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Mental health and wellbeing outcomes of climate change mitigation and adaptation strategies: a systematic review

Elaine C Flores[1,2,3,*] ⬤, Laura J Brown[4], Ritsuko Kakuma[3], Julian Eaton[3] and Alan D Dangour[1]

1 Centre on Climate Change & Planetary Health, London School of Hygiene and Tropical Medicine, London, United Kingdom
2 Stanford Center for Innovation in Global Health, Stanford University, Stanford, CA, United States of America
3 Centre for Global Mental Health, London School of Hygiene and Tropical Medicine, London, United Kingdom
4 Institute for Global Health, University College London, London, United Kingdom
* Author to whom any correspondence should be addressed.

E-mail: elaine.flores@lshtm.ac.uk

Abstract

Climate change has already impacted the health and wellbeing of ∼5 billion people globally. However, the potential influence of climate change mitigation and adaptation strategies on mental health and wellbeing outcomes in low-and-middle-income countries (LMICs) remains insufficiently understood. We aimed to determine the effect of these strategies on mental health and wellbeing outcomes among LMIC beneficiaries. We carried out a systematic review to identify intervention and case studies published from 2013 to 2022, searching OVID Medline, Embase, PsycINFO, Global Health, Cochrane Library, GreenFile, Web of Science, and a subset of studies from the 'Global Adaptation Mapping Initiative' database. We included controlled, quasi-experimental, pilot, and focussed case studies reporting mental health or wellbeing outcomes assessments of climate change mitigation and adaptation strategies. We categorised studies by design, geographic region, target population, setting, environmental hazard, strategy type and primary outcomes. PROSPERO registry: CRD42021262711. A total of 9532 studies were initially retrieved, and 15 studies involving 12 255 participants met the inclusion criteria. Among these, twelve studies described evidence from single-adaptation strategies in nine LMICs, while three reported mitigation programmes. Only two randomised evaluations assessed common mental disorders such as depression, trauma or anxiety using validated scales. Most studies evaluated broader wellbeing at the community and individual levels. Nine studies (53.3%) reported significant beneficial changes in mental health or wellbeing outcomes among beneficiaries, while six (46.7%) obtained mixed results linked to local and sociocultural factors. The interventions 'practical significance and overall impact remained unclear due to the heterogeneous reporting in program effectiveness, gaps in effect size assessments or qualitative insights. Our review highlights the scarcity and limited nature of the current evidence, underscoring the need for further equitable research. The ongoing global climate and mental health crises press us to fully understand and address these strategies' psychosocial impacts and translate these findings into effective policy and transdisciplinary action as an opportunity to prevent and ameliorate significant, long-term problems in the population's mental health and wellbeing.

1. Introduction

The climate change crisis negatively affects human health [1–3], particularly mental health and overall wellbeing [4, 5]. Low-and-middle-income countries (LMICs) are disproportionately vulnerable to these impacts and have the least resources to prepare for [6, 7] and recover from them [8]. The interconnected consequences include far-reaching, profound impacts [9], such as increased frequency and severity of extreme weather events, sea level rise and coastal erosion, changes in precipitation patterns, food and

water insecurity, displacement, and loss of livelihoods [10]. Unfortunately, there is a lack of research on the mechanisms and extent of these impacts, including the effects of protective interventions on mental health, particularly in LMICs [7].

Climate change exacerbates the risk factors, mechanisms, and drivers of poor mental health and psychosocial wellbeing at both population and individual levels. The World Health Organization acknowledges that '*Several environmental, social, and economic determinants of mental health are negatively affected by climate change*' [11]. These effects include increased rates of common mental disorders, decreased social cohesion, and increased violence [12], especially targeting historically marginalised groups [13, 14].

