



Impact of Climate Change on Women's Mental Health: A Narrative Review

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Abstract

Introduction: Climate change is the primary threat to public health in the 21st century, with far-reaching and measurable adverse impacts on physical and mental health. Extreme weather events have heightened the pre-existing gender inequalities. Women confront gendered vulnerability due to factors including societal roles, resource limitations, and increased exposure to extreme weather events. This renders them more susceptible to harm, increased mortality risk, and shorter life expectancies following climate-related disasters. Despite a wealth of literature on mental health consequences, gender-specific mental health impacts of climate change remain underrepresented in research. This review aims to explore and summarise the evidence on mental health vulnerabilities affecting women amid global warming and climate change. **Methods:** A review of literature was conducted in line with the PRISMA flowchart across four databases: PubMed, Scopus, Embase and Web of Science. A total of 5458 articles were identified, of which 11 were retained for analysis. **Results:** Adverse mental health outcomes in women were identified resulting from floods and cyclones (n = 3), gender-based violence (n = 2), humidity (n = 3) and rising temperature (n = 7). The following themes were derived: women's mental health related to flooding and cyclones, climate-related gender-based violence, relationship between humidity and women's mental health and impact of rising temperature/heatwaves on women's mental health. **Conclusion:** This review provided evidence for the association between climate change and adverse mental health outcomes in women. These findings emphasize the need for supporting women's engagement on climate-related decision-making and implementing gender-sensitive interventions. Further research with stronger study designs and methodologies is recommended.

Subject Areas

Women's Health

Keywords

Climate Change, Mental Health, Women, Tropical and Sub-Tropical Countries

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change (CC) as alterations in the climate directly or indirectly caused by human activities that modify the composition of the earth's atmosphere, contributing to natural climatic variations [1]. These variations have produced natural disasters across the globe from acute events such as floods, wildfires, storms, cyclones and heatwaves to persistent alterations, such as rising sea levels, melting permafrost and ice, and drought. In fact, it has increasingly been described as the biggest global public health threat of the 21st century that could reverse years of progress in the public health sector [2]. The Intergovernmental Panel on Climate Change (IPCC) has expressed "high to very high confidence" in CC's contribution to the global burden of diseases. With recent crises such as the COVID-19 pandemic further exacerbating the challenges of economic costs and health risks of CC [3].

The prevalence of adverse physical health outcomes is a well-established risk of [4]-[9]. Of emerging interest is the effect of environmental degradation and extreme weather on mental health and psychological wellbeing [10]. Global mental illness is a significant health burden, with 13.0% of DALYs (disability-adjusted life years) and 32.4% of YLDs (years lived with disability) attributed to it [8]. Mental disorders are estimated by the World Health Organisation (WHO) to have a lifetime prevalence between 18.1% - 36.1%, exerting a considerable influence on suicide rates [11] [12] [13]. The conceptual framework for the influence of CC on mental health encompasses both direct and indirect mechanisms, with the former pertaining to the psychological stress and trauma linked to the increased frequency, greater severity, and reduced predictability of weather-related incidents and natural disasters. The indirect mechanism is influenced by the resultant deterioration in physical condition and changes in socioeconomic circumstances [14] [15]. There is growing evidence linking CC, pollution, and pandemics, including COVID-19, to negative mental health effects. Several studies have reported, during high temperature periods, increased relative risks of admissions [16] [17] and emergency room visits in people with mental illness [18] [19] [20]. Suicide rates were also found to increase with warmer temperatures in multiple regions [21] [22] [23]. A commonly cited outcome in survivors of acute weather events is post-traumatic stress disorders (PTSD), among other problems, including depression, suicidal ideation, anxiety, substance abuse and domestic violence emerging long after the event [24] [25] [26].

Health vulnerabilities fall disproportionately on women and other underpri-

vileged populations, irrespective of a country's economic status and resource availability [27]. The most vulnerable groups were those with limited access to resources for adapting to extreme temperatures, rendering them more susceptible to challenges caused by CC, which include women, children, the disabled, and the elderly.

Given these factors, an exploration of women's mental health in the context of a rapidly changing climate and unprecedented extreme weather events is essential. While other review articles have investigated the impact of CC on mental health, this article explores gendered vulnerability pertaining to the adverse mental health outcomes in the context of CC.

