalized Difference Vegetation Index
OA	Open Access
OECD	Organization for Economic Co-operation and Development
PES	Payment for Ecosystem Services
PSM	Propensity Score Matching
R&D	Research and Development
RCT	Randomized Controlled Trial
RDD	Regression Discontinuity Design
SCI	Smart Cities Initiative
SDGs	Sustainable Development Goals
SMS	Maryland Scientific Methods Scale
SSA	Sub-Saharan African
SUTVA	Stable Unit Treatment Value Assumption
UN	United Nations
WaSH	Water, Sanitation, and Hygiene
WFH	Weight-for-Height

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Introduction

Rising temperatures, extreme weather events, and shifting ecosystems are pressing global challenges, with far-reaching consequences for both the environment and human societies. These phenomena are already altering the way people live and interact with their surroundings. While they are universal concerns, their impacts are not distributed evenly across the world. Evidence shows that those countries that are more vulnerable to rising temperatures due to their geographic location (e.g.: Sub Saharan Africa) are also those with the lowest footprint (Bruckner et al., 2022).

But inequalities can also be dramatic at a within-country level. There is an ongoing discussion regarding the heightened vulnerability of specific demographic groups—particularly women, Indigenous Peoples, and Afro-descendant populations—to climate-related risks. These groups are often cited as being disproportionately affected due to social, economic, and environmental factors. At the same time, some perspectives suggest that these populations may also possess unique knowledge, cultural practices, and adaptive strategies that could contribute to mitigating climate change and fostering resilience.

This report presents a systematic review of individual academic peer-reviewed studies that have examined the relationship between climate change and the vulnerabilities and capacities of women, Indigenous Peoples, and/or Afro-descendants. These studies provide a more granular analysis of the mechanisms through which climate change affects these populations. Additionally, academic literature sheds light on the ways in which traditional ecological knowledge and community-led initiatives contribute to adaptation and mitigation, providing valuable insights into alternative strategies for addressing climate challenges.

The findings of this report aim to contribute to a more evidence-based discussion on climate change and social inequality. By identifying gaps in the existing knowledge base, we also highlight areas where further research is needed to support more effective and equitable climate policies.

This report is structured into four sections. Section 2 details the methodology used to conduct the review of the literature, while Section 3 presents our findings and Section 4 concludes and identifies research gaps that need further attention.

2

Literature Review Methodology

This report examines rigorous quantitative causal studies on the impact of climate change on women, Indigenous Peoples, and Afro-descendants across three key dimensions: impact, adaptation, and mitigation.

By systematically evaluating which subcategories of these three dimensions are supported by robust evidence and identifying areas requiring further research, this review seeks to clarify the relationship between climate change and the mentioned populations. Additionally, it explores the mechanisms through which climate change affects these groups and identifies adaptation and mitigation efforts. The findings contribute to a deeper understanding of climate change's differentiated effects and highlight critical gaps for future research.

2.1 Eligibility Criteria

To achieve the objective above, we follow the Maryland Scientific Methods Scale (Madaleno and Waights, 2016)—from now on "SMS"—to identify studies that provide causal evidence. This scale, which ranges from Level 1 (simple cross-sectional correlations) to Level 5 (randomized controlled trials or RCTs), allows us to assess the rigor of causal inference. In our analysis, we include only studies that score Level 3 or above, as these ensure a higher degree of methodological robustness.

From highest to lowest, SMS levels are defined as follows:

Level 5 represents the gold standard of causal inference, reserved for studies that involve explicit randomization. This level is achieved exclusively through randomized controlled trials (RCTs).

Level 4 includes quasi-randomized designs, where treatment and control groups are credibly comparable, differing only in their exposure to treatment due to a quasi-random assignment mechanism. This category includes methods such as instrumental variables (IV) and regression discontinuity design (RDD).

Level 3 consists of studies that compare pre- and post-intervention outcomes in a treated group, using an external comparison group to provide a counterfactual. The difference-in-differences (DiD) method and panel methods, such as panel fixed effects (FE) or first differences (FD), are primary examples of this level.

Level 2 includes studies that rely on cross-sectional comparisons of treated and untreated groups or before-and-after comparisons within a treated group, but without a robust control group.

Level 1 is the weakest level, encompassing studies based on simple cross-sectional correlations or before-and-after comparisons without an untreated comparison group.

In addition, some methodologies, such as hazard regressions, Heckman selection models, and the control function (CF) approach, are classified as Level 3/4, meaning they may be classified as either Level 3 or Level 4 depending on how they are specified. These methods require careful specification and implementation to meet the criteria for either level. Specifically, they must incorporate valid identification strategies and satisfy the necessary assumption outlined in the SMS framework.

While we recognize the valuable insights offered by Level 1 and 2 studies, these fall outside the scope of our analysis, as they provide correlational evidence rather than causal evidence, which is essential for generating generalizable insights and drawing relevant policy conclusions.

It is important to note that, while certain methodologies are associated with each level, simply employing a particular methodology does not guarantee that a study will achieve that level. To qualify, studies must meet specific criteria and undergo assumptions testing. Consequently, the assigned level represents the maximum possible category a study can achieve if all necessary criteria are met. Otherwise, the level is adjusted downward according to the SMS criteria.

Moreover, less common methodologies not explicitly included in the SMS classification were also considered, as long as they fulfilled the identification and robustness criteria of the corresponding level. The same applies to studies that did not explicitly name the method used, but clearly followed the logic and assumptions of an eligible design (e.g., a study that did not explicitly state it was using a difference-in-differences design but compared pre- and post-intervention changes between a treatment and a control group, while also assessing parallel trends and other key assumptions associated with the approach).

Discrepancies in SMS scoring or classification were discussed and resolved collectively to maintain consistency. In cases where a study employed multiple methodological strategies, only the results from methods that met the minimum SMS level required (Level 3 or above) were extracted and included in the review.

Finally, we restricted the selection to the most recent version of articles, books, and book chapters that were published in English, had reached their final publication stage, and had undergone peer review. Grey literature was excluded from this review. Appendix 2 presents the Classification of quantitative methods and the code used to associate the studies with an specific level.

2.2 Search Method and Strategy

We searched the Scopus and ISI Web of Science databases, conducting searches on September 29, 2024, for Scopus and October 30, 2024, for ISI Web of Science. A final update was performed on December 11, 2024, to include articles published during the research period[1].

The search strategy included a combination of keywords[2] following the structure described below:

Climate change + Group + Impact/Adaptation/Mitigation + Quantitative + Geographic + Language + Final Publication Stage

a) Climate change: We included the term "climate change" to ensure the search is focused on this topic and no other related topics like energy or pollution

b) Groups: We included a term related to one of the five populations of interest: Women, Indigenous Peoples, Indigenous Women, Afro-descendant, or Afro-descendant women.

c) Impact/Adaptation/Mitigation: Terms related to one of these categories were added as needed.

d) Quantitative: Only quantitative evidence from Levels 5 to 3 was included, following the Maryland Scientific Methods Scale (SMS).

e) Geographic: Although all the global evidence was included, this criterion distinguishes evidence from Latin America and the Caribbean from information related to other regions of the world.

f) Language: Only evidence published in English was included.

g) Final publication stage: The search is limited to publications that are in their final form, ready for public access.

Each criterion was searched within the title, abstract, keywords and keyword plus of the documents. However, in Scopus, the quantitative criterion was searched throughout the full text, as the methodology is not always explicit in these sections. In the case of ISI Web of Science this option was not available.

Additionally, the search was extended to reference lists of relevant articles to ensure that no significant studies were unintentionally omitted. All articles found in the bibliographies that met the eligibility criteria were included. In specific cases, texts from bibliographies that did not explicitly mention climate change in the title, abstract, keywords, or keyword plus were also included if they were strongly related to climate change topics—such as droughts,

1. Additionally, the terms "ethnic" and "ethnicity" were also incorporated into the subcategory of Indigenous and Indigenous women within the groups category, which was not included in the first search.

2. The full list of keywords is included in Appendix 2.

hurricanes, or other extreme weather events—and were relevant to the research.

2.3 Selection and Data Collection Process

A total of 1,541 studies were retrieved from Scopus and 407 from ISI Web of Science. We removed all documents that were not articles, books or book chapters based on the document type category, resulting in the exclusion of 239 documents, and leaving us with 1,333 from Scopus and 376 from ISI Web of Science, respectively. Next, we removed 189 duplicate documents—189 duplicated across both databases and 3 within the same database—based on their title and year of publication.

In addition, there are 10 studies that we were unable to access. We contacted the authors directly to request access, but as of March 21, 2025, we had not received any response.

The remaining 1,510 studies were screened by a single investigator. Since our target groups—women, Indigenous Peoples, and Afro-descendants—are sometimes the secondary focus in the studies, we conducted a full-text screening for each document, following a pre-established protocol. Documents were excluded if they failed to meet any of the following criteria, in this order: 1) related to climate change, 2) focused on human populations, 3) included at least one of the target groups, and 4) provided quantitative evidence. A total of 1001 studies were excluded for failing to meet at least one of these criteria.

Following this initial screening, the remaining 509 studies were independently reviewed by six investigators. The reviewers coordinated to assess the methodological strength of each study using the Maryland Scientific Methods Scale (SMS). Only studies that reached Level 3 or higher were retained[3]. An additional 393 studies were excluded at this stage for not meeting this minimum threshold.

For all 116 studies that met the inclusion criteria and SMS threshold, data were independently extracted by the six reviewers. The systematized variables collected for each study included: the methodology used, the causal relationships analyzed, sample size, direction of the effect (sign), effect size, and statistical significance. We also recorded whether the study included policy recommendations or proposals for future research, as well as the SMS level assigned. Additionally, it was manually confirmed the target group(s) mentioned in the study and whether the study focused on the categories impact, adaptation, or mitigation, and whether the evidence came from Latin America and the Caribbean (LAC).

3. In cases where a study employed multiple methodologies, we only considered the results from those that met the minimum SMS level required for inclusion.

The collected information was analyzed, conducting a brief re-reading of each study, and examining the reference lists of the reviewed texts. If additional studies were found in the bibliographies and met our eligibility criteria, they were also included. This step led to the incorporation of 33 additional studies.

Moreover, in a small number of cases, we incorporated additional literature that was not identified through the systematic search but met all the established inclusion criteria[4]. These studies were either already known by members of the research team or identified through targeted web searches. Their inclusion was conditional on fully satisfying our criteria and being considered highly relevant for the review. This process added 25 more studies to the final selection of studies. In total, 174 studies were ultimately included in this systematic review. Appendix 3 summarizes the flaw diagram of literature review.

2.4 Synthesis Methods

This review adopts a structured narrative synthesis approach, focusing exclusively on quantitative studies that meet a minimum methodological threshold for causal inference, as defined by the Maryland Scientific Methods Scale (SMS).

The synthesis was guided by the IPCC (2022b) classification, which organizes the literature into three overarching thematic areas—Impact, Adaptation, and Mitigation—and their respective subcategories (see Appendix 1)[5]. Within each area, studies were further grouped into these subcategories to facilitate structured comparison and identify patterns across contexts, populations, and methodological approaches.

Given the interconnected nature of the effects studied—and the fact that a single outcome can have implications across multiple dimensions, many studies were relevant to more than one category or subcategory. In such cases, each study was assigned to a primary category and, where useful, also repeated in relevant secondary categories. This approach allowed us to preserve thematic coherence while acknowledging the multidimensionality of climate change impacts and responses.

In instances where a topic clearly spans more than one category—such as migration or forced displacement, which may represent both impacts and adaptive responses—we opted to assign it to a single category to enhance consistency and comparability across

4. The only inclusion criterion for which a more flexible approach was adopted was climate change. Specifically, we included studies that, although not always explicitly using the term 'climate change' in their title or abstract, clearly addressed its consequences—such as droughts, floods, extreme temperatures, or other climate-related phenomena.

5. Some subcategories were grouped together in a practical way to improve clarity and facilitate synthesis across closely related topics.

studies. For example, migration was classified under Impact – Human Dimension[6], despite its recognized role as a potential form of adaptation.

For some subcategories, no studies meeting the inclusion criteria were identified. These gaps are explicitly reported in the synthesis, and their absence is also considered relevant information that highlights areas for future research.

Importantly, beyond assessing the effects of climate change, we also examined the mechanisms through which it affects different groups, as well as the strategies adopted for adaptation or mitigation. Particular attention was given to identifying whether the studies explored causal pathways—such as economic shocks, health vulnerabilities, or institutional barriers—that mediate the relationship between climate change and differentiated outcomes for women, Indigenous peoples, and Afro-descendants.

2.5 Reporting Bias Assessment

We took several measures to minimize the risk of bias in this review. First, we limited the analysis to studies published in peer-reviewed journals and explicitly excluded gray literature. Second, we searched two major academic databases—Scopus and ISI Web of Science—and extended our search to reference lists of included studies. Additionally, we conducted a non-exhaustive complementary search through web searches and studies already known to the research team.

Third, we followed a strict protocol for assessing methodological quality, applying the Maryland Scientific Methods Scale (SMS). All studies were independently classified based on SMS criteria, and any discrepancies in scoring were discussed and resolved collectively to ensure consistency across reviewers.

Despite these efforts, some relevant studies may still have been missed. This may be due to the complexity of how "climate change" is defined and reported. Not all authors explicitly use the term "climate change," even when discussing related phenomena such as droughts, floods, or extreme temperatures. Additionally, not all relevant studies may be indexed in the selected databases.

Furthermore, our keyword strategy focused on searching within the title, abstract, keywords, and keyword plus fields of each document. However, not all studies include the full set of relevant terms in these sections. In some cases, indexing limitations within Scopus or Web of Science may have also prevented the retrieval of eligible studies—even when they contained all the relevant search terms. Finally, there are some studies that we could not find and wrote directly to the authors but did not get a response.

6. This classification does not preclude the fact that migration may also be related to other subcategories, such as Poverty, Livelihoods, and Sustainable Development, or others.

3

Literature Review Results

This section presents the results of the systematic review, organized according to the categories and subcategories outlined above. Each subcategory includes a summary highlighting the main findings and key lessons from the available evidence.

3.1 Impact

3.1.1 Ecosystems and Their Products

As climate change increases global temperatures and alters precipitation patterns, growing water scarcity threatens to reinforce gender-based disparities by placing greater burdens on women, who are often responsible for water collection. By combining and harmonizing survey data from various regions across the global South—including El Salvador, Haiti, Colombia, and Peru—Carr et al. (2024) offer a comprehensive picture of the burden water collection imposes on women and how it is likely to be aggravated by climate change. In 2020, nearly half of the women across the sampled regions lacked access to running water, spending an average of 23 minutes per day collecting it. However, this average masks significant regional heterogeneity, with some areas in Africa reporting daily collection times of over an hour. The authors provide plausible causal evidence of the link between changes in temperature and precipitation and water collection time: an additional Celsius degree and a 10-millimeter reduction in precipitation increase average collection time by approximately 4 and 1.4 minutes, respectively. While the impact of temperature appeared independent of baseline levels, the marginal effect of reduced precipitation was larger in regions that were already drier. By using their estimated model to project the impacts of predicted changes in temperature and precipitation, the authors provide a grim outlook for the end of the century under a business-as-usual scenario, with the average time dedicated to water collection increasing by twenty minutes. While these results should draw policymakers' attention to the implications of water security for gender disparities, further research is needed to examine the effects of other short-term shocks—like natural disasters that affect access to water, expand the geographical scope of the analysis, and explore how the severity of impacts is shaped by local gender norms.

3.1.2 Cities, settlements, and infrastructure

The reviewed papers did not include studies on cities, settlements, and infrastructure related to the impacts of climate change in women, Indigenous Peoples, and Afro-descendants.

3.1.3 Health

3.1.3.1 Climate Change and Maternal Health

Women may be particularly vulnerable to climate-related challenges, especially extreme temperatures and natural disasters. During pregnancy, women experience physiological changes including elevated core temperature and metabolic demands, which could potentially increase their sensitivity to temperature extremes. These physiological changes may create vulnerability through several hypothesized mechanisms: heat exposure could cause cardiovascular strain and dehydration as the body struggles to maintain thermoregulation while supporting pregnancy, potentially resulting in placental insufficiency. For natural disasters, impacts may primarily operate through maternal stress, while also potentially disrupting access to healthcare and exposing women to environmental hazards. The effects on women could materialize both directly through these physiological mechanisms and indirectly through childcare responsibilities and healthcare costs when climate-related challenges also affect the newborn.

However, establishing clear causal links between climate exposures and women's outcomes presents significant methodological challenges. A fundamental difficulty lies in disentangling climate effects from other correlated health and socioeconomic factors. For instance, seasonal patterns in birth timing often reflect underlying socioeconomic differences among mothers, while geographic variations in climate tend to correlate with disparities in healthcare access. These confounding relationships complicate efforts to isolate the causal effect of environmental exposures on women's health and economic outcomes. The analysis faces additional complexity due to selective migration—women may relocate in response to extreme heat or natural disasters, introducing potential bias into studies measuring the direct health impacts of these climate-related exposures.

Despite these methodological challenges, several studies from the United States have successfully isolated the causal effects of environmental stressors on maternal health, typically using panel data analysis with county and month-fixed effects to control for unobserved spatial and temporal heterogeneity. Cil and Cameron (2017) documented direct effects on maternal health, finding that heat wave exposure during pregnancy increased women's risk of several complications including pregnancy-associated hypertension, uterine bleeding, eclampsia, and cervical insufficiency. The same study also found that heat waves increased the likelihood of abnormal conditions at birth in newborns, such as fetal distress, need for ventilator assistance for more than 30 minutes, and meconium aspiration syndrome —conditions that may create additional caregiving demands for mothers. Supporting the evidence on direct maternal health effects, Kim et al. (2021) demonstrated that exposure to above-average temperatures increased pregnancy-related hospitalizations, particularly for emergency and urgent care, primarily driven by hypertension and other potentially life-threatening pregnancy complications. Their study also found that some adaptation strategies may be key to reducing the health impacts of pregnant women, which also revealed large structural disparities: Black women were more likely to experience extreme temperatures during pregnancy (due to historical housing policies and residential segregation) and had less access to adaptive technologies like air conditioning. Their results suggest that climate change could further exacerbate existing racial disparities in maternal health outcomes.