On the other hand, climate change mitigation and adaptation responses can positively impact human health and wellbeing [15] by addressing risks [16], promoting resilience, improving global health and benefiting vulnerable populations [17, 18]. Globally, climate change mitigation strategies such as transitioning to clean energy sources can improve air and water quality, reduce noise pollution, and create new economic opportunities [19]. Adaptation strategies [20], such as building resilient infrastructure and early surveillance systems for environmental hazards, can improve safety and reduce the negative impacts of extreme weather events. These strategies have been linked to general health co-benefits [15, 21], although their specific impact on mental health and wellbeing outcomes [19], especially in LMICs, remains limited. For example, providing agricultural extension services and financial resources can alleviate stress and anxiety among subsistence farmers [22]. Implementing integrated screening programs and participatory community-level activities can decrease depression and domestic violence and increase conflict resolution and community resilience in post-flooding settings [23]. Successful recovery efforts from flooding events require local knowledge and interdisciplinary collaboration, with careful consideration of unintended consequences associated with psychosocial interventions [24]. Urban centres can benefit from adaptation actions such as expanding green spaces, strengthening health systems, and building resilient infrastructure [25]. However, these strategies need greater attention and consideration for underserved communities and their potential impact on mental health and wellbeing in LMICs.

Despite the well-established evidence on the negative impact of climate change on mental health and wellbeing, few ongoing efforts to implement mitigation and adaptation strategies incorporate mental health measurements into their evaluation. To effectively address the impacts of climate change, it is crucial to integrate mental health considerations into the design and evaluation of these strategies.

This comprehensive approach allows us to understand the full impact of these strategies and consider the complex interplay between socioeconomic, structural, and political factors that contribute to human vulnerability to climate change effects and extreme weather events [26, 27].

Considering mental health and wellbeing as key outcomes that cut across the lifespan in response to climate change can improve mitigation and adaptation planning efforts and ensure effective and equitable results. Such an approach would address the root causes of climate change threats, structural vulnerabilities, and contextual synergies that affect communities with high climatic and environmental exposures. It could provide an argument for a more streamlined, coordinated, and cost-efficient climate action approach across households, researchers, and policymakers.

Despite the reported benefits of these strategies, depending on population groups and geographical contexts they can also be harmful [17] linked to complex social dynamics. For example, programs that relocate at-risk communities can potentially cause distress linked to loss of cultural identity and disruption of social cohesion [28] Particularly if these strategies are not implemented widely across communities or fail to consider unique local aspects, they can lead to local injustices. For instance, a renewable energy-based electrification project in rural communities of Cajamarca, Peru [29] caused community discord when some households were selected for the intervention while others were not. Similarly, projects focusing on livelihood diversification through technology can address environmental shocks and poverty but may also exacerbate income and wellbeing inequities for those facing structural entry barriers [30].

The evidence base regarding the co-benefits of mental health and wellbeing remains limited, highlighting the need for further studies exploring the effects of climate change responses on human health. Existing reviews have addressed specific aspects but have not fully assessed the effects of both mitigation and adaptation strategies on mental health outcomes. For example, a systematic mapping of global research on climate change adaptation interventions and health emphasised the scarcity of evidence in this area [16]. A recent systematic review [31] focussed on the conceptual framings of individual and community-level mitigation actions and explored mental health themes but did not specifically assess the effects of mitigation strategies. Another scoping review [32] examined the health impacts of adaptation strategies in informal settlements in LMICs but did not report results on mental health outcomes. Finally, a systematic review on urban green spaces and wellbeing [33] found positive effects on human wellbeing, including health aspects;

however, evidence regarding mental health and well-being outcomes related to climate change mitigation and adaptation strategies remains scarce.

This review addresses this knowledge gap by compiling and assessing evidence on the co-benefits of climate change mitigation and adaptation interventions for mental health and wellbeing in LMICs by (1) examining the impact of climate change mitigation and adaptation interventions on mental health and wellbeing outcomes in LMICs, (2) reviewing the evidence base of this association, and (3) evaluating the effects of those interventions by type, climatic/environmental risk, and by their impact on different population groups and context.

This systematic review is timely given the major impacts of climate events on mental health outcomes in LMICs [7, 34] and the increasing implementation of climate change adaptation and mitigation strategies in these settings [35, 36]. Health and human wellbeing must be central in climate action, and research is critically needed to inform evidence-based policy and practice in this area.