2. Materials and Methods

2.1. Study Selection Criteria

2.1.1. Inclusion Criteria

The selected articles were those that offered insights into the adverse mental health outcomes caused by CC in adults. This review included papers on all genders to widen the scope of the search and provide insight into women's experiences relative to men. Hence, articles with "women" OR "gender" in any field were included. Additionally, only original research articles including qualitative, quantitative and mixed-methods study designs published in English were included. Studies conducted in tropical and subtropical regions were included. Lastly, only articles published in 2018 or later were included.

2.1.2. Exclusion Criteria

Articles discussing normal psychology or investigating the effects of non-weather-related natural disasters were excluded from the search. All articles published before 2018 and those that focused on pediatric age groups were also excluded.

2.2. Literature Search Strategy

A systematic electronic search of literature was conducted in September 2023 across four databases, namely Scopus, PubMed, Web of Sciences and Embase via OVID, to identify relevant studies. Two primary concept terms were "mental health" and "climate change"; while searching in the databases, the Medical subject headings (MeSH) or free terms ("Mental health" OR "mental disorders" OR "mental disease") AND ("Climate change" OR "global warming" OR "climate warming") were used.

In total, 5458 articles were identified from the four databases: PubMed (773 articles), Embase (1927 articles), Scopus (1571 articles) and Web of Science (1187articles). There were 2136 duplicates which were removed by using the Endnote and 3322 articles were screened by abstract and title. Finally, based on inclusion criteria, full-text review was conducted on 25 articles and 11 were selected for this review as shown in **Figure 1** and **Table 1**.

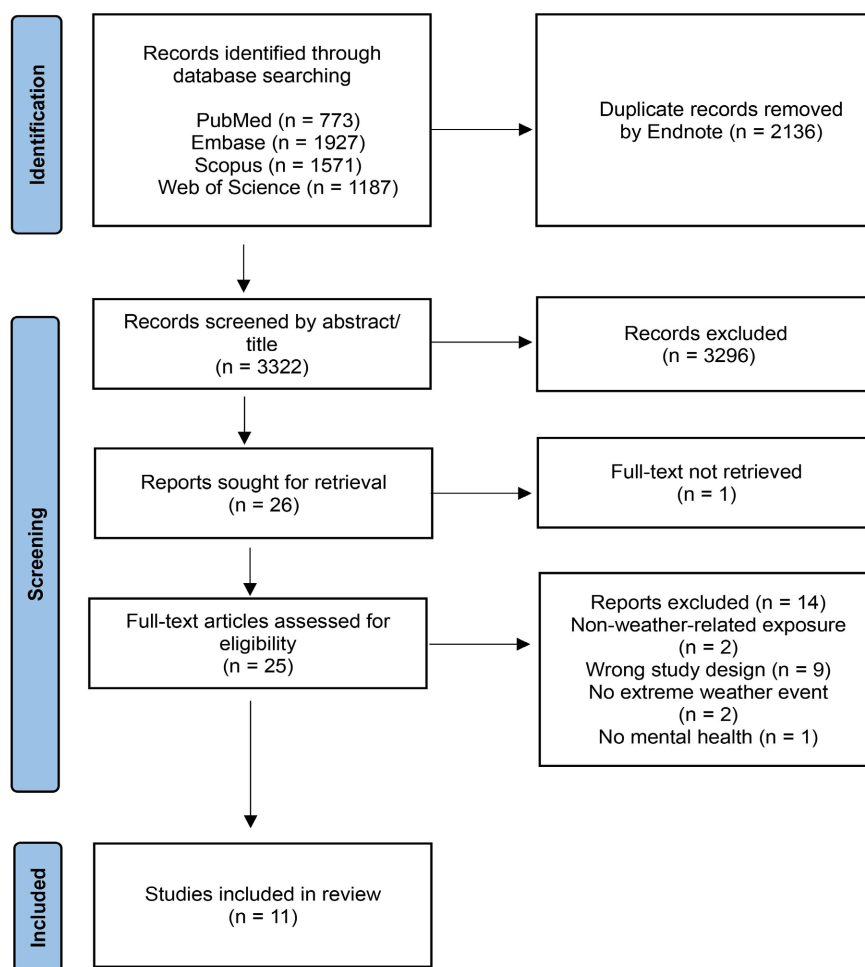


Figure 1. PRISMA Flow diagram for review of articles and screening process [28].

Table 1. List of selected articles with the main findings and conclusion.