While the evidence from the United States establishes clear impacts in a high-income country context, the effects of climate change on maternal health may be even more severe in developing countries. High temperatures during growing seasons can reduce agricultural yields and wages, potentially affecting fetal health through reduced nutritional intake and limited access to prenatal care. Temperature may also indirectly impact health through increased disease prevalence, as demonstrated by Banerjee and Maharaj (2020) in rural India, where high temperatures during pregnancy increased infant mortality[7]. The authors identify two key mechanisms through which this occurs: first, elevated temperatures increase the general incidence of diseases, making pregnant mothers more susceptible to illnesses that can cause nutritional loss to the fetus; second, when siblings and other children in resource-constrained households fall sick due to high temperatures during pregnancy, household resources are diverted from pregnant mothers to treat these sick children, adversely impacting fetal health. Though importantly, they found that health programs can effectively mitigate this relationship. Flatø and Kotsadam (2014) supported this argument by showing that infant mortality had gender differentiated patterns: droughts caused significantly higher female infant mortality than male infant mortality. Interestingly, the difference was only present in communities with low levels of female employment, where it would be expected a preference for sons.

Evidence consistently shows that heat exposure during pregnancy reduces gestational age and birthweight across different developing contexts. Recent evidence from Nepal showed that exposure to high ambient temperatures during pregnancy significantly increased the risk of preterm birth, with effects being particularly pronounced among socially disadvantaged populations (Kc et al., 2024). Similarly, in Sub-Saharan Africa, Andriano (2023) demonstrated that exposure to heat waves in utero led to significantly lower birth weight through reduced gestational age. These impacts may have lasting consequences: recent evidence from China showed that prenatal exposure to high temperatures

7. The authors mention two main pathways for this effect: first, higher temperatures increase disease rates, augmenting pregnant women's vulnerability to illnesses that may deprive the fetus of nutrients; second, when children in households become ill due to heat, limited resources are redirected away from expectant mothers to care for the sick, negatively affecting fetal health.

reduced child height and increased the likelihood of mental health disorders during adolescence. These effects could operate through multiple mechanisms including reduced birth weight, decreased household income, and impaired cognitive development (Ai & Tan, 2023; 2024).

However, cold exposure can also be detrimental, particularly where infrastructure is limited. G. Yu et al. (2023) found in a nationwide study in China that exposure to cold spells increased the risk of preterm birth, especially among rural women lacking access to heating infrastructure. These findings align with historical evidence: analyzing data from industrializing Japan in the 1920s, Ogasawara and Yumitori (2019) found that cold wave exposure led to lasting developmental impacts, with exposed children being shorter by 0.6-0.8 cm in the coldest regions, particularly affecting those in warmer areas less adapted to cold temperatures.

Research on climate-related risks to maternal health in the US also examines the effects of natural disasters. Currie and Rossin-Slater (2013) demonstrated that hurricane exposure during pregnancy posed significant health risks to both mother and child. Their study found that hurricane exposure during the first and third trimesters increased the likelihood of newborns requiring prolonged assisted ventilation, while exposure during any trimester raised the risk of meconium aspiration syndrome. These adverse birth outcomes likely create additional burdens for mothers through increased childcare demands, though this indirect channel of impact remains empirically untested. Similarly, Rocha and Soares (2015) found that rainfall fluctuations during the gestational period had impacts in terms of infant mortality, where they did not find differences between girls and boys.

Similarly, natural disasters in developing countries create far more severe challenges than in developed nations. While in the U.S. effects primarily operate through maternal stress due to robust infrastructure, disasters in developing countries can affect expectant mothers through multiple channels: physical injury, disruption of essential services, exposure to environmental toxins, limited healthcare access, and overcrowded shelter conditions. Ahsanuzzaman and Islam (2020) illustrates these compounded risks, finding that exposure to cyclones in Bangladesh significantly deteriorated children's nutritional status, particularly for those exposed during pregnancy or early infancy—highlighting the heightened vulnerability of households with limited resources to manage health shocks. Natural disasters can increase the infant mortality rate, especially in contexts of scarcity. In the Philippines, a study conducted by Anttila-Hughes and Hsiang (2013) found that the infant mortality rate rose the year after the typhoon, as the mortality was highest in households where infant daughters had to compete over resources, particularly if their siblings were male. Finally, Boyd (2023) focused on whether weather shocks affect mothers' time allocation to care provision for their children, thus deepening the understanding of the underlying mechanisms of the impacts of climate shocks on child nutrition. The author found that mothers decreased time use in water collecting-related activities when facing positive rainfall variability (wetter than normal) and did not change the time share dedicated to domestic activities like childcare. This wetter period also appeared to decrease the probability of a child being underweight. These results support the conclusion that reduction of time dedicated to childcare is not a relevant mechanism for the effect of climate shocks on child nutrition.

3.1.3.2 Climate Change and Early Childhood Development

Climate change may have differentiated effects on children's health by gender, race or ethnicity. These effects could span various stages of life, from in utero exposure to health outcomes during childhood and adolescence. The previous subsection touched tangentially on children's health when discussing maternal health, but in this one we review child development in greater detail.

The first and most extensive group of studies reviewed examines the effects of climate change shocks occurring in utero. Findings on whether the effects are stronger for boys or girls are mixed. Ai and Tan (2023; 2024) propose one explanation: male fetuses require more nutrients and oxygen to develop, making them more vulnerable to complications. Supporting this hypothesis, Ai and Tan (2024) documented the negative impacts of in utero exposure to high temperatures in China on child outcomes such as height-for-age z-scores (HAZ), stunting, and severe stunting, with effects being stronger for male children. Andriano (2023) reports heatwave-induced reductions in birthweight in Sub-Saharan Africa, with effects observed predominantly in boys. In the same line, Carrillo (2020) found that male fetuses are more vulnerable to detrimental influences in utero of adverse rainfall shocks, suggesting a higher biological vulnerability. This led 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.

Conversely, G. Yu et al. (2023), using data from China, found stronger effects of extreme temperatures (both high and low) on preterm births for female babies compared to boys. The authors emphasize that cold spells were particularly significant in explaining their results, which may account for differences with other studies using data from China (that only focus on extreme heat). Finally, two studies reported no gender differences: Basu et al. (2010), using U.S. data on preterm births, and Ai and Tan (2023), who examined the same heatwave shock as in Ai and Tan (2024) but focused on mental health outcomes. The latter study suggests that maternal health during pregnancy, which can also be adversely affected by heatwaves, may have had stronger implications for girls due to differences in household investments and care. This hypothesis suggests the need for further research in this area.

A second group of studies explores the differentiated effects of climate shocks on children after birth, with mixed results. Bernstein et al. (2022) identified the causal effects of heat waves on emergency room visits among girls and minority children in the U.S. The effects were driven by heat-related illnesses, bacterial enteritis, and otitis media and external. Meanwhile, Freudenreich et al. (2022) used data from the Kyrgyz Republic to examine weather shocks' impacts on child stunting and suggested that the negative effects were primarily driven by boys, though their estimates were imprecise and not statistically significant. Regarding other aspects of health, Trentinaglia et al. (2021) presented causal effects of extreme temperatures on obesity, with the effects being stronger for girls (and women) than for boys (and men).

In a paper that may reconcile evidence from prenatal and postnatal exposure, Ogasawara and Yumitori (2019), using historical data from Japan from the 1920s—and therefore a context more similar to developing countries today—, documented that extreme cold temperatures increased stunting for both boys and girls, but prenatal (postnatal) exposure was more important for boys (girls). In a related result, Thiede and Gray (2020) used data from Indonesia to document the impacts of temperature, precipitation, and monsoon onset on children's height and weight and found negative effects on Height-for-Age (HFA) and Weight-for-Height (WFH), with mixed heterogeneities by gender: negative effect on HFA for boys during the prenatal period and insignificant for boys. And with the opposite patterns for WFH. This also confirms that shocks in pre- and post-natal periods may be different for boys and girls. However, McMahon and Gray (2021) studied what they call climate anomalies using data for South Asia and found a nuisance pattern of effects: anomalous prenatal precipitation affects Height-for-Age Z-Score HAZ for girls only. First-year precipitation, meanwhile, caused a marginally significant decrease in HAZ for both boys and girls. After birth, boys appeared to benefit from higher-than-average temperatures. In all, these results suggest that it is key to disentangle the different effects of pre- and post-natal climate-related shocks by gender.

Although relevant evidence exists in this regard, more research is still needed. The literature that focuses on the relationship between climate-related disasters and children's health outcomes is still scarce. Raker (2022) studied the effects that Hurricane Harvey had on children's generalized health status, finding that the disaster led to worse health levels, particularly in flooded communities, with a slightly more negative effect for girls than for boys. However, possible mechanisms that explained these results were not discussed. Finally, Ahsanuzzaman and Islam (2020) found the effects of cyclones on the health outcomes of children (HAZ and probability of stunning) varied by gender of the child depending on their age and on the measure. The results are hard to interpret and suggest no clear patterns.

3.1.3.3 Climate Change and General Adult Health

Rising global temperatures may adversely affect both physical and mental health outcomes, as well as cognitive performance. There could be gender differences in how these temperature changes affect health and cognition, stemming from physiological variations, distinct social roles, exposure patterns, and potentially different adaptive capacities. In what follows, we first examine evidence on physical health impacts, followed by a discussion of mental health and cognitive outcomes. For all these dimensions, we focus particularly on documenting gender differences in vulnerability to extreme temperatures.

Extreme temperatures can affect physical health through direct and indirect channels. Direct effects of heat include heat stress and heat stroke, while direct effects of cold include hypothermia and cardiovascular strain. Both heat and cold can be fatal. Indirect effects occur mainly through enhanced transmission of water-borne, food-borne, and vector-borne pathogens during hot periods, while cold temperatures can increase vulnerability to seasonal illnesses like influenza. To understand these health impacts comprehensively, the literature has examined both mortality (deaths) and morbidity (illness and disease), which reveal different patterns and demographic disparities.

Looking first at mortality outcomes, several studies document clear links between extreme temperatures and deaths. Carleton et al. (2022) analyzed data from forty countries, finding a U-shaped relationship where extreme temperatures increased mortality rates, particularly among the elderly. This relationship weakened with higher incomes and local climate adaptation. Healy et al. (2023) corroborate these findings, showing that 1° C increases in seasonal temperature variability raised mortality rates by 1.54% and 0.69% for warm and cold seasons, respectively in the U.S. Medicare population. Notably, gender differences in mortality appeared to favor women: Khatana et al. (2022) found more substantial effects for men in the U.S., particularly among older and non-Hispanic Black adults. The patterns observed for mortality often differed from those of morbidity; this is not surprising as the causes of morbidity and mortality outcomes frequently diverge—many conditions cause illness without leading to death—and these different causes may respond differently to temperature. Also, deaths occur disproportionately among older adults, who may have other environmental exposures or underlying responses to environmental factors. In contrast, illness and poor health are more evenly distributed.

A separate branch of research analyzes the effect of extreme temperatures on morbidity. These studies show a different pattern than mortality findings, with women generally experiencing greater vulnerability to temperature extremes. In Indonesia, Fritz (2022) found that high-temperature days increased overall healthcare visits by 8%, with women showing higher utilization rates and more severe impacts, evidenced by increased referrals to advanced care. Women experienced particularly large increases in diabetes (25%) and cardiovascular disease visits (14%). As mentioned before, the relationship between climate change and obesity has also been studied. Trentinaglia et al. (2021) used data from 134 countries and found a U-shaped relationship between temperature and body mass; that is, body mass increased most in extreme cold and hot temperatures. The findings were more robust for girls and women. In developing countries, an increase of 1° C led to a 5% increase in body mass index (BMI) for girls and 2% for women. Meanwhile, development and agricultural productivity played a mediating role in the effects on boys and men. No effect of precipitation on body mass was found. The main mechanism argued by the authors was the reduction of physical activity when facing extreme temperatures, where a gender gap was found to get larger in more extreme temperatures. Chen and Qin (2022) provide additional evidence of gender disparities in physical health impacts among elderly Chinese. While heat exposure showed similar effects across genders, extremely cold temperatures disproportionately affected women, significantly impairing their daily activities, increasing chronic disease prevalence, and negatively impacting cognitive function. Men showed no statistically significant effects on these outcomes during cold exposure.

Yang et al. (2021) studied the effects of temperature on both physical and mental health in China, particularly focusing on extreme hot and cold temperatures. The authors found that temperature and both measurements of health had a nonlinear relationship that followed an inverted U-curve. In terms of overall health, women were more likely to be negatively impacted by extremely cold temperatures and men by extremely hot temperatures. The authors argue the reason for this may be related to muscular and metabolic differences, which lead to different body surface temperatures between genders. As an additional indirect consequence of extreme temperatures, Ireland et al. (2023) explored the phenomenon in the context of the workforce, examining how extreme heat may impact workers' health in Australia. The main findings suggest a negative causal effect of high temperatures on health claims, mostly among manual workers in outdoor jobs. Subgroup analysis showed that, within each occupation, females were more negatively affected than men, although the gender difference was not statistically significant. The effect appeared to be constant over time, suggesting the ineffectiveness of adaptation measures.

As an alternative approach to studying how climate-related disasters can affect health, Loebach and Korinek (2019) examined the effects of Hurricane Mitch in Nicaragua, where individuals from households led by women experienced a higher probability of displacement to shelters. This displacement, in turn, increased the odds of suffering a respiratory disease among these households, disproportionately affecting households headed by women. Natural disasters increase mortality rates as well; a study using panel data from 141 countries over the period 1981 to 2002 found that natural disasters lowered the life expectancy of women more than that of men, and that this effect was stronger for women from a low socio-economic status (Neumayer & Plümper, 2007). Finally, Liao et al. (2020) studied the effect of flooding on infectious diarrheal disease in China. They found that children, males, and non-farmers were particularly vulnerable to flooding impacts. Although they did not study the mechanisms behind, the authors suggest that gender difference may be related to the male's hygiene habits and rescue efforts, which are more likely to lead to the exposure of diarrheal pathogens during the flood events.

3.1.3.4 Mental Health

Climate change may also affect mental health outcomes in heterogeneous ways among groups. Y. Xu et al. (2024), using panel data from Australia, found that extreme events (both droughts and high temperatures) increased total suicide rates, with stronger effects for younger men who were more vulnerable and in areas with higher percentages of Indigenous Peoples. Green space coverage (and to some extent higher incomes) moderated the drought and suicide relationship. On the other hand, comparing results from different studies appears to show that there is no conclusive evidence in terms of gender differences of the effect of climate shocks on mental health. Y. Xu et al. (2024) found that, while effects for women were not statistically significant for females overall, some groups were affected: suicide rates of both males and females aged 10–49 were both statistically significantly positively associated with extreme drought. However, higher monthly temperatures impacted only male suicide rates. Kabir et al. (2024) found that sea-level rise caused psychological distress among coastal communities in Bangladesh, where gender acted as a moderator of the effect, with particularly higher levels of distress experienced by women and older adults. However, Mitchell et al. (2024) found no gender difference in the Australian population when studying the effects of repeated climate disasters on mental health.

Regarding the effect of extreme temperatures on mental health and cognitive outcomes, studies indicate notable differences on mental health impacts. Extreme temperatures can trigger negative emotions and disrupt basic physiological functions: studies show that high temperatures reduce sleep duration, with particularly strong effects for women (Hajdu, 2024; Minor et al., 2022). Beyond physiological effects, extreme temperatures can compound stressors through increased physical illness and economic pressure. Research shows evidence of women's heightened vulnerability. Hua et al. (2023) found that temperatures above 30°C significantly increased depression likelihood among Chinese individuals, with women experiencing 50.7% larger effects than men compared to moderate temperatures (20-25°C). These gender disparities were further confirmed by Obradovich et al. (2018), who analyzed data from nearly 2 million US residents. Their study showed that shifts from moderate (25-30°C) to high temperatures

(>30°C) had approximately 1.6 times greater effect on women's mental health difficulties compared to men. This vulnerability was particularly pronounced among low-income women, who showed twice the mental health sensitivity to high temperatures compared to high-income men. Chen et al. (2023) further revealed gender differences in cold temperature vulnerability by documenting that women's depression scores increased 4.8 times more than men's during periods of extreme cold exposure.

Beyond mental health, evidence also suggests that extreme temperatures can impair cognitive performance, with particularly pronounced effects in women. Yi et al. (2021) conducted a comprehensive study using nationally representative surveys in China, revealing that exposure to temperatures above 25°C reduced performance on both verbal and math tests among middle-aged and elderly adults. Notably, middle-aged women exhibited significantly greater heat stress-induced reductions in cognitive test scores compared to their male counterparts. However, Yin et al. (2024) also studied the effect of extreme temperatures on cognitive function in China and found contrasting results. Their gender analysis showed that males were more vulnerable to these extreme high-temperature effects, showing higher levels of temperature-induced cognitive decline. The authors hypothesized several factors—like skin moisture, blood flow, and metabolic rates—as the drivers of these gender differences.

3.1.4 Poverty, Livelihoods, and Sustainable Development

Several studies provide evidence of significantly stronger causal effects of climate change shocks on women, particularly in dimensions related to poverty and welfare. Mahajan (2017) examined the differential impact of rainfall shocks on male and female wages in Indian agriculture, focusing on women's role in rice cultivation and found that in rainfed areas, female wages increased more than male wages during periods of abundant rainfall, as women's labor is more critical in rice production. Similarly, Alfani et al. (2024) employed data from Morocco and found that severe and extreme drought events led to job displacement and medium-term increases in unemployment, with stronger effects for women. Li and Pan (2021), reported that high-temperature shocks in rural China disproportionately affected women, who are more likely than men to reduce working hours in agricultural jobs and shift to non-agricultural work as an adaptation strategy to extreme heat. Quisumbing et al. (2018) found that drought shocks had a negative and significant impact on wives' non-land assets in Uganda, and it appeared that households affected were coping by disposing of their wives' non-land assets. Conversely, some evidence argues that, in some contexts, climate change could affect men more than women's assets, as they are critical to agricultural activities (Rakib & Matz, 2016).