2. Methods

2.1. Search strategy and selection criteria

In this systematic review, we defined climate change mitigation activities as those that '*contributes to stabilising greenhouse gas (GHG) concentrations in the atmosphere to prevent anthropogenic interference with the climate system by reducing or limiting GHG emissions or enhancing GHG sequestration*'. A climate change adaptation refers to '*activities that reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, and enhance adaptive capacity and resilience*' [37]. The term 'adaptation' was deliberately not included in the search. Some authors may not have explicitly framed their studies about adaptation but would have incorporated key elements that matched this review's definition and inclusion criteria. Kelly and Adjer [38] define vulnerability as the capacity to '*anticipate, cope with, resist, and recover from a natural hazard*' and highlight that reducing vulnerability is essential for adaptation.

For mental health and wellbeing outcomes, we considered mental and behavioural disorders classified in the International Classification of Diseases 11th Revision (ICD-11) [39] or The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) [40], respectively, measured in the general adult population, as well as pertinent psychosocial proxies. Wellbeing was understood as a multidimensional construct encompassing different aspects such as good social relations, freedom of choice and action, security, health, and essential materials for living well

and can be measured subjectively or objectively using composite indicators [41].

This systematic review followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines [42].

The protocol for this systematic review was registered on PROSPERO (doi:10.15124/CRD42021262711).

We systematically searched seven databases that provide comprehensive coverage of research done in climate change, health, mental health, and LMICs (OVID MEDLINE, EMBASE, Global Health, PsycINFO, Web of Science Core Collection, COCHRANE and GreenFILE) for studies published from 1 January 2013 until 10 September 2022 with no language restrictions. We excluded papers published before 1 January 2013, using the 5th IPCC report—published in 2014—as a reference point [43].

We used a combination of MeSH (medical subject heading) terms and keywords related to climate change, mental health, wellbeing and LMICs. Our OVID MEDLINE search strategy is appended online (supplementary file 1). Additional records were identified from the outputs Scheelbeek *et al* [16] and colleagues reported using the 'Global Adaptation Mapping Initiative' (GAMI) database, which was constructed through systematic literature searches in Scopus, Web of Science and Google Scholar from 2013 to 2020 [44]. The search methods of the GAMI database are made available in detail elsewhere [45–47]. Finally, we conducted manual backward search of reference lists and a forward-citation search for all included papers and related reviews.

2.2. Eligibility criteria

Study inclusion and exclusion criteria were defined a priori (supplementary file 2). We included peer-reviewed, published studies that: (1) examined mental health or wellbeing outcomes related to climate change mitigation and adaptation strategies in general adult populations (>18 years old) living in LMICs, (2) the studies could use controlled evaluations, quasi-experimental methods, pilot assessments or focussed case study designs to collect quantitative or qualitative data; (3) measured mental health and behavioural conditions measured using self-report tool, assessments by mental health workers or broad wellbeing outcomes and psychosocial proxies; and (4) included indicators of successful mitigation and/or adaptation interventions linked to a change in mental health outcomes (e.g. change in depression scores or change in the proportion of those diagnosed with a mental disorder), change in social functioning skills (e.g. improved coping skills, social functioning, self-esteem) and any other secondary outcomes

related to psychosocial conditions and wellbeing (e.g. quality of life) were also considered.

2.3. Selection process

We screened titles and abstracts initially and collated them using EndNote referencing software [48]. After de-duplication, the first author (ECF) screened titles and abstracts against the eligibility criteria and uploaded the selected references for full-text screening into Rayyan [49]. Approximately one-third of the articles and full-text screening was performed by two co-authors independently, who resolved disagreements through discussion. Articles fulfilling all the inclusion criteria were included in the review. See supplementary file 3 for the details of excluded studies.