Article; study country; year of publication (references no)	Type of study	Sample size	Main findings	Conclusion
Adams <i>et al.</i> ; Ghana; 2021 [29]	Participatory Action Research	20 individuals	<ul style="list-style-type: none"> The study revealed several adverse physical and mental health impacts of flooding, with vulnerability differentiated based particularly on gender and age. 	<ul style="list-style-type: none"> Findings suggest to improve mental health by linking the social and contextual to the medical.
Chen <i>et al.</i> ; Taiwan; 2019 [30]	Retrospective population-based, observational study	9,539,752 person-years; 9723 cases	<ul style="list-style-type: none"> People residing in regions with long-term temperature of 20°C - 23°C had the lowest risk of developing major depressive disorder (MDD). Risk for MDD incidence was higher among residents in regions with average temperature N 23°C, at 7% increase per 1°C increment (95% CI = 2% - 12%). 	<ul style="list-style-type: none"> Long-term residence in regions with extreme cold or heat may increase the risk of MDD incidence, especially higher temperature.

Continued

Chen <i>et al.</i> ; China; 2023 [31]	Longitudinal, observational study	945,171 individuals	<ul style="list-style-type: none"> This study demonstrates that heat and cold exposure days in the past year significantly increase the measured depression level of adults over age 45 by 1.75 and 3.00 per cent, respectively, controlling for the city, year, and individual fixed effects. The effect is heterogeneous across three components of depression symptoms as well as age, gender, and areas of residency, and air conditioning and heating equipment are effective in alleviating the adverse impact of heat and cold exposure. The yearly average effect of local cold exposure is a 4.86 per cent increase in CES-D score for women, which indicates a 4.8 times greater vulnerability than for men. 	<ul style="list-style-type: none"> Findings provide evidence on the long-term and accumulative cost of extreme temperature to middle-aged and elderly human capital, contributing to the understanding of the social cost of climate change and the consequent mental health inequality.
Goudet <i>et al.</i> ; Bangladesh; 2023 [32]	Observational study: qualitative research	59 in-depth interviews and 3 focus group discussions	<ul style="list-style-type: none"> Women are more vulnerable to climate change impacts on mental health due to their gender roles and responsibilities. Responsible for taking care of their families, they have to face additional challenges due to climate change impacts, such as increased workload, water scarcity, and food insecurity, social insecurity as many of their husband migrates to the cities for jobs. Women also face social and cultural barriers, which exacerbates their vulnerability to climate change impacts on mental health. 	<ul style="list-style-type: none"> It is crucial to consider the specific mental health impacts of climate change on vulnerable groups, such as women, mothers, and widows, particularly in rural areas where resources and support may be limited.
Mamun <i>et al.</i> ; Bangladesh; 2019 [33]	Pilot study	111 women	<ul style="list-style-type: none"> The prevalence of depression was 64.9% and 36.9% of the women failed to receive any alert prior to the disaster. Lower age group (18 - 30 years), being an income earner, disaster-related physical injury, and post-disaster work absenteeism emerged as the risk factors associated with depressive symptoms. 	<ul style="list-style-type: none"> Disaster preparedness programs and management protocols should incorporate measures aimed at palliating the risk factor elements that promote depression among vulnerable women following a disaster.
Ngu <i>et al.</i> ; several countries; 2021 [34]	Observational epidemiological study	60 countries	<ul style="list-style-type: none"> Relative humidity showed a more significant correlation with suicide compared to heatwaves. Women seemed to be more significantly affected by changes in humidity and heatwave counts in comparison with the rest of the population. 	<ul style="list-style-type: none"> Any interventions should prioritise the groups most affected.