Another interesting study investigated the gender-differentiated effects of a cyclone in India. The study, which focused on consumption, found that the cyclone significantly reduced household consumption, with the largest decreases observed for women (Christian et al., 2019). In another example, Asfaw and Maggio (2018) reported that in Malawi high temperature shocks disrupted households' food consumption and caloric intake, as well as non-food consumption, when plots in the household were solely managed by women. In terms of food security, a study from India found that the consequences of a drought were more severe for female-headed households in fat consumption, while there were no significant differences in the reduction of other groups of food compared to men (Carpena, 2019). Finally, Chowdhury et al. (2022), using evidence from India, reported that flood damage affected female agricultural employment more negatively than males' in the long run. Women also suffered disproportionately in obtaining employment in the non-agricultural sector in the aftermath of the shock, as gender norms discouraged them from migrating or engaging in economic activities.

In contrast, Liu and Lin (2023), using panel data techniques for a sample of countries, found that global warming affected unemployment heterogeneously across nations based on geographic factors. However, in cases where unemployment was negatively affected, only men experienced these impacts, not women. This discrepancy with prior findings may stem from weaker identification strategies in country-level analyses or from the focus on formal labor markets, where men's higher participation in formal labor markets could lead to stronger observed effects.

Effects of Climate Change on Human Capital

Climate change can affect human capital accumulation through several channels: direct health impacts, effects on school supply, and income effects within households. Additionally, the income effects may influence child labor, study-time, both in and outside school, and investments in complementary educational inputs.

Regarding the effects on educational outcomes, using data from India, Joshi (2019) showed that girls were more negatively affected by droughts in terms of educational performance compared to boys. Similarly, Björkman-Nyqvist (2013) showed how variations in rainfall can affect the enrollment of girls and boys in schools, mainly because rainfall stimulated shocks to household income, leading to lower enrollment and a decline in children's academic performance. This study found negative effects on school performance mainly in girls, even when education is free. These results show how households respond to income shocks by varying the resources allocated to girls' education, while boys continue their education even in situations of income scarcity. In a similar study, Groppo and Kraehnert (2017) documented the adverse effects of climate shocks, specifically livestock mortality, on educational outcomes in Mongolia. Although they did not find gender-differentiated effects, the study identified that the negative impacts on education stemmed from declines in household income rather than school closures or increased child labor. Garg et al. (2020), also using data from India, found negative effects of heat on test scores. While they did not report gender-differentiated impacts, their findings suggest that economic mechanisms drove these effects. Another study with no gender difference in educational outcomes was conducted by Nübler et. al., (2021), where the authors found that early life rainfall shocks reduced both achievement and cognitive test scores for both girls and boys in Kenya.

In contrast, Miller and Hui (2022), using data from California, estimated significant negative impacts of wildfire-related school closures on the academic performance of grades 3–5 students, particularly in mathematics and English for African American children. Differences between these results and those of Garg et al. (2020) may reflect the importance of school attendance and quality in high-income countries compared to poorer settings. Hamlet et al. (2021), using data from India, showed that increased time spent fetching water due to water scarcity had a more significant negative impact on girls' test scores than boys', as girls are more likely to be tasked with water collection. Several studies using detailed administrative data have examined the effects of heat on test scores. Marchetta et al. (2019) found rainfall shocks and cyclones negatively affected cognitive test scores for all children and the probability of attending school and encouraged girls more than boys to enter the workforce. Analyzing data from the U.S., Park et al. (2020) found no gender-differentiated effects but did identify significantly larger impacts on minority students, including African American children. They attributed these disparities to higher exposure to heat and inadequate infrastructure, particularly lack of air conditioning, in schools serving minority populations.

There is also literature about the effects of early-life climate related shocks on long term schooling, health, and economic outcomes by gender. Using data from Indonesia, Maccini and Yang (2009) found that early-life rainfall had positive and significant effects on women's health, schooling, and socioeconomic status, while there was no statistically significant relationship in the case of men. The results showed a stronger relationship for birth year rainfall than for the following years, highlighting that this effect may be driven in part by how rainfall relates to the quality of nutrition in early infancy. Authors argue in favor of a chain of causations that starts from early-life rainfall, then to infant health, to educational level, to adult socioeconomic level, showing an intricate connection between these outcomes. Evidence from rural Vietnam showed that above-average rainfall was associated with an increase in the likelihood that children enter work. Here, the authors found that boys experienced an increase in the probability of entering agricultural work while girls were more likely to undertake chores (Trinh et. al., 2020). Interestingly, Shah and Steinberg (2017) focused only on the human capital component in a sample of rural India and, contrary to Maccini and Yang (2009), found no gender difference and that people who were exposed to more rainfall during school years had less years of schooling and lower wages in the long term. This result is explained because in years of more rain, agricultural work yields higher returns, and thus children and mothers report a higher likelihood of work during these types of years, at the expense of attending school.

Natural disasters may also have long-lasting effects on education and other socioeconomic outcomes. Hussain and Mukhopadhyay (2024), analyzing data from India, found that natural disasters —such as floods, hailstorms, and droughts— negatively impacted educational attainment, with stronger and more precisely estimated effects for women and minorities. These findings suggest similarities with other contexts, such as Latin America and the Caribbean. Some studies have found gender differences in these negative effects among boys and girls, mainly due to decision making structures in households. Deuchert and Felbe (2015) focused on the short and long-run effects on education and health of children exposed to a typhoon in the Philippines. They found negative and persistent effects only on education, and that the effects were stronger in girls than in boys. The authors argued this effect was possibly driven by a shift in parental investment decisions to cope with the economic damages of the natural disaster, having to sacrifice their children's schooling. Similarly, Dessy et al. (2023) studied Malawi and Indonesia separately and found that patrilocal households—where sons co-reside with their parents after marriage and are expected to provide old-age support—were more likely to sacrifice their daughters' schooling in favor of sons during periods of drought, particularly when schooling entailed the payment of fees. In contrast, matrilocal households—where daughters remain with their parents after marriage—did not exhibit this pattern. The authors argued that these findings were driven by disparities in women's empowerment and the extent of son preference between matrilocal and patrilocal groups.

Caruso (2017) studied the exposure in childhood to natural disasters in several countries of Latin America and showed that children born to mothers that had lived through a disaster had less education and an increased probability of child labor. These results point in favor of the existence of an intergenerational transmission of the effects of these climate related shocks. Le and Nguyen (2023), used panel data from 28 African countries to show that rainfall exposure during the first thousand days of life significantly influences women's long-term educational attainment. The effects were particularly pronounced during the agricultural season in low-income countries and in areas with poor market integration. These findings align with the studies by Groppo and Kraehnert (2017) and Garg et al. (2020), underscoring the role of economic consequences in explaining the negative impacts of climate shocks on human capital accumulation. Similarly, climate change can affect households in several ways. In a paper that found no heterogeneity by gender or race, Raker (2022) studied the effects of a hurricane in the U.S. The study suggests that intense household disruption and home damage were universal mechanisms driving these effects, overwhelming potential heterogeneities.

Moving now to the effects of climate shocks for adult populations, Yin et al. (2024), used data from China and found that extremely high temperatures negatively affected cognitive function, with stronger impacts on men. The study attributed these results to biological differences, such as higher skin moisture, blood flow rates, and metabolic rates in males under high-temperature conditions. Conversely, Yi et al. (2021), also with data from China, reported stronger effects of heat on cognitive function among middle-aged women, particularly in verbal test scores, whereas math test scores showed smaller or no significant gender differences. The reasons for these discrepancies are unclear, warranting further research. Finally, Ireland et al. (2023), using a long panel data for Australia, found that extreme heat negatively affected cognition, learning, and task performance, with the effects within occupations being stronger for female than for males (the within occupation part is key because if one considers general patterns, men tend to work more often in occupations that are more affected by heat).

3.1.5 Human Dimension

Causal literature that relates climate shocks with increased risk of conflict for women, Indigenous Peoples, and Afro-descendants was found to be scarce. The study that most closely relates to this dimension was Sekhri and Storeygard (2014), that studied the effects of rainfall shocks on dowry deaths in India. The authors found that a one standard deviation decline in annual rainfall increased deaths of married women who are murdered over disputes about dowry by almost 8%. In the study, there appeared to be a consumption smoothing mechanism affecting the behavior of husbands towards seeking the monetary value of the dowry. Similarly, Miguel (2005) found that, in rural Tanzania, extreme rainfall (drought or flood) provoked a large increase in elderly women' murders, typically killed by relatives as a response to poverty.

Climate change may also affect welfare through several dimensions related to time use. One of them is sleep time. Hajdu (2024), using data for Hungary, documented how high temperature affected sleep duration, identifying negative effects that were stronger for men than for women. In contrast, Minor et al. (2022) using a global sample, found that the effects of temperature on the quantity and quality of sleep were stronger for women than for men. Finally, H. Yu et al. (2023), using data from first year university students in China, found significant effects of temperature on physical activity and sleep duration with no differences between male and female students. Both genders showed increased physical activity and decreased sleep duration with rising temperatures (the effect was slightly higher for women but is not statistically significant). In other dimensions of time use, Carr et al. (2024) studied the effect of climate conditions on self-reported water collection times using panel data models for subnational regions, finding that reduced precipitation and increased temperatures affected collection time for women. Boyd (2023) documented that increased time variability in India affected time use of mothers, but without affecting children's outcomes. Using panel data from Pakistan, Akter (2021) found that village-level flood inundation depth changed the time allocation of men and women towards a more egalitarian distribution of time with respect to both productive and reproductive hours. The shift was stronger the higher the level of women's decision-making power and depended on men's beliefs about gender equality. Maitra and Tagat (2024) found that precipitation changed the time allocation of men and women, as rainfall shortages resulted in men allocating more time in agriculture while women, in contrast, spent less time attending educational institutions and increased the time they allocated to domestic duties. Conversely, using data from West-Central and East and Southern Africa, Nico and Azzarri (2022) found that both droughts and heat waves reduced the number of hours worked in agriculture, however the reduction was lower for women.

Another dimension where climate change had negative effects was on migration patterns. Defrance et al. (2023), using panel data from Mali, showed that droughts affected net migration with similar effects for men and women. Using data from Indian workers, Afridi et al. (2022) found that women's workdays were 19% lower than men's after a drought. This effect was likely driven by the limited opportunities for females to migrate and work outside their village, thus lowering their ability to diversify their workdays towards the non-farm sector. The authors provided evidence of the role that gender norms played in limiting women's labor mobility. Halliday (2012) showed similar results for a sample of workers from rural El Salvador, where male migration to the US increased and female migration decreased following adverse agricultural productivity shocks caused by droughts and earthquakes. A study from Tanzania supports this argument, as the author found that adverse temperature shocks reduced long-term migration among men due to migration costs. However, they did not affect females' decisions because they were largely motivated by marriage and family rather than work (Hirvonen, 2016). Bohra-Mishra et al. (2017), using panel data from the Philippines, reported that migration decisions of males, younger individuals, and those with higher levels of education were more sensitive to rising temperature and typhoons, following a decline in agricultural productivity. Similarly, Dillon et. al. (2011), using data from Nigeria, showed that men were more likely to migrate to mitigate both ex ante and ex post agricultural risk, especially in the presence of more frequent hot shocks. These findings suggest that households use migration as a risk management strategy in response to risk, but that migration responses are gender specific. However, when studying intra-national migration in a large sample of youth migrants in Central America and the Caribbean, Baez et al. (2017) only found a positive significant effect on migration of women to a provincial capital in response to heat exposure. The authors explained this finding by suggesting that households may rely on women to diversify risk and generate supplementary income, as the opportunity cost of a young woman's absence is often perceived to be lower than that of a man. Gray and Mueller (2012), using data from rural Ethiopia, found that droughts had an asymmetric impact on migration by gender: while labor related migration increased for men, marriage related migration decreased for women, potentially due to the costs associated with marriage during times of resource scarcity. Becerra-Valbuena and Millock (2021) also presented a series of mixed results using data for the effect of drought on migration patterns by gender in Malawi. Drought increased work-related migration for younger women while decreasing child marriage rates. Older women showed higher marriage-related migration within districts. This age pattern is reasonable and consistent with the previous results in Ethiopia.

Following with effects on child marriage, Caruso et al. (2024) found with data from Malawi that droughts increased women's probability of being married by the age of 18. Another study conducted in Madagascar showed similar results, as the authors found that drought occurring in the agricultural season increased the fertility of young women living in agricultural households, but did not affect marriage time, which provoked a reduction of female agricultural income (Dessy et. al., 2020). Corno et al. (2020) showed similar results when analyzing this same relationship across Sub-Saharan Africa, with an increase of the annual hazard into child marriage of 3%, but a reduction of 4% for the sample of women in India. The comparison between these two samples is interesting because it helps to dive into some possible mechanisms of these effects, thanks to their differences in cultural traditions. In India, the bride's family typically pays an amount of money to the groom for the marriage; in contrast, in Sub-Saharan Africa the monetary transfer is received by the bride's family. The authors frame the result in a model of the marriage market where parents decide when their children marry to smooth consumption when facing an income shock—that in this case takes the form of a drought—, so Indian families will prefer to delay the marriage, and African families will push it forward.

3.2 Adaptation

3.2.1 Ecosystems and Their Products

Agricultural systems are particularly vulnerable to climate change as they depend on temperature and water patterns. The disruption of those patterns in the form of droughts, floods, heatwaves, and other extreme weather events fueled by climate change make adapting agricultural systems to more hostile conditions an increasingly important issue. In this context, women face opportunities and challenges for adaptation. While traditional roles—such as serving as seed custodians—can position women to effectively promote new technologies, restrictive customs and legal frameworks, including limited access to credit or land tenure, often constrain their ability to adapt.

We only found one source of experimental evidence from Dar et al. (2020) in Eastern India on these topics. The authors provided climate-resilient seeds and quality seed production training to randomly selected treatment farmers and explicitly considered the differential effect on females and males. The study found that female farmers responded more than males to quality seed production training and that such programs complemented the adoption of drought-tolerant seeds. Although the study found no evidence of gender being a significant determinant in the direct adoption of such seeds, there was evidence that training on quality seed production leads to greater adoption of improved seeds by female farmers compared to males in both the extensive and intensive margins. Moreover, a study by Shikuku (2019) in Uganda suggests that training female farmers had a more substantial effect than training male farmers on disseminating information on climate-smart agriculture practices, which translated into higher adoption of improved maize varieties.

There is a considerable amount of quasi-experimental evidence on women's adoption of adaptation strategies to climate change. In Kenya, Ngigi et al. (2017) found clear gender roles influencing climate change adaptation. Wives typically adopted agriculture-related strategies while husbands focused on agroforestry and livestock. Additionally, wives' perception of climate risks and trust in information affected the decision to adopt adaptation strategies individually and at the household level, but it was the social capital of the husbands—not of the wives—that affected adoption. In Kenya, Uganda, and Senegal, Ginbo and Hansson (2023) found that higher risk perceptions of climate change by females led to potentially higher adoption of climate-smart agriculture (CSA) if they had the means to act but took the lower baseline adoption of female farmers as a given. Similarly, Agamile et al. (2021) found that weather shocks in Uganda allowed women to enter the commercial crop market by allocating land from subsistence to income-generating crops.

In contrast, Fisher and Kandiwa (2014) studied adaptation in Malawi and found that the probability of adopting modern maize was between 11-12% lower for females relative to male farmers. Similarly, using evidence from Nigeria, Kolapo and Kolapo (2023) found that the adoption of mitigation strategies decreases with female farmers. The authors suggest that this might be due to farm size, with female farmers having smaller farms and farm size being a significant predictor, yet this is already controlled for in the estimation. Better evidence on barriers to adaptation is found in Malawi by Lovo (2016), who concluded that insecure land tenure reduced women's investments in land adaptation strategies, specifically in soil conservation, while the reduction in men was not statistically significant.

Apart from the evidence on determinants of adoption of adaptation strategies, we also found quasi-experimental evidence on the effect of such strategies on women. In Ethiopia, Teklewold et al. (2019) found that female-led households that adapted not only improved on food diversity, per capita calorie consumption, and per capita protein consumption, but did so more than male-led households. In Togo, Koudjom (2022) found that adaptation strategies employed more by men and married women than by unmarried women led the former to higher productivity. Moreover, in Malawi, Nigeria, Tanzania, and Uganda, Azzarri and Nico (2022) related training through agricultural extension services to agriculture outcomes and found that women beneficiaries—on their own or jointly with men—yielded higher results than only-men beneficiaries and that the effect was greatest when controlling for climate-related shocks. In contrast, Warinda et al. (2020) studied more than one hundred projects in 15 years in five African countries. They found that agricultural interventions increased female farmers´ income but the comparison with male farmers showed significant variations. In Burundi and Tanzania, females´ income increased more, in Kenya and Rwanda less, and in Uganda it was virtually the same. Another study in Uganda by Maggio et al. (2021) also found positive, yet no clear, gender-differential effects of intercropping and organic fertilizer on the value of crop production.

3.2.2 Cities, Settlements, and Infrastructure

There is scarce evidence on the causal heterogeneity of adaptation related to investments in more resilient cities. In this section, we identified only two causal studies. L. Xu et al. (2024) estimated the impacts of implementing the Smart Cities Initiative (SCI)[8] on child development outcomes in China. These initiatives involve leveraging Information and Communication Technologies (5G, the Internet of Things, Big Data, and Artificial Intelligence) to enhance urban functionality through improved planning. The authors found

8. According to the World Bank, sustainable cities are "resilient cities that are able to adapt to, mitigate, and promote economic, social, and environmental change". Source: https://www.worldbank.org/en/region/eca/brief/sustainable-cities-initiative

a positive impact of SCI, including reduced stunting and improved weight-to-height ratios. While their heterogeneous analysis suggested a slightly smaller impact for girls—consistent with prior studies documenting gender bias favoring boys in Chinese families—the point estimates were very similar, and the authors did not report whether the difference was statistically significant. Therefore, further research is needed to assess whether SCI has differential impacts across genders in China and other contexts.