2.4. Data extraction and analytic approach

All studies were in English except for one in Portuguese. This article was double translated into English and Spanish, and data were extracted by ECF, a native speaker of Spanish and fluent in English. Data were extracted from each included study:

(a) Bibliographic information: first author, country, year of publication, language
(b) Study characteristics: objectives, aim, context (country development level, setting where the programme operates), design, sample size, exclusions, and attrition rate.
(c) Participants of strategy/programme details: behavioural and psychosocial disorder diagnosis, mode of diagnosis, severity, treatment (if applicable), age of diagnosis
(d) Exposure measurement: climatic/environmental risk, adaptation strategy characteristics/description, comparison group
(e) Outcome assessment: measure/assessment used, blinding, score standardisation, use of classification criteria.
(f) Measures of effect: effectiveness of climate change mitigation/adaptation strategy, assessment times and follow-up, studies' results, and conclusions.

2.5. Quality assessment

Due to the variety of included study designs, we used the Specialist Unit for Review Evidence (SURE) for the critical appraisal of randomised controlled trials and other experimental studies [50], the Joanna Briggs Institute guidelines for quasi-experimental studies [51] and the Critical Appraisal Skills Programme checklist [52] to assess qualitative case studies. The quality assessment (supplemental file 4) did not exclude low-quality articles, but their limitations were discussed.

2.6. Data analysis

Due to the heterogeneity of research designs, assessment approaches, and strategies, it was not possible to pool the results for meta-analysis. Therefore, we provide a narrative description of the findings.

3. Results

3.1. Study selection

The results of the search are summarised below in figure 1. A total of 9514 records were identified in the database search and an additional 18 were found through additional methods.

Fifteen studies were ultimately included in the review comprising data from 12 255 participants.

3.2. Study characteristics

Details for the 15 included studies are shown in table 1.

The Sample sizes of the included studies varied between 48 and 4000, and their designs were heterogeneous. Three (20%) were randomised clinical trials (RCTs) [53–55], four (26.7%) were randomised evaluations of interventions [56–59], four (26.7%) were quasi-experimental studies [60–63], two (13.3%) were qualitative evaluations of interventions [28, 64], and the remaining two (13.3%) were field experimental studies [65, 66]. The most common regions where the studies occurred were South America, South Asia, and sub-Saharan Africa (figure 2).

Of the included studies, two (13.3%) targeted specific population groups (e.g. pregnant women [53], older adults [66]) in urban areas, and the other thirteen (86.7%) were population-based studies [28, 54–65] in rural areas considered at high-risk for environmental hazards. Two studies [53, 55] had all-female samples, one had an all-male sample [66], and two [28, 64] reported gender-disaggregated data in the qualitative analysis. The remaining ten studies [54, 56–63] did not report data differentiated by sex or gender, although some mentioned females were a significant component of their samples.

3.3. Sources of bias

Supplementary file 4 contains the results of the quality assessment. Generally, controlled, and experimental studies were scored as medium quality using the SURE checklist, and only three were appraised as high quality. The risk of bias was not discussed in five of the nine controlled studies, only three offered an appraisal of the generalisability of their results, and only four disclosed funding or conflict of interest information. Across the 13 quantitative studies, the statistical methods were described sparsely in three of

Table 1. General characteristics and summary results of the studies included in the review, grouped by study design ($n = 15$).