Continued

Wahid <i>et al.</i> ; Bangladesh; 2023 [35]	Cross-sectional study	3606 individuals	<ul style="list-style-type: none"> An increase in mean temperature of 1°C within the 2 months preceding the surveys was associated with increased odds of anxiety and increased odds of co-occurring depression and anxiety, whereas increased temperature was not associated with depression. Exposure to flooding was associated with increased odds depression, anxiety, and co-occurring depression and anxiety. An increase in mean humidity of 1 g/m³ was associated with co-occurring depression and anxiety. 	<ul style="list-style-type: none"> Climate-related shocks and other stressors have an important association with the burden of depression and anxiety in Bangladesh.
Yang <i>et al.</i> ; China; 2021 [36]	Cross-sectional study	98,423 individuals	<ul style="list-style-type: none"> Women and low-income households are more likely to be impacted by extreme cold. 	<ul style="list-style-type: none"> Study results highlight the potential effects of extreme temperatures on physical and mental health and provide implications for future policy decisions to protect human health under a changing climate.
Zhang <i>et al.</i> ; China; 2023 [37]	Cross-sectional study	23,393 individuals	<ul style="list-style-type: none"> With each additional heatwave event, mental health scores decreased by an average of 0.027 points, which is equivalent to 0.3% of the average level. Heat is more likely to affect groups with low education, no medical insurance, and living in rural areas. 	<ul style="list-style-type: none"> This study corroborates the impact of heat on spiritual welfare, and demonstrates the mechanisms and channels of impact, which can help reduce global economic losses due to mental health problems.
Zhou <i>et al.</i> ; China; 2023 [38]	Time series analysis	155,436 visits for depression	<ul style="list-style-type: none"> Depression outpatient visits were significantly associated with extremely high humidex (≥ 40). Hierarchical analyses showed that females and the elderly (≥ 60 years) appeared to be more susceptible to extremely high humidex. 	<ul style="list-style-type: none"> Extremely high humidex can potentially increase the risk of depression, especially in females and the elderly.
Zhu <i>et al.</i> ; India, Nepal, Pakistan; 2023 [39]	Cross-sectional study	194,871 individuals	<ul style="list-style-type: none"> A significant association was found between high ambient temperature and the prevalence of intimate partner violence (IPV) against women, with each 1°C increase in the annual mean temperature associated with a mean increase in IPV prevalence of 4.49% (95% CI, 4.20% - 4.78%). The projected increases in the prevalence of physical (28.3%) and sexual (26.1%) violence were greater than that of emotional violence (8.9%). In the 2090s, India was estimated to experience the highest IPV prevalence increase (23.5%) among the 3 countries, compared with Nepal (14.8%) and Pakistan (5.9%). 	<ul style="list-style-type: none"> This cross-sectional, multicountry study provides ample epidemiological evidence to support that high ambient temperature may be associated with the risk of IPV against women. These findings highlight the vulnerabilities and inequalities of women experiencing IPV in low- and middle-income countries in the context of global climate warming.

Studies were then excluded in line with the exclusion criteria. Articles that met the inclusion criteria were retained for full-text review (n = 25). Screening for the relevance of the articles was then performed (n = 11), which were subsequently imported to the NVivo for data extraction and analysis.

Data extraction and plan for analysis:

Two reviewers (MMTB and NKJ¹) were involved to extract data from each selected article onto a standardized form designed for this review. The form includes the followings: study design, sample size, main study findings and conclusion. This process contributed to diminish biases and human error. Later, they compared the extracted data for accurateness before came to an overall agreement. The third reviewer (CGP²) contributed to resolving when any inconsistencies raised between two primary reviewers. Data was extracted by using the Nvivo software under four different themes before doing thematic analysis. These themes are: Women's mental health related to flooding and cyclones, Climate-related gender-based violence (GBV), Relationship between humidity and women's mental health, and Impact of rising temperature/heatwaves on women's mental health.

3. Results

While reviewing the 11 selected articles, authors extracted the main findings and conclusion in the **Table 1** and organized the main findings and conclusion under four themes for thematic analysis.

These four themes are: Women's mental health related to flooding and cyclones, Climate-related gender-based violence (GBV), Relationship between humidity and women's mental health, and Impact of rising temperature/heatwaves on women's mental health.

3.1. Women's Mental Health Related to Flooding and Cyclones

Women are disproportionately affected by the mental health impacts of flooding, as evidenced by the findings of Adams *et al.*'s study [29]. Women bear a unique burden during disasters and flooding events due to the gendered division of labour making them more vulnerable to the impacts of the floods. Women's assigned caregiver roles placed them at a heightened vulnerability, as they cared for children and the elderly and stayed behind in flooded compounds. Women were often unable to pursue their work as they lost their trade investments to floods and were expected to prioritize domestic duties over economic gain. Many participants asserted that women's vulnerability to the mental health impacts of flooding is amplified by the intersection of multiple social characteristics, including class, gender, and age. These roles may undermine a woman's capacity to cope with climate-related crises, ultimately leading to a disproportionate mental health burden during flooding events, such as acute anxiety, chronic

¹MMTB: Mariam Mohamed Taha Bakir; NKJ: Nowrozy Kamar Jahan.

²CGY: Christina Gertrude Yap.

stress and threat to the sense of place [29].