Hamlet et al. (2021) examined the effect of reduced water collection time on learning achievements in India, finding that decreasing the time spent collecting water among primary school children had a more significant positive impact on girls, improving their performance in both mathematics and reading. Furthermore, the study also found that when women spent less time fetching water, the children's academic performance in their household improved. These findings suggest that water access and infrastructure investments may enhance educational outcomes and help reduce gender gaps in education.

We found no study in other contexts or specifically addressing Indigenous or Afro-descendant populations.

3.2.3 Poverty, Livelihoods, and Sustainable Development

We found quasi-experimental evidence that examined the role of financial tools and vehicles in mitigating the impacts of natural disasters on women. For instance, Christian et al. (2019) analyzed the protective effects over consumption of a rural livelihoods intervention related to microfinance in the context of Cyclone Phailin in India. While the microfinance intervention had no apparent overall effects, it mitigated some reductions in non-food expenditures and women's consumption, though food expenditures remained unaffected. Although the estimated impact on women's consumption was not statistically significant, it was approximately half the size of the double-difference estimate without the program, which suggests that the intervention may have buffered the impact of Phailin for some women. In another example, Abedifar et al. (2024) found that after an unexpected flood in Iran, female farmers were 1.27% less likely to receive new loans after the flood, which evidenced the credit constraints faced by women. However, if they had a prior relationship with their bank branch, they were 1.06% more likely to receive recovery loans than their male counterpart, which suggests that women may be better at establishing trust-based financial relationships, and this prior relationship could improve women's access to credit during catastrophes. Along the same line, Chatterjee and Merfeld (2021) provided evidence that introducing a national workfare program in India—a society with a strong son preference—enabled rural households to mitigate income risks during adverse years. This program also attenuated the effects of agricultural income shocks on the sex selection of infants and reduced gender gaps in child health investments.

In a broader context, Doku (2024), using panel data from 46 Sub-Saharan African (SSA) countries, found that climate finance decreased the impact of weather shocks on gender inequality in both the short and long run. The study showed that controlling corruption and strengthening institutions can enhance the efficacy of climate funds and reduce gender inequality. This suggests climate finance[9] helps mitigate and adapt to climate change and bridges the gender gap in these contexts. In addition, Issoufou-Ahmed and Sebri (2024) showed that income inequality was exacerbated by vulnerability to climate change. They also found that the adverse effect of climate change on income inequality was further compounded through the agriculture sector, while it was alleviated via education and gender channels. Thus, the authors argue that empowering women in agriculture and other economic sectors could help climate adaptation.

In the migration and remittance context, Obi et al. (2020), using data from Nigeria, found that households with connections to international migrants—and therefore a higher probability of receiving remittances—had better capability to maintain food security when facing adverse climate shocks in both the short and long term. While the study did not directly analyze the effects on women, it argued that this impact is crucial for them, as women are more vulnerable to food insecurity than men. Women head the majority of remittance-receiving households, particularly older females likely to be widowed or divorced. In this regard, Tibesigwa et al. (2015) also argued that male-headed households are more food secure than female-headed ones, with the latter depending more on agriculture, which is more pronounced in rural areas. The main mechanisms argued by Obi et al. (2020) to explain these findings were that receiving remittances lowers the probability of adopting unhealthy coping strategies and reduces concerns about food insecurity due to economic reasons.

Finally, in the labor context, a study less related to our groups explored the response of crop workers to heat exposure under different payment structures by gender in California. Pan et al. (2021) found no significant gender differences when comparing fixed versus piece-rate payment contracts, using a matched sample to control for selection bias. However, the reasons behind the lack of gender differences were not explored.

Overall, the reviewed evidence focuses on India or sub-Saharan Africa, and we could not find evidence specifically addressing Indigenous Peoples or Afro-descendants. However, despite the limited evidence in this specific section, financial constraints consistently emerge as key barriers to adaptation and mitigation across all sections, especially for women, where we have the most evidence. This reinforces the importance

9. The study's climate finance data was based on OECD-DAC climate-related finance database.

of integrating gender-responsive financial strategies into adaptation policies and highlights the need for further research on the heterogeneous effects of different financial mechanisms in supporting climate adaptation for women, Indigenous Peoples, and Afro-descendant populations.

3.2.4 Health, Well-being, and Communities

Health, well-being, and community-related climate change adaptation include various strategies like heat action plans (HAPs), initiatives to combat malnutrition, vector control programs, improving water, sanitation, and hygiene (WaSH), syndromic surveillance, early warning systems, and integration with disaster risk reduction strategies, among others. However, within these approaches, the quantity and quality of research differ significantly. For example, although we found comparatively more causal evidence on heatwave-related adaptation strategies, we did not find anything causal on WaSH-related interventions. Additionally, much of the existing evidence concentrates on women, and studies explicitly addressing Indigenous Peoples and Afro-descendants remain limited.

3.2.4.1 Gender Differences

Research reveals some disparities in accessing and benefiting from adaptation measures, driven by structural barriers such as gender roles, unequal access to resources, and limited representation in decision-making processes.

Educational Interventions, Information Dissemination, and Early Warning Systems

Evidence suggests that education and community-based approaches may play an important role in climate adaptation for women, with varying effectiveness depending on the context. In China, Li et al. (2016; 2022) studied community-based intervention programs against heat waves on adults (Li et al., 2016) and children (Li et al., 2022). Li et al. (2016) found that heat protection education and public health measures significantly reduced the number of heat-related illnesses among adult women. Li et al. (2022) evaluated a primary school-based intervention program aimed at improving knowledge, attitudes, and practices (KAP) related to extreme heat and climate change. They found that the program effectively enhanced knowledge and behavior among both students and their parents. Boys showed slightly greater gains in KAP scores than girls, though the difference was not statistically significant. Mothers had higher improvements compared to fathers. Additionally, they suggest that improvement in children's cognition can promote parents' awareness and cognition, creating a virtuous circle.

Moving to the household level, we found evidence that climate risk perception significantly influences adaptation strategies on women. For instance, Ginbo and Hansson (2023) documented a gender gap in adaptation within households in sub-Saharan Africa. In their sample, about 63% of women and 71% of men adopted climate change adaptation strategies. The authors found that higher climate risk perception among female spouses relative to males reduced the gender adaptation gap by increasing the likelihood of women's adoption of soil and water conservation practices. Disparities in land ownership and access to weather information exacerbated the gap by increasing the likelihood of males adopting climate change adaptation, but not of females. These findings suggest that enhancing women's awareness of climate change risk and addressing structural gender inequalities in resources and information access could help close the gender gap in adaptation, reduce climate vulnerability, and foster sustainability in developing countries.

In rural Kenya, Ngigi et al. (2017) examined gender differences in climate adaptation strategies within households. They showed that wives were more likely to adopt crop-related strategies, while husbands preferred livestock and agroforestry practices. Additionally, the study also found that trust in information significantly influenced wives' decisions to adopt climate-smart practices, whereas access to multiple sources of agricultural information had less impact on husbands. These findings highlight the importance of designing gender sensitive policies and group-based approaches. In Vietnam, Binh et al. (2020) found that communication about risks and how to cope with floods changed household's risk perception, fear feelings, and therefore indirectly increased coping capacities for non-structural measures. However, women's participation in risk communication had no significant effect, which the authors argued could be attributed to the fact that women's participation was often passive. In fact, although women were encouraged to express their opinions in the public places during the training course, only 14.6% actively contributed, showing that "women´s participation" was actually mere presence. Therefore, men were still the final decision makers in the household. These findings suggest that without women's empowerment, the benefits of educational interventions could be undermined.

Additionally, related to how to present the information to make it more effective, Adebayo et al. (2020) compare the effectiveness of narrative versus didactic formats in educating pregnant women about climate change risks related to maternal and child health. They found that the narrative approach was significantly more effective across various measures, including perceived and actual knowledge, risk perception, self-efficacy, behavioral intentions, and subsequent information-seeking behavior. Although we just found this single study in the climate change context, it aligns with other studies in the area of health communication.

One specific policy widely implemented in many countries is employing early warning and alert systems, which aim to inform the public about extreme weather events and associated health risks. While just a few studies have assessed their overall effectiveness and heterogeneous impacts, emerging evidence highlights their role in influencing the behaviours of vulnerable groups and addressing climate-related health outcomes, particularly on heat waves. In Argentina, Rabassa et al. (2021) examined the direct behavioral impact of heat warnings, disseminated through various media outlets, on cycling trips. They found that all users older than 60 years and females of all ages were highly responsive to heat alerts, effectively reducing their daily trips. This suggests that information affects different social groups in different ways, especially more vulnerable targeted groups. Notably, women were not considered part of the vulnerable group in this case but were also affected as a spillover.

Similarly, Mehiriz et al. (2018) explored the effects of an automated phone warning and advisory system in Canada. They found that while the warnings increased awareness of heat protection measures and encouraged individuals to follow heat related recommendations, the reduction in health service usage was only significant among women, particularly those with chronic illnesses. Based on these findings, the authors suggested that phone warnings with specific guidelines could serve as an effective and low-cost method for reaching subpopulations more vulnerable to heat, which complement the existing warning systems rather than being a replacement. In contrast, Benmarhnia et al. (2016) evaluated the Montreal Heat Action Plans (HAPs), implemented in 2004 in Canada. These plans combined early alerts and advisories with emergency public health measures. The study found that HAPs significantly reduced heat wave-related mortality, although no significant gender differences were detected. Instead, the benefits were more pronounced among elderly populations and individuals living in low-education neighborhoods. The reason remains unexplored.

Decision Making and Women Political Empowerment

Several studies provide evidence that women's empowerment is a key driver for improving resilience to climate change and fostering development in different contexts. Moreover, some studies highlight that this impact is amplified with higher female education levels. However, structural barriers, such as persistent gender norms and limited representation in crucial political and administrative positions or corruption, remain significant obstacles to achieving the full potential of women's empowerment in addressing climate change. For instance, Grillos (2018), examined the role of women in pastoralist communities in Kenya and investigated whether increased involvement in environmental decision-making affected household and community resilience to climate change. She found that, at the community level, there was an increase in women's political awareness and participation in formal decision-making processes, yet this was not reflected in meaningful outcomes. However, at the household level, there was a significant and positive effect on drought preparedness actions, particularly through pre-emptive livestock sales. The key factor in the intervention's household-level success was the inclusion of a men's workshop, which emphasized the benefits of empowering women to engage in alternative income-generating activities. The author explained that the workshop aimed to frame empowerment as a positive-sum game from which both men and women could benefit. It is especially interesting that the men's workshop was included into the intervention at the direct request of women who had previously participated in the program, demonstrating their agency in shaping the initiative.

Moving to the impacts of women's empowerment and political representation, Foudjo and Keneck-Massil (2024) used a sample of 107 developed countries and found that women's political empowerment and female education significantly mitigated the negative effects of climate vulnerability on mortality and vaccination rates of children. The authors suggested that women's participation in the political sphere enhanced institutional quality, resulting in an effective allocation of resources to social sectors such as health and education, and promoted pro-environmental investment. Furthermore, the impact of women's political representation was amplified when accompanied by higher levels of female education. In the same line, Asongu et al. (2022), used panel data from 169 countries for the period from 1995 to 2017 and found that women's political empowerment significantly reduced vulnerability to climate change. This effect is most pronounced in upper-middle-income countries, Latin America, and small or fragile states. The study identified public spending on education, governance effectiveness, and education as key transmission channels.

A study that explores the impact of women's administrative and political representation on disaster mortality in India, by Chowdhury et al. (2024), found that women's administrative representation significantly reduced disaster mortality. However, these effects were observed with a lag, suggesting that the benefits of women's presence in senior-level public administration take time to materialize. The study identified two main mechanisms as critical pathways to improve resilience against disasters: improved educational outcomes—including higher enrollment and lower dropout rates for girls—and expanded employment opportunities for women—particularly in manufacturing industries. In contrast, the study did not find a significant effect when analyzing the impact of women's political representation on disaster mortality, which, according to the authors, was likely due to the persistently low number of women in state legislatures in India, a number insufficient to influence a significant change. These findings are particularly relevant to countries where women's political representation remains limited. In a related context, Javeed et al. (2022), analyzed manufacturing firms in China and found that increasing gender diversity on board can be beneficial to development of green market growth and corporate financing.

Finally, Dutta et al. (2024) used cross-sectional data from 83 countries and deepened previous studies, finding that women's representation in parliament had a significant and most effective impact on climate change policy outcomes in countries with low levels of corruption. However, the authors noted that this positive effect diminished as corruption increased and could eventually turn negative. In the same line, Lv et al. (2022), using annual data from 119 countries between 2002 and 2012, pointed out that female political representation in national parliaments and CO_2 emissions is conditioned by the governance quality. While female participation in politics decreased CO_2 emissions in high government-quality settings, it led to increases in CO_2 emissions in countries with poor governance.

Evidence from Specific Plans or Interventions on Health

We identified some studies that use quasi-experimental methods to explore the heterogeneous effects of various measures, interventions, or plans on women in the context of health adaptation. For instance, Hu et al. (2021) studied the effects of central heating on winter mortality in China. They found that protective effects were stronger for women than for men. Physiological differences, variations in exposure patterns, and differences in occupational exposure between genders may explain this disparity. In the cash transfers context, LaPointe et al. (2024) documented that the negative impacts of prenatal exposure to high-temperature shocks were significantly reduced for women receiving cash transfers through the Livelihood Empowerment Against Poverty (LEAP 1000) program in Ghana. This program targeted pregnant and lactating women living in rural households with the primary objective of reducing stunting among children during the first 1,000 days of life.

Lee and Zou (2024) used data from 207 counties over the period 2000–2020 to explore the impact of the energy transition (ET) on public health in children and adults. They did not find a significant gender difference in infant mortality, yet for adults it was significant. The coefficient for adult men was nearly twice that of adult women. The authors attributed this difference to social divisions of labour. While the childhood environment of girls and boys was almost the same, social divisions of labour intensified with age. Men were more likely to work outdoors and have more contact with energy, whereas women were more likely to work indoors in roles such as education or home care. As a result, men derived greater benefits, from the environmental improvements and cleaner air associated with the energy transition, than women.

Overall, we found that while some interventions demonstrate clear benefits for women, others exacerbate existing disparities. These findings highlight the importance of integrating gender consideration into climate change adaptation policies. Otherwise, gender norms and structural inequalities could shape the distribution of environmental and development benefits, perpetuating inequities and limiting the transformative potential of these interventions.

3.2.4.2 Indigenous Peoples and Land Ownership

Causal research on Indigenous Peoples remains limited, but we found two studies that highlight the critical importance of community ownership and traditional knowledge in adaptation strategies. A panel data analysis in Canada, by Zapata (2024), found that renewable energy projects were associated with higher levels of community well-being when Indigenous Peoples had majority ownerships. Conversely, projects with minority Indigenous ownership were linked to lower levels of community well-being. However, the channels through which this relationship occurred remain unidentified. Meanwhile, a study by Karim (2024) in Bangladesh, that used Indigenous knowledge as an instrumental variable to examine responsiveness of disaster preparedness, identified Indigenous knowledge and community-based training as critical drivers for improving knowledge and risk perception. They significantly enhance the Disaster Preparedness Index, which plays a crucial role in reducing household losses through unemployment and production channels during climate shocks.

Overall, the evidence reviewed shows important findings for adaptation, including the recognition of gender-sensitive adaptation strategies, the empowerment of women in decision-making processes, and the integration of community-based approaches to strengthen resilience. However, notable gaps remain, especially regarding the mechanisms behind the findings, which are often theorized but remain unevaluated in most cases. Additionally, significant gaps in knowledge persist concerning Indigenous Peoples and Afro-descendant communities, where we found much less causal evidence. In fact, causal studies on the impacts of adaptation strategies for Indigenous Peoples were very limited, and we did not find any evidence for Afro-descendant communities in this section. This absence highlights a critical concern in understanding the unique challenges and opportunities these groups face.

3.3 Mitigation

3.3.1 Energy

The adoption of low-carbon energy sources is fundamental for climate change mitigation. There is quasi-experimental evidence that women can play a particular role in transforming the energy system, particularly based on aggregate panel data methods. These methods adhere to the general eligibility criteria, but it is noted that when used with macro quantitative data they result in a weaker form of casual relation. Njangang et al. (2024) used panel data from 62 countries during thirteen years to study the effect of female parliamentarians on energy justice (partly composed of dependence on fossil fuels). The authors found a statistically significant positive effect of the percentage of seats held by women in national parliaments on an aggregate quantitative indicator of energy justice and on the three categories that comprise it. Among these categories, the effect on distributive justice (which contains the dependence on fossil fuels) came in the middle, while the effect on restorative justice was the strongest and on procedural justice the weakest. Similarly, Salamon (2023) used panel data from one hundred countries over twenty years to study the effect of women's parliamentary participation on renewable energy consumption. The author found that while the percentage of women in parliament reduced renewable energy consumption, the interaction with GDP per capita increased it. This implies that the total effect of the percentage of women in parliament on renewable energy consumption was negative in low- and mid-income countries and positive in high-income ones. Lastly, Opoku et al. (2021) used data from 36 African countries during sixteen years and found that there was no strong impact of women in parliament on renewable energy consumption.