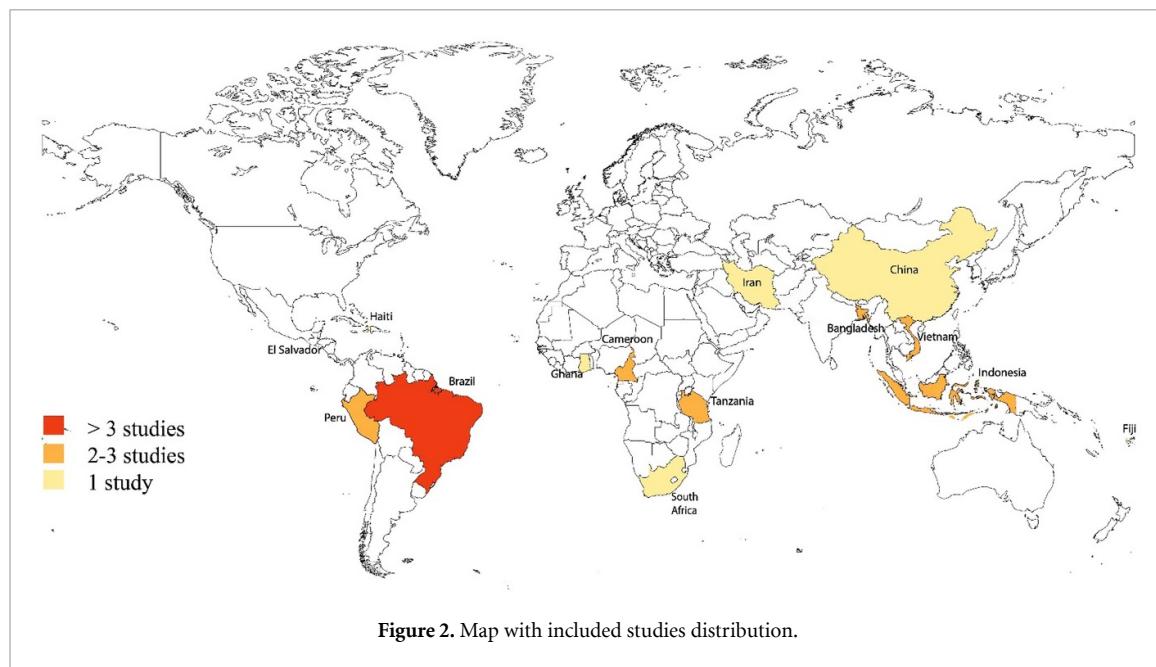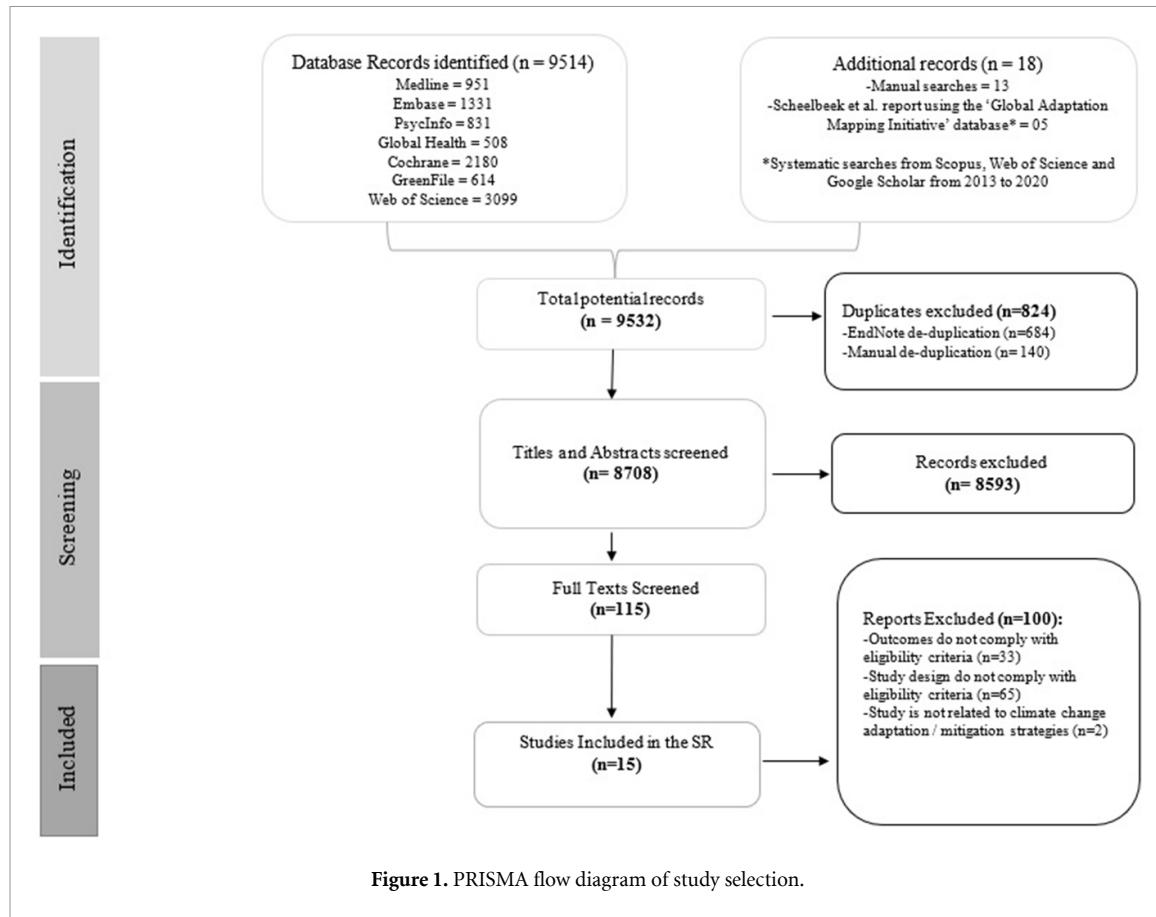| Author, year	Country	Country development level	Type of strategy	Climatic/ environmental hazard	Mental health or wellbeing outcome	Main result
Studies with experimental design						
Araban *et al* (2017)	Iran	Upper-middle income	Adaptation	Air pollution	Wellbeing, self-efficacy	↑ Behavioural prevention changes, ↑ Self-efficacy
Bedran-Martins *et al* (2018)	Brazil	Upper-middle income	Adaptation	Drought and vulnerability (e.g. food insecurity)	Subjective wellbeing, material QoL (MQoL)	↑ MQoL ↔ Mixed results in perceived vulnerabilities (health, safety)
Binh *et al* (2020)	Vietnam	Middle-income	Adaptation	Reduce vulnerability to floods	Self-efficacy, Self-satisfaction, negative emotions	↑ Positive outcomes in threat and coping appraisals and motivation to act to mitigate floods
Davids *et al* (2022)	South Africa	Upper-middle income	Adaptation	Ecosystem services, Biodiversity protection	QoL	↑ QoL