The results of the survey conducted in Bangladesh revealed that exposure to flooding within the 12 months preceding the survey rounds was associated with increased odds of depression, anxiety, and co-occurring depression and anxiety in women, highlighting the adverse impact of climate-related events on women's mental health [35]. Echoing these findings, Mamun *et al.* [33] also found that Bangladeshi women were more likely to experience adverse mental health outcomes following cyclone Mora, including depression and PTSD. This is due to factors such as women's gender roles as primary caregivers, social stigma surrounding mental health and economic vulnerability, as women are more likely to live in poverty and be economically dependent on others. Women who were younger (18 - 30 years) and those who were physically injured or had to miss work as a result of the cyclone were more likely to report depressive symptoms [33]. These findings underscore the substantial mental health burden experienced by women in the aftermath of floods and cyclones.

3.2. Climate-Related Gender-Based Violence (GBV)

While violence against women is not an uncommon occurrence outside the context of a changing climate, it is, however, more prevalent, recurrent, and intensified by CC. Goudet *et al.* [32] reports that CC can lead to economic insecurity in Bangladesh, disrupting livelihoods and limiting men's opportunities to generate income, as crops fail, livestock die and businesses collapse. The economic strain may lead male partners to fall into substance-use as a coping mechanism, with women unable to financially support themselves due to their assigned roles, GBV escalates. Additionally, women's isolation, lack of support, and the reporting of complaints by close relatives, like mothers-in-law, exacerbate the situation and contribute to women's stress and isolation. In rural Bangladesh, the negative impacts of CC, coupled with existing financial struggles, worsen the mental health of families, particularly women who bear care giving responsibilities [32].

In South Asian countries, increasing ambient temperatures between 2010 and 2018 were associated with an increase in the prevalence of IPV, with the highest percentages of physical and sexual violence in India compared to Nepal and Pakistan [39]. Under the unlimited emissions scenario (SSP5-8.5), IPV is projected to increase by 21% by the 2090s, with the largest increase in India, followed by Nepal and Pakistan [39]. Having partners who were younger or had a lower educational attainment or lower income emerged as risk factors for IPV.

GBV is often rooted in cultural practices that normalize male dominance and female subordination. These norms are exacerbated during periods of climate stress, as women are more likely to abandon employment in favor of household and care giving work. This creates an inescapable situation, influenced by societal norms and expectations, where women feel trapped in their marriages, face isolation and are unable to seek assistance or leave due to their roles as wives, mothers, and caregivers, further exacerbating their mental wellbeing.

3.3. Relationship between Humidity and Women's Mental Health

Outpatient visits for depression in China were analyzed in relation to high humidity [38]. Significant gender disparities were revealed, as females accounted for nearly two-thirds of the total cases of depression, with the number of visits for females almost twice that of males. The relationship between depression and high humidex (≥ 40) varied by gender, where females exhibited a more pronounced sensitivity, with a higher attributable fraction of clinic visits attributed to high humidex compared to males [38]. The cumulative effects of extremely high humidex on depression were more evident in females and those aged 60 years or older, meaning these groups experienced prolonged impacts over time. Similarly, In Bangladesh, an increase in mean humidity of 1 g/m^3 showed a borderline association with co-occurring depression and anxiety in women [35].

Moreover, Ngu *et al.*'s [34] findings reveal a concerning relationship between relative humidity and suicide rates in women. As relative humidity rises, there is a significant increase in female suicide rates, with an average rise of 5.3% per unit increase in humidity, compared to 4.3% in males.

3.4. Impact of Rising Temperature/Heatwaves on Women's Mental Health

An increase in mean temperature of 1°C within 2 months preceding the surveys conducted in Bangladesh was associated with increased odds of anxiety and co-occurring depression and anxiety among women, with women having higher odds of depression than men [35]. Likewise, a study in China, found that as the frequency of heatwave events increases, there is a corresponding decrease in mental health scores, equating to approximately 0.3% below the average level [37]. Conversely, Yang *et al.* [36], a study that used a combined score for physical and mental health indicators based on the CFPS national survey data from 2010 to 2016, finds that women are more vulnerable to cold temperatures, while men are more sensitive to heat. Similarly, Chen *et al.* [31] reported both heat and cold exposure increasing the measured depression level of adults aged 45 years and above by 1.75 and 3%, respectively. With 4.8 times greater vulnerability in women to cold exposure than in men, suggesting that cold exposure poses more threats to women's mental health than men's. The study concluded that women, the elderly and rural residents were at higher mental vulnerability in response to extreme temperatures, which raises the concern of heightened susceptibility to adverse mental health outcomes when these factors intersect.