Atif et al. (2020) also studied the effect of women's participation on renewable energy consumption but in company boards instead of national parliaments. The authors analyzed panel data on US firms in the S&P 1500 between 2008 and 2016 and found a positive effect of the percentage of women directors on the board on the percentage of renewable energy in the firm's total energy consumption. Focusing on CO2 emissions instead of energy consumption, McGee et al. (2020) studied the effect of a composite known as the Gender Inequality Index (GII) on country-level CO2 emissions using fixed effects with a panel of 140 countries over seven years. The authors found a positive relation between the GII and CO2 emissions (higher GII means more gender inequality), although the relation showed nuances associated with the degree of income of countries, as the interaction between GII and GDP per capita is stronger in low-income countries compared to high-income ones. Lastly, Lv & Deng (2019) used panel Autoregressive Distributed Lag Model ARDL with data on 72 countries during 1971-2012 to study the relation between the degree of women's political empowerment and the level of CO2 emissions and found a negative association between them. In particular, the authors found that a one-unit increase in the index of women empowerment led to an 11.5 % decrease in CO2 emissions.

Women might not only have different preferences towards renewable energy than men, but also a different disposition to change perceptions towards these technologies. In Komatsu et al. (2024), an RCT with 4,000 participants was conducted to study how information can change perceptions of offshore wind power generation. Although the authors found that women had a higher risk aversion than men at baseline, the provision of information had a significantly stronger effect on improving perceptions of risk in women, especially when the information was provided with age-tailored illustrations.

Heterogeneous effects may also arise in the differential impacts of mitigation efforts. Using panel data from 107 countries over a 21-year period, Lee and Zou (2024) examined the relationship between the energy transition and mortality rates, focusing on gender differences. They found that mitigation efforts had gender-differentiated effects among adults, with males experiencing a reduction in mortality roughly twice as large as that observed for females. The interpretation given was that the gendered-division of labor makes males more exposed to the negative impacts of fossil-based energy systems.

3.3.2 Agriculture, Forestry, and Other Land Use (AFOLU)

3.3.2.1 Indigenous Peoples and Afro-descendants

Indigenous Peoples are estimated to manage up to a quarter of the Earth's land surface, overlapping with 40% of protected areas (Garnett et al., 2018). Empowering Indigenous Peoples as stewards of their lands has significant potential to play a central role in climate change mitigation strategies related to Agriculture, Forestry, and Other Land Uses (AFOLU). This potential is rooted in the importance of ancestral territories to Indigenous Peoples' cultural identities and their collective land tenure systems. The argument suggests that, when empowered to manage their land, Indigenous Peoples are more likely to conserve their territories than non-Indigenous settlers.

Early studies on this topic primarily focused on the capacity of Indigenous Peoples to contribute to climate change mitigation by deterring deforestation in their territories. Methodologically, a key challenge in assessing the effectiveness of Indigenous stewardship as an institutional mechanism to reduce deforestation lies in the selective location of Indigenous territories. In some cases, these territories are situated in remote areas that would have experienced low levels of deforestation even in the absence of Indigenous stewardship; in other cases, they are located on the agricultural frontier, where deforestation pressure is high. However, a growing body of research has addressed this challenge by employing non-experimental methods of causal inference. Nepstad et al. (2006) pioneered the use of land on the outer perimeter of protected territories in Brazil (including national parks and Indigenous territories) as a counterfactual for the deforestation that would have occurred inside protected territories in the absence of protection. They found substantial impacts of protection between 1997 and 2000. While the ratio of deforestation inside to outside the perimeter was higher in national parks (20-fold) compared to Indigenous territories (8-fold), the authors noted that Indigenous territories were more extensive and more likely to be located on the agricultural frontier, where baseline deforestation levels are higher. This leads them to conclude that "Indigenous lands (...) are currently the most important barrier to Amazon deforestation" (Nepstad et al., 2006, p. 1).

Interestingly, the authors explored the hypothesis that Indigenous land use converges with non-Indigenous land use as Indigenous Peoples come into frequent contact with non-Indigenous settlers, potentially eroding the effects of Indigenous stewardship. They found a weak negative correlation between avoided deforestation and time since first contact, although even territories whose inhabitants were contacted two centuries ago exhibited lower deforestation rates compared to the surrounding areas. Further exploration of the relationship between exposure to non-Indigenous society and environmental stewardship represents an interesting avenue for future research on this topic.

More recently, several studies in Brazil have exploited the staggered formalization of Indigenous territories in the country to estimate the impact of Indigenous stewardship on various variables related to land-based climate change mitigation. This process, which implements the mandate in the 1988 Constitution to recognize Indigenous territories, involves several steps, with the last two being the demarcation of the territory and formal recognition by the Union. BenYishay et al. (2017) did not detect an impact of demarcation on the Normalized Difference Vegetation Index (NDVI)—a measure correlated with forest coverage and forest health. In contrast to BenYishay et al. (2017), Baragwanath and Bayi (2020) found a strong negative impact on deforestation using a larger sample. Their findings were robust to the bias inherent in two-way fixed effects estimators in staggered settings (Goodman-Bacon, 2021), which were used by BenYishay et al. (2017). More importantly for policy design, they showed that Indigenous stewardship was only effective after full recognition of territories. Territories that have been demarcated but not fully recognized exhibited no sharp reduction in deforestation at their boundaries. As noted by the authors, this aligns with Ostrom's (1990) principles for the successful management of Common Pool Resources, where the recognition of communities' rights to manage their commons plays a central role. In this context, formal recognition may have operated through granting Indigenous communities access to the Union's enforcement resources. Understanding the mechanisms through which formal recognition empowers Indigenous communities constitutes an important topic for future research to inform the design of Indigenous land policy.

In a similar study, Baragwanath et al. (2023) demonstrated that the impact of formalization extended beyond deterring deforestation. They found that full recognition of property rights also led to increased forest regeneration, with secondary forests growing at a higher rate and being older within Indigenous territories. These findings highlight that the contribution of Indigenous stewardship to climate mitigation is not limited to preserving existing carbon stocks but also extends to carbon uptake through forest regeneration. The authors further stressed the significance of the type of forest that regenerates within Indigenous territories, specifically focusing on native forests rather than monocultures, which some developing countries have promoted as part of their carbon uptake strategies. Native forests accumulate more carbon and provide greater ecosystem services at local and regional scales, underscoring the potential of Indigenous Peoples as strategic partners in achieving holistic restoration of degraded lands.

The displacement of deforestation from the inner to the outer periphery of Indigenous territories would violate the Stable Unit Treatment Value Assumption (SUTVA) of the Geographic Discontinuity Design used by Nepstad et al. (2006) and Baragwanath and Bayi (2020). A recent publication by West (2024) addressed this concern by matching Indigenous territories that have been granted full property rights to those that are set to obtain them in the future. Using a matching difference-in-differences method developed by Imai et al. (2023), West (2024) found a moderate but consistent reduction in deforestation inside Indigenous territories following full recognition, with no impact outside their boundaries. This suggests that spatial spillovers do not confound the findings of previous studies. Additionally, the study identified higher impacts of recognition in the Cerrado biome, located in the "arc of deforestation," where deforestation pressures are particularly high. These findings are consistent with Nepstad et al.'s (2006) early conclusion that Indigenous territories are especially effective in deterring deforestation at the agricultural frontier.

Few rigorous quantitative studies have estimated the impact of Indigenous stewardship outside of Brazil. Alejo et al. (2021) compared remotely sensed measures of carbon stocks on the inner and outer sides of Indigenous territories in the Amazon Basin across four countries (Colombia, Peru, Ecuador, and Brazil) as well as Panama. Interestingly, the analysis of carbon stocks captured all perturbations—or lack thereof—that are relevant from a climate mitigation perspective, including clear-cuts, thinning, forest degradation, and forest regeneration. The study found consistently higher levels of carbon stocks within Indigenous territories across all countries, with the largest impacts observed in Brazil and Panama.

Bonilla-Mejía and Higuera-Mendieta (2019) estimated the impact of protected areas in Colombia—including National and Regional Protected Areas, Indigenous territories, and Afro- descendant territories. They found a negative effect of Indigenous and Afro-descendant territories on deforestation rates. Interestingly, they observed that these territories' impact was larger in more remote municipalities, providing fewer public goods or displaying higher levels of violence, contrary to the findings for National Protected Areas. These results suggest that, in the context of Colombia, local communities fill the void created by low state capacity, acting as substitutes for national enforcement. This finding stands in sharp contrast to the complementarity between national and local institutions suggested by Bargwanath and Bayi (2020). Further research is needed to understand the factors that shape the relationship between local and national institutions in the context of forest conservation by Indigenous and Afro-descendant populations in Latin America.

In addition to directly impacting carbon stocks by reducing deforestation and promoting regeneration, Indigenous stewardship can help maintain carbon stocks in the ground by reducing the severity of wildfires. Bliege Bird et al. (2012) showed that the traditional use of hunting fires by the Martu people in Western Australia reduced both the geographical extent and severity of wildfires. These small, controlled burns helped manage the buildup of natural fuel that accumulates after rainy years. In turn, this led to higher levels of biodiversity in lands managed by the Martu. The authors concluded that Aboriginal hunters should be considered trophic facilitators and that policies aimed at preventing large wildfires should embrace traditional Indigenous practices, including the use of fire.

3.3.2.2 Gender Differences in Conservation Effort

In addition to recognizing and supporting property rights for local forest users, including Indigenous Peoples and Afro-descendants, policymakers have access to several market and non-market instruments to support carbon uptake through land-based climate actions. These include Command and Control (CC) measures and Payment for Ecosystem Services (PES), among others. A recent strand of literature has employed framed field experiments, where actual forest users participate in lab-in-the-field experiments simulating realistic forest-use social dilemmas, to assess the relative effectiveness of different policy instruments and how their success varies with modifications to the institutional context. Some of these studies have also explored gender differences in forest use and responsiveness to policy interventions.

In comparing the performance of Open Access (OA), Community Forest Management (CFM), CC, and payment for ecosystem services among forest users in Tanzania, Handberg and Angelsen (2015) found that while women harvested at higher rates under OA, they were significantly more responsive to the three incentive schemes. Cook et al. (2019) identified a related pattern at the aggregate level in a framed experiment on forest harvesting with forest users in Indonesia, Peru, and Tanzania. Groups that were randomly assigned to a gender parity treatment tended to harvest slightly more under OA but exhibited a larger reduction in harvest rates when a PES was introduced. Interestingly, these groups also shared the benefits of the PES program more broadly. This effect was not mediated by women's leadership but rather by the gender composition of the group. The authors argued that women advocated more strongly for a more egalitarian distribution of benefits by the group's leaders, who had unilateral discretion over benefit distribution under the experimental design.

Shifting the focus from deterring deforestation to forest restoration, two framed experiments in Vietnam provided evidence that women exerted more effort in a consequential conservation task involving the preparation of biodegradable bags with fertile soil for later seedling use in reforestation. Loft et al. (2019) showed that women were considerably more productive than men in this task, a finding they attributed to the task being culturally perceived as more appropriate for females. In a later study, Loft et al. (2020) replicated this finding in a separate framed experiment.

Among the cited studies exploring the interaction between gender and conservation efforts, only Cook et al. (2019) experimentally manipulated the gender composition of groups, allowing for causal interpretation. Further research is needed to understand how gender influences conservation efforts at both the individual and collective levels, as well as for individuals occupying different roles in local forest group associations. Specifically, there is significant room to improve our understanding of the elements that differentiate genders (e.g., preferences, gender roles, maternity, biology) and explain the heterogeneities observed in these studies.

While most of the papers reviewed focus on conservation efforts by suppliers of agricultural and forestry products, Perino and Schwirplies (2022) conducted an online experiment to study the impact of different nudges on the demand for red meat in Germany. As beef production constitutes a substantial driver of deforestation in the tropics (Curtis et al., 2018), interventions aimed at reducing beef consumption offer a valuable policy option for high-income countries seeking to lower the environmental footprint of their populations' consumption. The authors randomized participants into three treatment groups, each exposed to articles emphasizing the negative impacts of beef on health, climate, or animal welfare, as well as a control group exposed to a placebo article about unhealthy snacks in schools. Participants were asked to record their intentions to eat red meat and complete dietary diaries to measure behavioral responses before and after the intervention. At the aggregate level, only animal welfare treatment reduced red meat consumption. However, this aggregate impact masked an interesting heterogeneity by gender: women responded to the health and climate treatments, while women eating in company responded to all three treatment arms. This result replicates the findings of Czap et al. (2018), who observed that financial incentives in the context of a framed experiment on conservation in the United States had a greater effect on males than on females, whereas empathy nudges had no effect on males but strong effects on females. While the authors argue that women might be more susceptible to social pressures, leading to a higher sensibility to nudges, these results should be interpreted with caution, as neither gender nor company during meals was randomly assigned. Wolfson et al. (2022), provided stronger evidence on this regard: based on an RCT, they found that women in the United States responded more strongly to food labels emphasizing the climate impacts of food. Similarly, Piester et al. (2020) conducted an experiment in a university cafe in the United States and found that sustainable label messages in food significantly increased actual purchases of sustainable foods among women but had no effect on men.

Women representation in decision-making positions have been shown as an effective mechanism to obtain positive effects on environmental policy outcomes, not only in the public sector but in the private sector as well. There is a large body of literature that focuses on how the presence of women on private companies' boards might affect the environmental performance of the firms. For example, Kyaw et al. (2022) studied the relationship between board gender diversity—measured as the percentage of female directors on the board—and the environmental emissions of the firm. Their results showed that board gender diversity was positively associated with firms' emission reduction across industries in the US. The authors also found that a critical mass of at least three women on the board had a significant impact on the probability of having a superior environmental performance compared to other firms that did not reach this critical mass. For the European context, Nuber and Velte (2021) provided causal evidence of the effect that board gender diversity had on carbon emissions intensity, finding that emissions intensity declined with more female members on the board.

Interestingly, this study also argued the existence of a threshold for the number of female directors needed to influence environmental performance outputs, but here, the critical mass was of at least two female directors instead of three. This positive relationship between board gender diversity and environmental performance appeared to be valid for the case of Japan as well (Abedin et al. 2023). Elsayih et al. (2021) studied the impact of different variables related to corporate governance on carbon performance in Australian firms and found that board gender diversity lowered GHG emissions. However, in the case of the UK, board gender diversity had a positive relationship with carbon reduction initiatives but was unrelated to the emissions of the firm (Haque, 2017). A possible explanation for the discrepancy with the previous literature is that the carbon reduction initiatives adopted by firms in this sample may have had a short-term focus, with results difficult to verify, so effective GHG emissions reduction had not materialized through these policies.

The previous four studies omitted the banking sector, given the natural differences between this sector and other industries. To address this gap, Gallego-Sosa et al. (2020) conducted a study with 52 banks from the most polluting Western regions (Europe and North America) and found that having a higher number of women on the board did not positively affect the environmental performance of firms. However, they argue this result may be influenced by the low number of women directors in the sample analyzed, which aligns with the critical mass argument supported by Kyaw et al. (2022) and Nuber and Velte (2021). Given the limited sample size in Gallego-Sosa et al. (2020), there is still room to test the robustness of these results.

Board gender diversity also might have a positive effect on voluntary environmental disclosure of firms, either through their Carbon Disclosure Project (CDP) score (Hossain et al., 2017), or their Environmental, Social and Governance (ESG) disclosure score (Bhatia & Marwaha, 2022). Chakraborty and Dey (2023) found no relation between board gender diversity and carbon disclosure but argued this is likely driven by the low number of female directors in the sample and the family-business-dominated nature of the firms, which may not ensure efficient monitoring.

Environmental innovation was another dimension that was positively related to presence of female directors (Farza et al. 2022), where this positive causal effect of board gender diversity on environmental R&D expenditure can possibly be explained by the new environmental perspective women provide, and also the better social and governmental support firms with more presence of female director receive. Corporate gender diversity also appeared to reduce the environmental violations of firms, and presence of female CEOs showed similar effects but only in firms with low female board representation (Liu, 2018). This could be interpreted as a substitution relationship between female CEOs and directors, contrary to the complementarity between female directors and managers found at (Haque et al. 2024).

Up to this point, all the literature reviewed in this private sector context focused on the effects of female representation on one specific role within companies: the board of directors. To see if these effects expand through different positions, Altunbas et al. (2022) studied the effects that female managers had on the Green House Gas GHG emissions of a firm. The study provided causal evidence of a 0.5% decrease in emissions following a one-percentage-point increase in the percentage of female managers within a firm. Interestingly, the authors showed that this relationship was stronger if females were also well-represented in political institutions and civil society organizations in the country where the firm was based. The authors argued that women's more empathic behavior, social sensitivity, and risk-aversion help female managers to incorporate the environmental dimension in their decisions, therefore achieving lower CO2 emissions. The presence of both female directors and female executive managers also seemed to play a complementary role in each other, reinforcing positive effects on procedure-oriented carbon management performance and the real carbon emission reduction performance of firms (Haque et al., 2024).

3.3.3. Cities, Settlements, and Infrastructure

The reviewed papers did not include studies referring to cities, settlements, and infrastructure in the context of mitigation.

3.3.4 Cross-sectoral

Different fields have hypothesized that women are more caring, cooperative, and more risk-averse, relative to men, and that these characteristics can, in turn, affect pro-environmental behaviors. Causal evidence for this hypothesis is scarce but convincing in favor of the existence of a positive relationship between women and pro-environmental outcomes. For example, Kube et al. (2024), using an RCT with online participants in Germany, showed that women were more responsive to interventions promoting accurate risk perception and pro-environmental behavior, significantly increasing their intentions to act against climate change. Conversely, men exhibited resistance to changing their pro-environmental intentions.

Furthermore, a series of experimental studies reveal interesting gender-differentiated responses to various incentives for improving sustainability outcomes. Loft et al. (2020), conducting an experiment on payments for environmental conservation with participants from Vietnam, found that women exerted higher conservation efforts overall, significantly outperforming men across all treatments, even those perceived as unfair. Handberg and Angelsen (2015), using an experiment in Tanzania, also observed that women exhibited greater elasticity in response to conservation incentives. In addition, in a paper with cross-country data, Asongu et al. (2022) found that women's empowerment diminishes the country's vulnerability to climate change.