Duchelle *et al* (2017)	Brazil, Peru, Cameroon, Tanzania, Indonesia, Vietnam	Upper & lower middle income	Mitigation	Deforestation	Subjective wellbeing [a]	↓ Perceived tenure security & Wellbeing (among those without incentives), ↑ Wellbeing when social safeguards added
James *et al* (2020)	Haiti	Low-income country	Adaptation	Environmental Hazards (floods, storms, earthquakes)	Disaster preparedness, depression, PTSD, anxiety, functional impairment (fx), social cohesion, help-giving, and help-seeking behaviour	↑ disaster preparedness, ↓ symptoms of depression, PTSD, anxiety, and fx, ↑ peer-based help-giving and help-seeking
Nunes *et al* (2021)	Brazil	Upper-middle income	Adaptation	Access to safe water supply	Perceived wellbeing based	↑ Living conditions (e.g., comfort, privacy, safety) ↓ time spent on domestic activities (e.g., fetching river water, washing in the river). No effects on other health impacts
Weston *et al* (2015)	Ghana	Lower-middle income	Adaptation	Deforestation	Subjective wellbeing	↑ Psychosocial Wellbeing (optimism, leadership, community solidarity)
Williams *et al* (2020)	Peru	Upper-middle income	Mitigation	Household Air Pollution	QoL	↑ Perceived QoL, ↑ Saved time (for leisure, rest, and income-generating activities)