Furthermore, in Taiwan, people living in regions where temperatures were above 23°C faced a 7% increased risk of MDD for each 1°C increment. Females were more susceptible to heat-related MDD compared to males [30]. Moreover, a significant increase in suicide rates of 3.5% was observed for every unit increase in heatwave counts, with three times as many countries showing a significant increase in female suicide rates compared to males' in response to heatwaves [34]. Perhaps an overlooked indirect effect of increasing temperatures is how it complicates women's caregiver responsibilities. Goudet *et al.*'s [32] found

that women reported sleep problems among their children as a result of the higher temperatures in the slum's tin houses. Consequently, the mothers struggled to manage their children's behavior during the day, leading to increased anxiety and stress.

4. Discussion

The studies included for analysis were diverse in designs and findings, however, they shared sufficient commonalities to enable the identification of recurring and strongly interconnected themes. The evidence presented in this review underscores the disproportionate impact of CC on women's mental health. CC exacerbates the pre-existing gender inequities facing women, with climate factors such as extreme weather events, food insecurity and infectious diseases disproportionately affecting the health of women and girls [40]. A meteoric rise of 46% in extreme weather events has been recorded between 2000 and 2013 [41]. As the earth's surface is warming up rapidly and unequivocally, with the rise in global temperatures projected to reach 1.5°C by 2040, climate disasters are expected to increase both in frequency and intensity [42] [43]. In light of women overwhelmingly shouldering the resultant burden of CC, it is expected that these adverse mental health outcomes will escalate in the years to come.

Wright *et al.* [44] reports that gendered vulnerability is mediated through socioeconomic factors, including lower educational attainment, low economic status, economic inactivity, unequal access to resources, GBV, movement and travel constraints and disproportionate caring responsibilities [45]. Echoing this review's findings, escalations in both intensity and frequency of extreme weather incidents have been linked to an increase in GBV against women. For instance, following the 1980 eruption of Mount St. Helens in Canada, police reports showed a 46% surge in GBV cases. Likewise, during a severe ice storm in Montreal, Canada in 1997, a quarter of all calls received by the police were related to GBV [46]. While these were vastly different climate disasters, they corroborate our findings derived from countries in the global South [39]. WHO ascertains that during periods of instability, women are more likely to live in poverty, have less access to basic human rights and to experience GBV [27]. Consequently, Sorenson *et al.* [47] finds that post-disaster, women are at a higher risk of depression, anxiety and obstetric complications, including hemorrhage and low-birth weight infants.

In societies where female athleticism is not encouraged, women are more susceptible to injuries and increased mortality risk during natural disasters [47]. In addition to lower chances of surviving an acute weather event, women were also documented to suffer higher mortality rates and reduced life expectancy in the aftermath of a disaster due to unequal resource allocation, including food, in favor of other family members and their children [48] [49]. Moreover, due to women's increased care giving burden in times of natural disaster, women's own safety and wellbeing is often compromised, inevitably leading to poor mental health outcomes. Fatema [50] reports that when women take up domestic roles,

such as cooking, caring for children and the elderly, tending to animals and fetching water, their safety comes second. Additionally, the risk of sexual harassment in shelters is further heightened by the inadequate provision of separate toilets and bathing facilities [50].

Serotonin signaling might explain the reason conditions such as MDD occur more frequently in females in response to the weather. 5-hydroxyindoleacetic acid, the major metabolite of serotonin, was found to vary inversely with temperature in both males and females, and with humidity in females only [51] [52].

Women's participation in climate-related decision-making is limited, meaning women have less influence on climate governance and leadership [48] [53]. This review aims to raise this issue and the need for supporting the involvement of women in making climate-related policies.

5. Conclusion

This review offers compelling evidence of the association between CC and adverse mental health outcomes in women. It sheds light on the complex interplay of socially constructed gender roles and how they negatively affect women's mental health. These findings highlight the urgency of empowering women in climate-related decision-making, with an emphasis on advocacy for gender-sensitive interventions to address GBV and caregiving burden. Further research with robust study designs and methodologies is needed.

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Data Availability

All the data that were collected are presented in this paper.

Authors' Contributions

All authors contributed to the conceptualization of the study. MMTK completed the original draft. All authors reviewed and edited the final version of the manuscript.

Conflicts of Interest

The authors declare that they have no conflict of interest to announce.

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List of Abbreviations

CC	Climate change
CFPS	Chinese Family Panel Studies
DALYs	Disability-adjusted life years
GBV	Gender-based violence
IPCC	Intergovernmental Panel on Climate Change
IPV	Intimate partner violence
MeSH	Medical subject headings
MDD	Major depressive disorder
PTSD	Post-traumatic stress disorder
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation
YLDs	Years lived with disability