These studies suggest a pattern of more elastic responses among women to programs and incentives designed to promote adaptation and mitigation measures. We now turn to understanding if these inherent gender differences in environmental behaviors may translate into positive environmental outcomes, mostly GHG emissions reduction and climate policy, when women are in positions of power.

We first dive into studying if this relationship holds true in the public sector. Using an instrumental variables approach, Rios et al. (2024) showed that female political empowerment was positively associated with improved air quality in a sample of 27 European countries. The authors tested three potential mechanisms of the effect of female political empowerment and found that higher environmental policy stringency and institutional quality served as possible drivers of the main effect, while climate change awareness was found to be irrelevant. Mavisakalyan and Tarverdi (2019) directly tested one of these mechanisms using data for 91 countries, the authors show that higher female representation in national parliaments leads to more stringent climate change policies across countries, thereby resulting in lower carbon dioxide emissions. Kandemir et al. (2024), following a similar approach to Mavisakalyan & Tarverdi (2019) but using a sample of 160 countries over the period from 1997 to 2024, also found that female representation in national parliaments was a driving factor for more environmentally friendly fiscal policies. Fredriksson & Wang (2011) showed that this is also true in the case of the U.S House of Representatives. Using a regression discontinuity design, the authors found that female members voted more in favor of stricter environmental policies, relative to male legislators in a sample throughout 1970-1995. Dutta et al. (2024) deepened the analysis of the relationship between women in parliament and climate change policy outcomes, focusing on whether corruption mediates the effect. The authors showed evidence that the beneficial impact of women in parliament on climate change policy outcomes was more notable in countries with lower levels of corruption, whereas the effect might even become negative in those with the highest levels of corruption. This study provides evidence of cases where female presence might yield worse environmental outcomes. Similarly, Lv et al. (2022), using annual data from 119 countries between 2002 and 2012, found that the level of governance quality moderated the effect of increasing female political representation in national parliaments on CO_2 emissions.

There is an increasing body of literature that uses the Carbon Intensity of Well-being (CIWB), a ratio that measures the amount of carbon dioxide emissions per unit of life expectancy at birth, to examine ecological efficiency and inequality. Sileem and Al-Ayouty (2022), using data from 18 Middle East and North Africa region economies and Turkey over the period 1995–2018, explored the effect of gender equality on CIWB. They found that both female secondary education and female labor force participation reduced CIWB. These results contrast with those of Ergas et al. (2021), who analyzed data from seventy economies between 1995 and 2013 and found that female education reduces CIWB, but female labor force participation increases it. However, Sileem and Al-Ayouty (2022) suggest that this difference could be explained by the fact that Ergas et al. (2021) interacted the female labor force participation variable with the share of women in parliamentary seats, which is negative and may have reversed the sign of the effect.

Overall, evidence reviewed in this section showed support in favor of a positive causal relationship between women and both pro-environmental behaviors and climate policy outcomes. However, the mechanisms underlying these impacts remain less clear, and therefore, more research is needed. While some studies attributed the differences to intrinsic preferences or cultural traits, others highlighted variations in incentives driven by exposure to the consequences of climate change or disparities in knowledge and human capital related to specific practices. Nonetheless, all the evidence points to the critical role of women’s empowerment in facilitating adaptation to and mitigation of climate change.

4

Conclusions

This report has offered a comprehensive analysis on the association between climate change, gender, race and ethnicity issues. Overall, the findings from causal evidence reveal important impacts of climate change on women and in some extent in racial and ethnic groups and highlight the role of these populations in adaptation and mitigation strategies.

However, one of the most prominent limitations is the lack of disaggregated data and targeted research on specific communities, particularly Indigenous and Afro-descendant populations. Moreover, there is a lack of empirical evidence on the cultural impacts of climate change, particularly among Indigenous Peoples.

The effectiveness of adaptation measures also remains an area with space for further research. Although empirical evidence sheds light on the importance of adaptation, there are still methodological challenges in evaluating what works, for whom, and under which conditions. Similarly, there is limited evidence on the success of urban planning interventions and energy transition policies in vulnerable contexts, despite their frequent inclusion in policy agendas.

In the domain of climate mitigation, especially in relation to energy use and infrastructure, there are important gaps in our understanding. Some general literature assert that women and Indigenous Peoples have a smaller carbon footprint and consume energy more sustainably, but these claims lack consistent empirical support. More research is needed to determine whether these behaviors are structurally driven or context specific. Significant gaps exist regarding energy policies and their effectiveness in climate change mitigation.

Finally, there is a notably lack of evidence in Latin America and the Caribbean. Although we found relevant evidence in South America regarding the importance of recognize property rights and Indigenous stewardship of lands for environment conservation, some key areas still need more research, specifically those regarding the negative impacts and the adaptive capacity of vulnerable populations.

References

Abedifar, P., Kashizadeh, S. J., & Ongena, S. (2024). Flood, farms and credit: The role of branch banking in the era of climate change. *Journal Of Corporate Finance*, *85*, 102544. https://doi.org/10.1016/j.jcorpfin.2024.102544

Abedin, S. H., Subha, S., Anwar, M., Kabir, M. N., Tahat, Y. A., & Hossain, M. (2023). Environmental performance and corporate governance: evidence from Japan. *Sustainability*, *15*(4), 3273.

Adebayo, A. L., Mhonde, R. D., DeNicola, N., & Maibach, E. (2020). The Effectiveness of Narrative Versus Didactic Information Formats on Pregnant Women's Knowledge, Risk Perception, Self-Efficacy, and Information Seeking Related to Climate Change Health Risks. International *Journal of Environmental Research And Public Health, 17*(19), 6969.

Afridi, F., Mahajan, K., & Sangwan, N. (2022). The gendered effects of droughts: Production shocks and labor response in agriculture. *Labour Economics, 78,* 102227.

Agamile, P., Dimova, R., & Golan, J. (2021). Crop choice, drought and gender: new insights from smallholders' response to weather shocks in rural Uganda. *Journal of Agricultural Economics, 72*(3), 829-856.

Aguilar Revelo (2021). "La igualdad de género ante el cambio climático: ¿qué pueden hacer los mecanismos para el adelanto de las mujeres de América Latina y el Caribe?", serie Asuntos de Género, N° 159 (LC/TS.2021/79), Santiago, Comisión Económica para América Latina y el Caribe (CEPAL). https://www.cepal.org/es/publicaciones/46996-la-igualdad-genero-cambio-climatico-que-pueden-hacer-mecanismos-adelanto-mujeres

Ahsanuzzaman, N., & Islam, M. Q. (2020). Children's vulnerability to natural disasters: Evidence from natural experiments in Bangladesh. *World Development Perspectives*, 19, 100228. https://doi.org/10.1016/j.wdp.2020.100228

Ai, H., & Tan, X. (2023). The effects of exposure to high temperatures during pregnancy on adolescent mental health: Evidence from China. China Economic Review, 80, 101991.

Ai, H., & Tan, X. (2024). The impact of early-life exposure to high temperatures on child development: evidence from China. *Population And Environment, 46*(3).

Akter, S. (2021). Do catastrophic floods change the gender division of labor? Panel data evidence from Pakistan. *International Journal Of Disaster Risk Reduction, 60*, 102296.

Alejo, C., Meyer, C., Walker, W. S., Gorelik, S. R., Josse, C., Aragon-Osejo, J. L., Rios, S., Augusto, C., Llanos, A., Coomes, O. T., & Potvin, C. (2021). Are Indigenous territories effective natural climate solutions? A neotropical analysis using matching methods and geographic discontinuity designs. *PLoS ONE*, 16(7), e0245110. https://doi.org/10.1371/journal.pone.0245110

Alfani, F., Molini, V., Pallante, G., & Palma, A. (2024). Job displacement and reallocation failure. Evidence from climate shocks in Morocco. *European Review of Agricultural Economics*, *51*(1), 1-31.

Altunbas, Y., Gambacorta, L., Reghezza, A., & Velliscig, G. (2022). Does gender diversity in the workplace mitigate climate change? *Journal of Corporate Finance, 77*, 102303.

Andriano, L. (2023). On the Health Impacts of Climatic Shocks: How Heat Waves Reduce Birthweight in Sub-Saharan Africa. *Population And Development Review, 49*(4), 737-769.

Anttila-Hughes, J., & Hsiang, S. (2013). Destruction, disinvestment, and death: Economic and human losses following environmental disaster (Vol. 10). SSRN.

Asfaw, S., & Maggio, G. (2018). Gender, weather shocks and welfare: Evidence from Malawi. *The Journal of Development Studies*, *54*(2), 271-291.

Asongu, S. A., Messono, O. O., & Guttemberg, K. T. J. (2022). Women political empowerment and vulnerability to climate change: evidence from 169 countries. *Climatic Change*, *174*(3-4).

Atif, M., Hossain, M., Alam, M. S., & Goergen, M. (2020). Does board gender diversity affect renewable energy consumption? *Journal Of Corporate Finance, 66,* 101665. https://doi.org/10.1016/j.jcorpfin.2020.101665

Azzarri, C., & Nico, G. (2022). Sex-disaggregated agricultural extension and weather variability in Africa south of the Sahara. *World Development, 155,* 105897.

Baez, J., Caruso, G., Mueller, V., & Niu, C. (2017). Heat Exposure and Youth Migration in Central America and the Caribbean. *American Economic Review, 107*(5), 446-450.

Banerjee, R., & Maharaj, R. (2020). Heat, infant mortality, and adaptation: Evidence from India. *Journal Of Development Economics, 143*, 102378.

Baragwanath, K., & Bayi, E. (2020). Collective property rights reduce deforestation in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*, 117(34), 20495–20502. https://doi.org/10.1073/pnas.1917874117

Baragwanath, K., Bayi, E., & Shinde, N. (2023). Collective property rights lead to secondary forest growth in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*, 120(22). https://doi.org/10.1073/pnas.2221346120

Basu, R., Malig, B., & Ostro, B. (2010). High Ambient Temperature and the Risk of Preterm Delivery. *American Journal Of Epidemiology, 172*(10), 1108-1117.

Becerra-Valbuena, L. G., & Millock, K. (2021). Gendered migration responses to drought in Malawi. *Journal Of Demographic Economics, 87*(3), 437-477.

Benmarhnia, T., Bailey, Z., Kaiser, D., Auger, N., King, N., & Kaufman, J. S. (2016). A Difference-in-Differences Approach to Assess the Effect of a Heat Action Plan on Heat-Related Mortality, and Differences in Effectiveness According to Sex, Age, and Socioeconomic Status (Montreal, Quebec). *Environmental Health Perspectives, 124*(11), 1694-1699.

BenYishay, A., Heuser, S., Runfola, D., & Trichler, R. (2017). Indigenous land rights and deforestation: Evidence from the Brazilian Amazon. *Journal Of Environmental Economics And Management, 86*, 29-47.

Bernstein, A. S., Sun, S., Weinberger, K. R., Spangler, K. R., Sheffield, P. E., & Wellenius, G. A. (2022). Warm Season and Emergency Department Visits to U.S. Children's Hospitals. *Environmental Health Perspectives*, 130(1). https://doi.org/10.1289/ehp8083

Bhatia, S., & Marwaha, D. (2022). The Influence of Board Factors and Gender Diversity on the ESG Disclosure Score: A Study on Indian Companies. *Global Business Review, 23*(6), 1544-1557.

Binh, P. T., Zhu, X., Groeneveld, R. A., & Van Ierland, E. C. (2020). Risk communication, women's participation and flood mitigation in Vietnam: An experimental study. *Land Use Policy, 95*, 104436.

Bliege Bird, R., Codding, B. F., Kauhanen, P. G., & Bird, D. W. (2012). Aboriginal hunting buffers climate-driven fire-size variability in Australia's spinifex grasslands. *Proceedings of the National Academy of Sciences*, 109(26), 10287–10292. https://doi.org/10.1073/pnas.1204585109

Björkman-Nyqvist, M. (2013). Income shocks and gender gaps in education: Evidence from Uganda. *Journal of Development Economics*, *105*, 237-253.

Bohra-Mishra, P., Oppenheimer, M., Cai, R., Feng, S., & Licker, R. (2017). Climate variability and migration in the Philippines. *Population and environment, 38*(3), 286-308.

Bonilla-Mejía, L., & Higuera-Mendieta, I. (2019). Protected Areas under Weak Institutions: Evidence from Colombia. *World Development, 122*, 585-596.

Boyd, C. M. (2023). Rainfall, mothers' time use, and child nutrition: evidence from rural Uganda. *Population And Environment, 45*(3).

Bruckner, B., Hubacek, K., Shan, Y. et al. (2022).Impacts of poverty alleviation on national and global carbon emissions. *Nat Sustain* 5, 311–320 https://doi.org/10.1038/s41893-021-00842-z

Carleton, T., Jina, A., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., Hultgren, A., Kopp, R. E., McCusker, K. E., Nath, I., Rising, J., Rode, A., Seo, H. K., Viaene, A., Yuan, J., & Zhang, A. T. (2022). Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits. *The Quarterly Journal Of Economics, 137*(4), 2037-2105.

Carpena, F. (2019). How do droughts impact household food consumption and nutritional intake? A study of rural India. *World Development*, *122*, 349-369.

Carr, R., Kotz, M., Pichler, P., Weisz, H., Belmin, C., & Wenz, L. (2024). Climate change exacerbates the burden of water collection on women 's welfare globally. *Nature Climate Change, 14*(7), 700-706.

Carrillo, B. (2020). Early rainfall shocks and later-life outcomes: Evidence from Colombia. *The World Bank Economic Review*, *34*(1), 179-209.

Caruso, G. D. (2017). The legacy of natural disasters: The intergenerational impact of 100 years of disasters in Latin America. *Journal of Development Economics, 127*, 209-233.

Caruso, G., Mueller, V., & Villacis, A. (2024). Leveraging unsupervised machine learning to examine women's vulnerability to climate change. *Applied Economic Perspectives And Policy, 46*(4), 1355-1378.

Casas Varez, M. (2017). La transversalización del enfoque de género en las políticas públicas frente al cambio climático en América Latina. *Naciones Unidas*. https://www.cepal.org/es/publicaciones/41101-la-transversalizacion-enfoque-genero-politicas-publicas-frente-al-cambio

Chakraborty, R., & Dey, S. K. (2023). The effects of corporate governance mechanisms on voluntary corporate carbon disclosures: evidence from the emerging economy. *Journal of Economic and Administrative Sciences*.

Chatterjee, J., & Merfeld, J. D. (2021). Protecting girls from droughts with social safety nets. *World Development, 147*, 105624.

Chen, Y., & Qin, X. (2022). The Impact of Extreme Temperature Shocks on the Health Status of the Elderly in China. *International Journal Of Environmental Research And Public Health, 19*(23), 15729.

Chen, Y., Sun, R., Chen, X., & Qin, X. (2023). Does extreme temperature exposure take a toll on mental health? Evidence from the China Health and Retirement Longitudinal Study. *Environment And Development Economics, 28*(5), 486-510.

Chowdhury, J. R., Parida, Y., & Agarwal, P. (2022). How flood affects rural employment in India: A gender analysis. *International Journal of Disaster Risk Reduction*, *73*, 102881.

Chowdhury, J. R., Parida, Y., & Sahoo, P. K. (2024). Do women state legislators and administrators make any difference in preventing natural disaster mortality? Evidence from India. *Environment And Development Economics*, 1-22.

Christian, P., Kandpal, E., Palaniswamy, N., & Rao, V. (2019). Safety nets and natural disaster mitigation: evidence from cyclone Phailin in Odisha. *Climatic Change*, 153(1–2), 141–164. https://doi.org/10.1007/s10584-018-02364-8

Cil, G., & Cameron, T. A. (2017). Potential Climate Change Health Risks from Increases in Heat Waves: Abnormal Birth Outcomes and Adverse Maternal Health Conditions. *Risk Analysis, 37*(11), 2066-2079.

Cook, N. J., Grillos, T., & Andersson, K. P. (2019). Gender quotas increase the equality and effectiveness of climate policy interventions. *Nature Climate Change, 9*(4), 330-334.

Corno, L., Hildebrandt, N., & Voena, A. (2020). Age of Marriage, Weather Shocks, and the Direction of Marriage Payments. *Econometrica, 88*(3), 879-915.

Currie, J., & Rossin-Slater, M. (2013). Weathering the storm: Hurricanes and birth outcomes. *Journal Of Health Economics, 32*(3), 487-503.

Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. (2018). Classifying drivers of global forest loss. *Science, 361*(6407), 1108-1111.

Czap, N. V., Czap, H. J., Khachaturyan, M., & Burbach, M. E. (2018). Comparing Female and Male Response to Financial Incentives and Empathy Nudging in an Environmental Context. *Review Of Behavioral Economics, 5*(1), 61-84.

Dar, M. H., Waza, S. A., Nayak, S., Chakravorty, R., Zaidi, N. W., & Hossain, M. (2020). Gender focused training and knowledge enhances the adoption of climate resilient seeds. *Technology In Society, 63*, 101388.

Defrance, D., Delesalle, E., & Gubert, F. (2023). Migration response to drought in Mali. An analysis using panel data on Malian localities over the 1987-2009 period. *Environment and Development Economics, 28*(2), 171-190.

Dessy, S., Marchetta, F., Pongou, R., & Tiberti, L. (2020). *Climate shocks and teenage fertility* (No. 490). GLO Discussion Paper.

Dessy, S., Tiberti, L., & Zoundi, D. (2023). The gender education gap in developing countries: Roles of income shocks and culture. *Journal of Comparative Economics*, *51*(1), 160-180.

Deuchert, E., & Felfe, C. (2015). The tempest: Short-and long-term consequences of a natural disaster for children's development. *European Economic Review, 80,* 280-294.

Dillon, A., Mueller, V., & Salau, S. (2011). Migratory responses to agricultural risk in northern Nigeria. *American Journal of Agricultural Economics*, *93*(4), 1048-1061.

Doku, I. (2024). Rainfall Variability, Climate Finance and Gender Inequality: A Zoom in on Sub-saharan Africa Women. *International Journal Of Economics And Financial Issues, 14*(5), 210-219.