(Continued.)

Table 1. (Continued.)

Author, year	Country	Country development level	Type of strategy	Climatic/environmental hazard	Mental health or wellbeing outcome	Main result
Studies with quasi-experimental design						
Gori Maia *et al* (2021)	Brazil	Upper-middle income	Adaptation	Drought, deforestation, soil degradation	Subjective wellbeing [b], QoL	↑ Subjective measures of income, Quality of work, and QoL in general. No other differences (e.g., food quantity satisfaction)
Gros *et al* (2019)	Bangladesh	Lower-middle income	Adaptation	Extreme weather events (e.g. floods)	Psychosocial distress (feelings of unhappiness, being miserable, anxious, or depressed)	↓ Frequency of psychological distress or negative feelings
Sunderlin *et al* (2018)	Brazil, Peru, Cameroon, Tanzania, Indonesia	Upper & lower middle income	Mitigation	Deforestation	Subjective community wellbeing	↑ Perceived tenure security (Cameroon) and Wellbeing (in 3 5 countries). No effects on tenure preparedness.
Studies with pilot/focused case studies design						
Kundo *et al* (2022)	Bangladesh	Low-income country	Adaptation	Climate-induced short-term shocks (floods, cyclones) & long-term stresses (drought, sea-level rise).	Perceived wellbeing, resilience, vulnerability	NJLIP programme vs EGPP ↑ resilience. Mixed psychosocial wellbeing outcomes in both programmes
Li *et al* (2021)	China	Upper-middle income	Adaptation	Air Pollution	Emotions (positive and negative) Mood subscales, perceived restorativeness of environment	Daytime green environment ↑ positive emotions. Urban walking ↓ benefits, except during nighttime where benefits ↑ in both green and urban spaces
McMichael *et al* (2021)	Fiji	Upper-middle income	Adaptation	Sea-level rise, coastal flooding, erosion, and saltwater intrusion	Mental Wellbeing, emotions (anxiety, sadness), communal culture and identity	↑ Key facilitators for good health and Wellbeing, ↓ anxiety related to environmental stressors, ↑ risks and communal detachment/community culture

[a] Merriam-Webster (2010) definition of subjective Wellbeing, as 'the state of being happy, healthy and prosperous'.
[b] Life and income satisfaction.
QoL: quality of life; PTSD: post traumatic stress disorder; EGPP: Employment Generation Programme for the Poorest; NJLIP: Nuton Jibon livelihood Improvement Project.

Figure 1. PRISMA flow diagram of study selection.

Figure 2. Map with included studies distribution.

them. Common shortcomings of the qualitative studies included not referring to bias or author's positionality, not clearly showing thorough data interpretation and providing conclusions insufficiently substantiated by collected data. Other recurrent issues were the lack of recruitment details or a thorough assessment of the limitations of chosen methods. Validity testing of assessment tools for the study settings was largely absent, along with verification to establish credibility and reflexivity. Unvalidated tools may be culturally inappropriate or not accurately interpreted, leading to errors in responses, and

translations might not convey the intended meaning accurately, leading to information bias. The evidence base could be improved by greater attention to sources of bias and appropriate generalisability of results.

3.4. Environmental hazards
Studies investigated seven loose groups of environmental threats: three studies (20%) assessed air pollution [53, 55, 66], two (13.3%) evaluated droughts and food insecurity [56, 60], four (26.7%) investigated extreme weather events such as floods and storms [54, 63–65], three (20%) evaluated deforestation [58, 59, 62], one (6.7%) focused on the sea-level rise [28], one (6.7%) explored biodiversity protection [57], and the last one (6.7%) assessed access to safe water [61]. Details of the included studies, intervention design and their effectiveness are included in tables 2 and 3.

3.5. Adaptation and mitigation strategies
The types of strategy included in the 15 studies had heterogeneous designs, and differed in their goals and scale, as the adaptation studies focused on localised interventions. Twelve studies (80%) examined the effects of single adaptation strategies across nine LMICs [28, 53, 54, 56, 57, 59–61, 63–66]. Of the studies that assessed air pollution, two were adaptation studies based on behavioural interventions; One study used an RCT design [53] ($n = 110$) and the other a field experiment [66] ($n = 48$) to evaluate external air pollution.