Dutta, N., Kar, S., & Jahan, I. (2024). Environmental policy implementation, gender, and corruption. *Economics Of Governance, 25*(2), 257-290.

Elsayih, J., Datt, R., & Tang, Q. (2021). Corporate governance and carbon emissions performance: empirical evidence from Australia. *Australasian Journal of Environmental Management*, *28*(4), 433-459.

Ergas, C., Greiner, P. T., McGee, J. A., & Clement, M. T. (2021). Does gender climate influence climate change? The multidimensionality of gender equality and its countervailing effects on the carbon intensity of well-being. *Sustainability*, *13*(7), 3956.

FAO (2021). Indigenous peoples, Afro-descendants and climate change in Latin America – Ten scalable experiences of intercultural collaboration. Santiago. https://doi.org/10.4060/cb4847en

Farza, K., Ftiti, Z., Hlioui, Z., Louhichi, W., & Omri, A. (2022). The Effect of Corporate Board Characteristics on Environmental Innovation. *Environmental Modeling & Assessment, 27*(6), 1021-1042.

Fisher, M., & Kandiwa, V. (2014). Can agricultural input subsidies reduce the gender gap in modern maize adoption? *Evidence from Malawi. Food Policy, 45*, 101-111.

Flatø, M., & Kotsadam, A. (2014). *Droughts and gender bias in infant mortality in sub-Saharan Africa* (No. 02/2014). Memorandum.

Foudjo, S. I., & Keneck-Massil, J. (2024). Climate vulnerability and child health outcomes in developing countries: Do women's political empowerment and female education make the difference? *Social Science & Medicine*, 351, 116979. https://doi.org/10.1016/j.socscimed.2024.116979

Fredriksson, P. G., & Wang, L. (2011). Sex and environmental policy in the US House of Representatives. *Economics Letters, 113*(3), 228-230.

Freudenreich, H., Aladysheva, A., & Brück, T. (2022). Weather shocks across seasons and child health: Evidence from a panel study in the Kyrgyz Republic. *World Development, 155*, 105801.

Fritz, M. (2022). Temperature and non-communicable diseases: Evidence from Indonesia's primary health care system. *Health Economics, 31*(11), 2445-2464.

Gallego-Sosa, C., Fernández-Torres, Y., & Gutiérrez-Fernández, M. (2020). Does Gender Diversity Affect the Environmental Performance of Banks? *Sustainability, 12*(23), 10172.

Garg, T., Jagnani, M., & Taraz, V. (2020). Temperature and human capital in India. *Journal of the Association of Environmental and Resource Economists*, *7*(6), 1113-1150.

Garnett, S. T., Burgess, N. D., Fa, J. E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C. J., Watson, J. E. M., Zander, K. K., Austin, B., Brondizio, E. S., Collier, N. F., Duncan, T., Ellis, E., Geyle, H., Jackson, M. V., Jonas, H., Malmer, P., McGowan, B., Sivongxay, A., & Leiper, I. (2018). A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability, 1*(7), 369-374.

Ginbo, T., & Hansson, H. (2023). Intra-household risk perceptions and climate change adaptation in sub-Saharan Africa. *European Review Of Agricultural Economics, 50*(3), 1039-1063.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal Of Econometrics, 225*(2), 254-277.

Gray, C., & Mueller, V. (2012). Drought and Population Mobility in Rural Ethiopia. *World Development*, 40(1), 134–145. https://doi.org/10.1016/j.worlddev.2011.05.023

Grillos, T. (2018). Women's participation in environmental decision-making: Quasi-experimental evidence from northern Kenya. *World Development, 108*, 115-130.

Groppo, V., & Kraehnert, K. (2017). The impact of extreme weather events on education. *Journal of Population Economics, 30*(2), 433-472.

Hajdu, T. (2024). Temperature exposure and sleep duration: Evidence from time use surveys. *Economics & Human Biology, 54*, 101401.

Halliday, T. J. (2012). Intra-household labor supply, migration, and subsistence constraints in a risky environment: Evidence from rural El Salvador. *European Economic Review, 56*(6), 1001-1019.

Hamlet, L. C., Chakrabarti, S., & Kaminsky, J. (2021). Reduced water collection time improves learning achievement among primary school children in India. *Water Research, 203*, 117527.

Handberg, Ø. N., & Angelsen, A. (2015). Experimental tests of tropical forest conservation measures. *Journal Of Economic Behavior & Organization, 118*, 346-359.

Haque, F. (2017). The effects of board characteristics and sustainable compensation policy on carbon performance of UK firms. *The British Accounting Review, 49*(3), 347-364.

Haque, F., Adjei-Mensah, G., Nguyen, T. H. H., & Ntim, C. G. (2024). Does gender diversity in corporate boards and executive management teams influence carbon performance? Evidence from Europe. *Accounting Forum*, 1-30.

Healy, J. P., Yazdi, M. D., Wei, Y., Qiu, X., Shtein, A., Dominici, F., Shi, L., & Schwartz, J. D. (2023). Seasonal Temperature Variability and Mortality in the Medicare Population. *Environmental Health Perspectives*, 131(7). https://doi.org/10.1289/ehp11588

Hirvonen, K. (2016). Temperature changes, household consumption, and internal migration: evidence from Tanzania. *American Journal of Agricultural Economics*, *98*(4), 1230-1249.

Hossain, M., Farooque, O. A., Momin, M. A., & Almotairy, O. (2017). Women in the boardroom and their impact on climate change related disclosure. *Social Responsibility Journal, 13*(4), 828-855.

Hu, J., Gong, W., Yin, P., He, G., Qin, M., Hou, Z., Meng, R., Zhou, C., Xiao, Y., Yu, M., Huang, B., Xu, X., Lin, L., Liu, T., Xiao, J., Hu, R., Jin, D., Zhao, Q., Xu, Y., . . . Ma, W. (2021). Central heating and winter mortality in China: A national study based on 364 Chinese locations. *Urban Climate, 41*, 101045.

Hua, Y., Qiu, Y., & Tan, X. (2023). The effects of temperature on mental health: evidence from China. *Journal Of Population Economics, 36*(3), 1293-1332.

Hussain, Y. R., & Mukhopadhyay, P. (2024). Impact of natural disasters on educational attainment in India: a panel data analysis. *Discover Sustainability, 5*(1).

Imai, K., Kim, I. S., & Wang, E. H. (2023). Matching methods for causal inference with time-series cross-sectional data. American Journal of Political Science, 67(3), 587-605.

Inter-American Development Bank Group (IDB). (2021). Climate Action Plan 2021-2025. https://publications.iadb.org/es/publications/english/viewer/Inter-American-Development-Bank-Group-Climate-Change-Action-Plan-2021-2025.pdf

Intergovernmental Panel on Climate Change (IPCC) (2014). Impacts, Adaptation and Vulnerability Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. United Nations. https://www.ipcc.ch/report/ar5/wg2/

Intergovernmental Panel on Climate Change (IPCC) (2022a). Annex I: Glossary [van Diemen, R., J.B.R. Matthews, V. Möller, J.S. Fuglestvedt, V. Masson-Delmotte, C. Méndez, A. Reisinger, S. Semenov (eds)]. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: www.doi.org/10.1017/9781009157926.020

Intergovernmental Panel on Climate Change (IPCC) (2022b). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem,

B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: www.doi.org/10.1017/9781009325844

Intergovernmental Panel on Climate Change (IPCC) (2022c). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: www.doi.org/10.1017/9781009157926

Intergovernmental Panel on Climate Change (IPCC) (2023). Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

Ireland, A., Johnston, D., & Knott, R. (2023). Heat and worker health. *Journal Of Health Economics, 91*, 102800.

Issoufou-Ahmed, O., & Sebri, M. (2024). On the transmission channels driving climate change-income inequality nexus in sub-Saharan African countries. *Business Strategy & Development, 7*(1).

Javeed, S. A., Teh, B. H., Ong, T. S., Chong, L. L., Abd Rahim, M. F. B., & Latief, R. (2022). How does green innovation strategy influence corporate financing? Corporate social responsibility and gender diversity play a moderating role. *International Journal of Environmental Research and Public Health*, *19*(14), 8724.

Joshi, K. (2019). The impact of drought on human capital in rural India. *Environment and Development Economics, 24*(04), 413–436. https://doi.org/10.1017/s1355770x19000123

Kabir, S., Newnham, E. A., Dewan, A., Islam, M. M., & Hamamura, T. (2024). Sea-level rise and mental health among coastal communities: A quantitative survey and conditional process analysis. *SSM - Population Health, 25*, 101640.

Kandemir, A. S., Lone, R. R., & Simsek, R. (2024). Women in Parliaments and Environmentally Friendly Fiscal Policies: A Global Analysis. *Sustainability*, *16*(17), 7669.

Karim, A. (2024). Knowledge, perception or disaster experience? The new determinants of household disaster preparedness behaviour in Bangladesh. *Journal Of International Development, 36*(6), 2557-2580.

Kc, A., Aleš, U., Basnet, O., Albert, K., Vaezghasemi, M., & Rodriguez, O. F. (2024). Effect of non-optimal ambient temperature on preterm birth stratified by social positioning in Nepal: A space–time-stratified case-crossover study. *Environmental Research, 258*, 119501.

Khatana, S. A. M., Werner, R. M., & Groeneveld, P. W. (2022). Association of Extreme Heat With All-Cause Mortality in the Contiguous US, 2008-2017. *JAMA Network Open, 5*(5), e2212957.

Kim, J., Lee, A., & Rossin-Slater, M. (2021). What to Expect When It Gets Hotter. American *Journal Of Health Economics, 7*(3), 281-305.

Kolapo, A., & Kolapo, A. J. (2023). Implementation of conservation agricultural practices as an effective response to mitigate climate change impact and boost crop productivity in Nigeria. *Journal Of Agriculture And Food Research, 12,* 100557.

Komatsu, H., Kubota, H., Asano, K., & Nagai, Y. (2024). Effect of information provision by familial nudging on attitudes toward offshore wind power. *PLoS ONE, 19(*1), e0297199. https://doi.org/10.1371/journal.pone.0297199

Koudjom, E. (2022). Climate change adaptation and maize productivity: a gender-based analysis. *Climatic Change*, *173*(1), 9.

Kube, T., Wullenkord, M., Rozenkrantz, L., Kramer, P., Lieb, S., & Menzel, C. (2024). How people update their beliefs about climate change: An experimental investigation of the optimistic update bias and how to reduce it. *Political Psychology, 45*(1), 175-192.

Kyaw, K., Treepongkaruna, S., & Jiraporn, P. (2022). Board gender diversity and environmental emissions. *Business Strategy and the Environment, 31*(7), 2871-2881.

LaPointe, S., Mendola, P., Lin, S., Tian, L., Bonell, A., Adamba, C., & Palermo, T. (2024). Impact of cash transfers on the association between prenatal exposures to high temperatures and low birthweight: Retrospective analysis from the LEAP 1000 study. *BJOG An International Journal Of Obstetrics & Gynaecology, 131*(5), 641-650.

Le, K., & Nguyen, M. (2023). Early-life rainfall and long-term human capital accumulation of African women. *Economic Development and Cultural Change, 72*(1), 361-387.

Lee, C., & Zou, J. (2024). Impacts of the energy transition on public health in the context of country risk: From an international perspective. *Economic Analysis And Policy, 83*, 873-895.

Li, C., & Pan, Z. (2021). How do extremely high temperatures affect labor market performance? Evidence from rural China. *Empirical Economics*, *61*(4), 2265-2291.

Li, J., Xu, X., Wang, J., Zhao, Y., Song, X. P., Liu, Z. D., Cao, L. N., Jiang, B. F., & Liu, Q. Y. (2016). Analysis of a Community-based Intervention to Reduce Heat-related Illness during Heat Waves in Licheng, China: a Quasi-experimental Study. *PubMed, 29*(11), 802-813.

Li, Y., Sun, B., Yang, C., Zhuang, X., Huang, L., Wang, Q., Bi, P., Wang, Y., Yao, X., & Cheng, Y. (2022). Effectiveness Evaluation of a Primary School-Based Intervention against Heat waves in China. *International Journal Of Environmental Research And Public Health, 19*(5), 2532.

Liao, W., Wu, J., Yang, L., Benmarhnia, T., Liang, X. Z., Murtugudde, R., ... & Huang, C. (2020). Detecting the net effect of flooding on infectious diarrheal disease in Anhui Province, China: a quasi-experimental study. *Environmental Research Letters*, *15*(12), 125015.

Liu, C. (2018). Are women greener? Corporate gender diversity and environmental violations. *Journal of Corporate Finance, 52*, 118-142.

Liu, T., & Lin, Y. (2023). Does global warming affect unemployment? International evidence. *Economic Analysis And Policy, 80*, 991-1005.

Loebach, P., & Korinek, K. (2019). Disaster vulnerability, displacement, and infectious disease: Nicaragua and Hurricane Mitch. *Population And Environment, 40*(4), 434-455.

Loft, L., Gehrig, S., Le, D. N., & Rommel, J. (2019). Effectiveness and equity of Payments for Ecosystem Services: Real-effort experiments with Vietnamese land users. *Land Use Policy, 86*, 218-228.

Loft, L., Gehrig, S., Salk, C., & Rommel, J. (2020). Fair payments for effective environmental conservation. *Proceedings Of The National Academy Of Sciences, 117*(25), 14094-14101.

Lovo, S. (2016). Tenure insecurity and investment in soil conservation. Evidence from Malawi. *World Development*, *78*, 219-229.

Lv, Z., & Deng, C. (2019). Does women's political empowerment matter for improving the environment? A heterogeneous dynamic panel analysis. *Sustainable Development, 27*(4), 603-612.

Lv, Z., Jiang, F., & Xu, T. (2022). Female parliamentarians and environment nexus: The neglected role of governance quality. *Technological Forecasting and Social Change*, *184*, 122022.

Maccini, S., & Yang, D. (2009). Under the weather: Health, schooling, and economic consequences of early-life rainfall. *American Economic Review, 99*(3), 1006-1026.

Madaleno, M.., & Waights, S. (2016). Guide to scoring methods using the Maryland Scientific Methods Scale. *London: What Works Centre for Local Economic Growth*.

Maggio, G., Mastrorillo, M., & Sitko, N. J. (2021). Adapting to High Temperatures: Effect of Farm Practices and Their Adoption Duration on Total Value of Crop Production in Uganda. *American Journal Of Agricultural Economics, 104*(1), 385-403.

Mahajan, K. (2017). Rainfall shocks and the gender wage gap: Evidence from Indian agriculture. *World Development*, *91*, 156-172.

Maitra, P., & Tagat, A. (2024). Labor supply responses to rainfall shocks. *Review of Development Economics, 28*(3), 851-887.

Marchetta, F., Sahn, D. E., & Tiberti, L. (2019). The role of weather on schooling and work of young adults in Madagascar. *American Journal of Agricultural Economics, 101*(4), 1203-1227.

Mavisakalyan, A., & Tarverdi, Y. (2019). Gender and climate change: Do female parliamentarians make a difference? *European Journal of Political Economy, 56*, 151-164.

McGee, J. A., Greiner, P. T., Christensen, M., Ergas, C., & Clement, M. T. (2020). Gender inequality, reproductive justice, and decoupling economic growth and emissions: a panel analysis of the moderating association of gender equality on the relationship between economic growth and CO2 emissions. *Environmental Sociology, 6*(3), 254-267.

McMahon, K., & Gray, C. (2021). Climate change, social vulnerability and child nutrition in South Asia. *Global Environmental Change, 71*, 102414.

Mehiriz, K., Gosselin, P., Tardif, I., & Lemieux, M. (2018). The Effect of an Automated Phone Warning and Health Advisory System on Adaptation to High Heat Episodes and Health Services Use in Vulnerable Groups—Evidence from a Randomized Controlled Study. *International Journal Of Environmental Research And Public Health, 15*(8), 1581.

Miguel, E. (2005). Poverty and witch killing. *The Review of Economic Studies, 72*(4), 1153-1172.

Miller, R. K., & Hui, I. (2022). Impact of short school closures (1–5 days) on overall academic performance of schools in California. *Scientific Reports, 12*(1).

Minor, K., Bjerre-Nielsen, A., Jonasdottir, S. S., Lehmann, S., & Obradovich, N. (2022). Rising temperatures erode human sleep globally. *One Earth, 5*(5), 534-549.

Mitchell, A., Maheen, H., & Bowen, K. (2024). Mental health impacts from repeated climate disasters: an Australian longitudinal analysis. *The Lancet Regional Health - Western Pacific, 47*, 101087.

Nepstad, D., Schwartzman, S., Bamberger, B., Santilli, M., Ray, D., Schlesinger, P., Lefebvre, P., Alencar, A., Prinz, E., Fiske, G., & Rolla, A. (2006). Inhibition of Amazon Deforestation and Fire by Parks and Indigenous Lands. *Conservation Biology, 20*(1), 65-73.

Neumayer, E., & Plümper, T. (2007). The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life expectancy, 1981–2002. *Annals of the association of American Geographers, 97*(3), 551-566.

Ngigi, M. W., Mueller, U., & Birner, R. (2017). Gender Differences in Climate Change Adaptation Strategies and Participation in Group-based Approaches: An Intra-household Analysis From Rural Kenya. *Ecological Economics, 138*, 99-108.

Nico, G., & Azzarri, C. (2022). Weather variability and extreme shocks in Africa. In IFPRI Discussion Paper 2115. Washington, DC: IFPRI

Njangang, H., Tadadjeu, S., & Kamguia, B. (2024). From policy to progress: do female parliamentarians influence energy justice? *Climate Policy*, 1-15.

Nuber, C., & Velte, P. (2021). Board gender diversity and carbon emissions: European evidence on curvilinear relationships and critical mass. *Business Strategy And The Environment, 30*(4), 1958-1992.

Nübler, L., Austrian, K., Maluccio, J. A., & Pinchoff, J. (2021). Rainfall shocks, cognitive development and educational attainment among adolescents in a drought-prone region in Kenya. *Environment and Development Economics, 26*(5-6), 466-487.

Obi, C., Bartolini, F., & D'Haese, M. (2020). International migration, remittance and food security during food crises: the case study of Nigeria. *Food Security, 12*(1), 207-220.

Oelz, M., Dhir, R. K., & Harsdorff, M. (2017). Indigenous peoples and climate change: From victims to change agents through decent work. *International Labour Office, Gender, Equality and Diversity Branch*, 1-56.

Ogasawara, K., & Yumitori, M. (2019). Early-life exposure to weather shocks and child height: Evidence from industrializing Japan. *SSM-population health, 7*, 100317.

Opoku, E. E. O., Kufuor, N. K., & Manu, S. A. (2021). Gender, electricity access, renewable energy consumption and energy efficiency. *Technological Forecasting and Social Change*, *173*, 121121.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. Cambridge University.

Pan, Q., Sumner, D. A., Mitchell, D. C., & Schenker, M. (2021). Compensation incentives and heat exposure affect farm worker effort. *PLoS ONE, 16*(11), e0259459.

Park, R. J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and Learning. American *Economic Journal Economic Policy, 12*(2), 306-339.

Perino, G., & Schwirplies, C. (2022). Meaty arguments and fishy effects: Field experimental evidence on the impact of reasons to reduce meat consumption. *Journal of Environmental Economics and Management*, 114, 102667. https://doi.org/10.1016/j.jeem.2022.102667

Piester, H. E., DeRieux, C. M., Tucker, J., Buttrick, N. R., Galloway, J. N., & Wilson, T. D. (2020). "I'll try the veggie burger": Increasing purchases of sustainable foods with information about sustainability and taste. *Appetite*, *155*, 104842.

Quisumbing, A. R., Kumar, N., & Behrman, J. A. (2018). Do shocks affect men's and women's assets differently? Evidence from Bangladesh and Uganda. *Development Policy Review, 36*(1), 3-34.

Rabassa, M., Skoufias, E., & Jacoby, H. G. (2012). Weather and child health in rural Nigeria. World Bank Policy Research Working Paper, (6214).

Raker, E. J. (2022). Climate-Related Disasters and Children's Health: Evidence from Hurricane Harvey. *Socius Sociological Research for a Dynamic World*, 8, 237802312211359. https://doi.org/10.1177/23780231221135971

Rakib, M., & Matz, J. A. (2016). The impact of shocks on gender-differentiated asset dynamics in Bangladesh. *The Journal of Development Studies, 52*(3), 377-395.

Rios, V., Barba, I., Gianmoena, L., & Pascual, P. (2024). Clearing the smog ceiling: The impact of women's political empowerment on air quality in European regions. *European Journal Of Political Economy, 85*, 102551.

Rocha, R., & Soares, R. R. (2015). Water scarcity and birth outcomes in the Brazilian semiarid. *Journal of Development Economics, 112*, 72-91.

Salamon, H. (2023). The effect of women's parliamentary participation on renewable energy policy outcomes. European Journal of Political Research, 62(1), 174-196.

Sekhri, S., & Storeygard, A. (2014). Dowry deaths: Response to weather variability in India. *Journal of development economics, 111*, 212-223.

Shah, M., & Steinberg, B. M. (2017). Drought of opportunities: Contemporaneous and long-term impacts of rainfall shocks on human capital. *Journal of Political Economy, 125*(2), 527-561.

Shikuku, K. M. (2019). Information exchange links, knowledge exposure, and adoption of agricultural technologies in northern Uganda. World development, 115, 94-106.

Sileem, H., & Al-Ayouty, I. (2022). The effect of gender equality on the carbon intensity of well-being: panel data analysis for the MENA economies 1995-2018. *Journal of Chinese Economic and Foreign Trade Studies*, *15*(3), 239-260.

Strumskyte, S., Ramos Magaña, S., & Bendig, H. (2022). Women's leadership in environmental action (OECD Environment Working Papers No. 193). Paris: OECD Publishing. https://www.oecd-ilibrary.org/docserver/f0038d22-en.pdf?expires=1729885232&id=id&accname=guest&checksum=0829E5529AF7AB5C60A5C96F32445FFB

Teklewold, H., Gebrehiwot, T., & Bezabih, M. (2019). Climate smart agricultural practices and gender differentiated nutrition outcome: An empirical evidence from Ethiopia. *World development, 122*, 38-53.

Thiede, B. C., & Gray, C. (2020). Climate exposures and child undernutrition: Evidence from Indonesia. *Social Science & Medicine, 265*, 113298.

Tibesigwa, B., Visser, M., Hunter, L., Collinson, M., & Twine, W. (2015). Gender differences in climate change risk, food security and adaptation: a study of rural households' reliance on agriculture and natural resources to sustain livelihoods.

Trentinaglia, M. T., Parolini, M., Donzelli, F., & Olper, A. (2021). Climate change and obesity: A global analysis. *Global Food Security, 29*, 100539.

Trinh, T. A., Posso, A., & Feeny, S. (2020). Child labor and rainfall deviation: Panel data evidence from rural Vietnam. *The Developing Economies, 58*(1), 63-76.

Value for Women (2020). Study of the Impacts of Climate Change on the Women and Men of the Caribbean. Pilot Programme for Climate Resilience Countries. Inter American Development Bank. https://publications.iadb.org/en/publications/english/viewer/Study-of-the-Impacts-of-Climate-Change-on-the-Women-and-Men-in-the-Caribbean-Pilot-Programme-for-Climate-Resilience-Countries.pdf

Warinda, E., Nyariki, D. M., Wambua, S., Muasya, R. M., & Hanjra, M. A. (2020, February). Sustainable development in East Africa: impact evaluation of regional agricultural development projects in Burundi, Kenya, Rwanda, Tanzania, and Uganda. In *Natural Resources Forum* (Vol. 44, No. 1, pp. 3-39). Oxford, UK: Blackwell Publishing Ltd.

West, T. A. (2024). Formal designation of Brazilian Indigenous lands linked to small but consistent reductions in deforestation. *Ecological Economics*, 218, 108093. https://doi.org/10.1016/j.ecolecon.2023.108093

Wolfson, J. A., Musicus, A. A., Leung, C. W., Gearhardt, A. N., & Falbe, J. (2022). Effect of climate change impact menu labels on fast food ordering choices among US adults: a randomized clinical trial. *JAMA Network Open, 5*(12), e2248320-e2248320.

World Bank. (2024). Executive summary: Indigenous people's resilience framework. Washington, DC: World Bank. https://thedocs.worldbank.org/en/doc/4cafc3a906669ba0d34d4a39dc903472-0090012024/original/IndigenousPeoplesResilience-ExecutiveSummary-FINAL-Aug-8-2024.pdf

Xu, Y., Wheeler, S. A., & Zuo, A. (2024). Drought and hotter temperature impacts on suicide: Evidence from the Murray–Darling basin, Australia. *Climate Change Economics, 15*(01), 2350024.

Xu, L., Yu, H., & Shao, S. (2024). The smarter the city develops, the healthier the child grows? Evidence from China. *Cities, 152*, 105195.

Yang, Z., Yang, B., Liu, P., Zhang, Y., & Yuan, X. C. (2021). Impact of temperature on physical and mental health: evidence from China. *Weather, climate, and society, 13*(4), 709-727.

Yi, F., Zhou, T., Yu, L., McCarl, B., Wang, Y., Jiang, F., & Wang, Y. (2021). Outdoor heat stress and cognition: Effects on those over 40 years old in China. *Weather and Climate Extremes, 32*, 100308.

Yin, B., Fang, W., Liu, L., Guo, Y., Ma, X., & Di, Q. (2024). Effect of extreme high temperature on cognitive function at different time scales: A national difference-in-differences analysis. *Ecotoxicology and Environmental Safety*, 275, 116238. https://doi.org/10.1016/j.ecoenv.2024.116238

Yu, G., Yang, L., Liu, M., Wang, C., Shen, X., Fan, L., & Zhang, J. (2023). Extreme Temperature Exposure and Risks of Preterm Birth Subtypes Based on a Nationwide Survey in China. *Environmental Health Perspectives, 131*(8).

Yu, H., Song, Y., Wang, Y., Wang, X., Li, H., Feng, X., & Yu, M. (2023). The Impact of Temperature on 24-Hour Movement Behaviors among Chinese Freshmen Students. *International Journal Of Environmental Research And Public Health, 20*(6), 4970.

Zapata, O. (2024). Renewable energy and well-being in remote Indigenous communities of Canada: A panel analysis. *Ecological Economics*, 222, 108219. https://doi.org/10.1016/j.ecolecon.2024.108219.

Appendices

A1 Categories of Analysis

Categories and subcategories related to Impact, Adaptation, and Mitigation

IMPACT	ADAPTATION	MITIGATION
• Ecosystems and their products • Cities, settlements, and infrastructure • Health • Poverty, livelihoods, and sustainable development • Human dimension	• Ecosystems and their products • Cities, settlements, and infrastructure • Poverty, livelihoods, and sustainable development • Health, well-being, and communities	• Energy • Agriculture, Forestry, and Other Land Use (AFOLU) • Cities, settlements, and infrastructure • Cross-sectoral

Some subcategories appear in multiple categories. For instance, "Ecosystems and their products" is discussed both under Impact and Adaptation. This occurs because the subcategory is approached from different angles: in the first instance, we focus on how climate change affects populations living in ecosystems, while in the second, we explore how those populations can adapt to the changing conditions in the same ecosystems.

The reader may notice some repetition throughout the report, as certain topics are addressed in more than one subcategory (e.g., Indigenous knowledge is mentioned in both "Ecosystems and their products" and "Agriculture, Forestry, and Other Land Use (AFOLU)"). Although we are aware of this overlap, on some occasions we could not avoid repetition to make sure that the topics were correctly covered.

A2 Classification of Quantitative Methods

Maximum SMS score by method [10]

LEVEL	METHOD	CODE
Level 5	Randomized Control Trial (RCT) [11]	("randomised controlled trial*" OR "randomized controlled trial*" OR "natural experiment*" OR "field experiment*" OR "clinical trial")
Level 4	Instrumental variables (IV) [12]	("instrumental variable*" OR "two-stage least squares" OR "2SLS")
	Regression Discontinuity Design (RDD)[13]	("regression discontinuity*" OR "RDD" OR "sharp discontinuity" OR "fuzzy discontinuity" OR "regression discontinuity design*")
Level 3 or 4	Hazard regression[14]	("hazard regression*" OR "mixed proportional hazard*" OR "proportional hazards*")
	Heckman selection[15]	("heckman* two-stage*" OR "two-stage heckman*" OR "heckman two-stage model*")
	Control Function[16] (CF)	("control function*")
Level 3	Difference-in-Differences (DiD)[17]	("difference-in-difference*" OR "parallel trend*") OR "event study*")
	Panel data method[18]	("fixed effect model*" OR "fixed effect method*" OR "first difference model" OR "first difference method*" OR "arellano-bond" OR "fixed effect*")
	Propensity Score Matching (PSM)[19]	("propensity score matching*" OR "matching method*" OR "matching*")

10. Levels 1 and 2 were not included in our analysis, as they provide only correlational evidence. Examples include cross-sectional regressions or before-and-after comparisons, which may qualify for Level 2 if adequate control variables are used; otherwise, they fall under Level 1.

11. To achieve Level 5, three criteria must be met: successful randomization, properly addressed attrition (or no attrition issue), and absence of contamination.

12. To achieve Level 4, instruments must meet three criteria: relevance (they explain the treatment), exogeneity (they are not influenced by the outcome), and excludability (they do not directly affect the outcome).

13. To achieve Level 4, three assumptions must be satisfied: the treatment discontinuity must be sufficiently sharp or fuzzy, only the treatment should change at the threshold, and behavior must not be manipulated to meet the cutoff.

14. Mixed Proportional Hazards (MPH) models can achieve a maximum score of 4 if the key assumption of 'no anticipation' holds and there is sufficient variation in time, while Proportional Hazards (PH) models can achieve a maximum score of 3 when an adequate control group is established and the treatment date is known and single.

15. The Heckman method is used to address selection bias. The maximum score it can achieve depends on the method it is combined with and whether the selection equation includes a high-quality instrument that satisfies exogeneity, relevance, and exclusion restrictions.

16. Similarly to Heckman methods, the Control Function (CF) approach must be combined with another method. To achieve a higher score, the selection equation should include relevant observable variables, and the treatment date must be known and singular.

17. To achieve Level 3, two criteria must be satisfied: the parallel trends assumption—there must be a credible argument that the treatment group would have followed the same trend as the control group in the absence of treatment—and a clearly defined treatment period.

18. Panel methods include Panel Fixed Effects (FE), First Differences (FD), and Arellano-Bond (AB). To achieve Level 3, FE requires fixed effects at the unit of observation, year effects, and appropriate time-varying controls. FD and AB require year effects and appropriate time-varying controls. However, it is noted that when the analysis is conducted using macro-level data, these methods result in a weaker form of causal relationship, but they were also included as long as they met the criteria.

19. To achieve Level 3, it must be combined with other methods that attempt to control for unobservable characteristics. For instance, it can be used alongside methods that exploit time variation in treatment, such as DiD or panel methods. In this case, the matching criteria must be satisfied, along with the criteria of the combined method."

A3 Flow Diagram of Literature Review

IDENTIFICATION OF STUDIES VIA DATABASES AND REGISTERS

Identific

Records identified through searching databases:
Scopus (n = 1,541)
ISI Web of Science (n = 407)

Records removed before screening:
Records removed by type of document (n = 239)
Duplicate records removed (n = 189)
Not found (n = 10)

Screening

Records screened across the entire text (n = 1,510)

Records excluded:
Climate change (n = 137)
Humans (n = 345)
Groups (n = 333)
Quantitative (n = 186)

Reports sought for retrieval (n = 509)

Reports excluded for level:
(n = 393)

Eligibility

Reports evaluated for eligibility (n = 116)

Reports identified through citation searching: (n = 33)
Report identified through web searching: (n = 25)

Included

Studies included in review (n = 174)

A4 Keywords for Paper Search

Key codes for retrieving the studies

Climate change	("climate change" OR "global warming" OR "climatic change")
Impact	("impact*" OR "exposure*" OR "vulnerability*" OR "risk*" OR "hazard*")
Adaptation	("adapt*" OR "maladapt*")
Mitigation	("mitigat*" OR "emission* reduction*" OR "greenhouse gas reduction*" OR "GHG reduction*")
Geographic	("Latin America" OR "South America" OR "Central America" OR "Caribbean" OR "LAC" OR "LATAM" OR "Argentina" OR "Bolivia" OR "Brazil" OR "Chile" OR "Colombia" OR "Ecuador" OR "Guyana" OR "Paraguay" OR "Peru" OR "Suriname" OR "Uruguay" OR "Venezuela" OR "Belize" OR "Costa Rica" OR "El Salvador" OR "Guatemala" OR "Honduras" OR "Nicaragua" OR "Panama" OR "Mexico" OR "Antigua and Barbuda" OR "Bahamas" OR "Barbados" OR "Cuba" OR "Dominica" OR "Dominican Republic" OR "Grenada" OR "Haiti" OR "Jamaica" OR "Saint Kitts and Nevis" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR "Trinidad and Tobago" OR "Aruba" OR "Puerto Rico" OR "Guadeloupe" OR "Martinique" OR "British Virgin Islands" OR "Cayman Islands" OR "Montserrat" OR "Anguilla" OR "Bermuda" OR "Turks and Caicos Islands" OR "Sint Maarten" OR "Curaçao" OR "Saint Martin" OR "Saint Barthélemy" OR "Sint Eustatius" OR "Bonaire" OR "US Virgin Islands")

Codes for the population groups

GROUP	CODE
Women	("women*" OR "woman*" OR "gender*" OR "female*" OR "mother*" OR "girl*")
Indigenous People	("aboriginal*" OR "indigenous*" OR "first nation*" OR "tribal*" OR "native american*" OR "american indian*" OR "native people*" OR "native population*" OR "native communit*" OR "ethnic*" OR "ethnicity*")
Indigenous Women	(("aboriginal*" OR "indigenous*" OR "first nation*" OR "tribal" OR "native american*" OR "american indian*" OR "native people*" OR "native population*" OR "native communit*"OR "ethnic*" OR "ethnicity*") AND ("women*" OR "woman*" OR "gender*" OR "female*" OR "mother*" OR "girl*"))
Afro-Descendant	("race" OR "afro-descendant*" OR "african descendant*" OR "afro-american*" OR "african american*" OR "afro-latin*" OR "black people" OR "black communit*" OR "afro-caribbean*" OR "people of african descent" OR "african diaspora*" OR "afro*")
Afro-Descendant Women	("race" OR "afro-descendant*" OR "african descendant*" OR "afro-american*" OR "african american*" OR "afro-latin*" OR "black people" OR "black communit*" OR "black woman*" OR "black women*" OR "afro-caribbean*" OR "people of african descent" OR "african diaspora*" OR "afro*") AND ("women*" OR "woman*" OR "gender*" OR "female*" OR "mother*" OR "girl*"))

A5 Glossary

The following definitions are taken literally from IPCC (2022a)[20]:

Adaptation. In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC 2022a, p 2898).

Climate change. A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes (IPCC 2022a, p 2902).

Exposure. The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2022a, p 2908).

Hazard. The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (IPCC 2022a, p 2911).

Impacts. The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services) and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial (IPCC 2022a, p 2912).

Mitigation (of climate change). A human intervention to reduce emissions or enhance the sinks of greenhouse gases. (IPCC 2022a, p 2915).

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20. Quotation marks are not included for simplicity, as all the definitions are reproduced literally.

Risk. The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic changes and human decision-making. In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals (SDGs). Risks can arise for example from uncertainty in the implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions (IPCC 2022a, p 2921).

Vulnerability. The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. See also Exposure, Hazard and Risk. (IPCC 2022a, p 2927).

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