Droughts were assessed in two adaptation studies based on cash transfer programmes for farmers. One was a randomised evaluation [56] of anti-poverty programmes implemented by the Brazilian government ($n = 850$), and the other ($n = 100$) was a quasi-experimental study [60].

Of the four studies assessing extreme climatic events, all were adaptation strategies. One study ($n = 480$) conducted a field experiment to decrease flood vulnerability [65], another one ($n = 480$) did an RCT on disaster preparedness [54], another ($n = 100$) used a quasi-experimental design of unconditional cash transfers to flood-prone rural communities [63], and the last one ($n = 223$) conducted a randomised evaluation of two governmental programmes aimed at vulnerable groups to climate stressors [64]. A qualitative case study ($n = 89$) evaluated a planned relocation governmental programme for sea-level rise and coastal erosion [28]. One adaptation study on deforestation and forest degradation was a randomised evaluation [59] ($n = 400$).

Meanwhile three studies (20%) examined the effects of mitigation programmes [55, 58, 62]. For instance, the study by Williams ($n = 180$) used an RCT design to assess a household air pollution mitigation strategy involving cleaner cookstoves [55]. Two other studies assessed the same multi-country deforestation and forest degradation mitigation strategy: one study [58] performed a randomised evaluation ($n = 4000$), and the other ($n = 3754$) had a quasi-experimental design [62].

3.6. Mental health and wellbeing outcomes
Most studies (12 out of 15) used quantitative methods to assess the outcomes of climate change mitigation and adaptation strategies on mental health and wellbeing. Only two included studies [54, 63] used validated scales to assess common mental disorders. The study led by James *et al* [54] used the Zanmi Lasante Depression Symptom Inventory [67] (ZLDSI), the Modified Post Traumatic Syndrome Disorder Symptom Scale [68] (MPSS), the Beck Anxiety Inventory [69] (BAI), the functional impairment items tools adapted from Kaiser *et al* [70] and the adapted Social Cohesion.

Scale by Fone *et al* [71]. The study conducted by Gros [63] adapted the standardised perceived stress scale to assess psychosocial distress. The remaining 13 studies assessed broader terms of wellbeing at the community and individual levels, such as subjective wellbeing [56, 58–62, 64], emotions and mood [28, 72], quality of life [55, 57] and self-efficacy [53, 65].

3.7. Primary findings
The included studies had overall mixed outcomes; with most (8 out of 15) reporting positive effects of climate change mitigation and adaptation strategies on mental health [54, 63] and wellbeing [53, 55, 57, 59, 60, 65] In contrast, the remaining ones (7 out of 15) reported no significant impact [61] or mixed outcomes [28, 56, 58, 62, 64, 66] within the intervention groups. None reported adverse effects. In general, the findings from the 15 studies provide important insights into the effects of these interventions on mental health and wellbeing outcomes. However, the lack of specific effect sizes limits our ability to fully assess the magnitude and practical significance of the observed improvements.

For example, the study led by Araban *et al* [53] obtained positive effects on the individual's perceived benefits and self-efficacy in the intervention group compared to the control group. Similarly, the study by Bedran-Martin [56], showed varied changes in subjective wellbeing and perception of material quality of life varied across groups, indicating small to moderate improvements between the intervention groups. Binh's study [65] reported positive findings for fear feelings, structural measures, livelihoods measures, and self-efficacy among the groups participating in the intervention. Davids *et al* [57] used a comprehensive approach across ecological, socioeconomic and health categories to assess the impact significance of wellbeing outcomes and found improved social-economic outcomes among the participants. Gori Maia *et al* [60] found positive associations between participants' wellbeing and income, work,

Table 2. Characteristics of the interventions included in the review, grouped by study design ($n = 15$).

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Studies with experimental design							
Araban *et al* (2017)	RCT	Pregnant Women—Prenatal hospital ward, urban setting (Iran)	110	Healthy pregnant women (18–35 years), gestational age 20–24 weeks	Theory-based educational intervention. 3 components including: 1. One-hour motivational interviewing session focused on preventive behaviours to air pollution exposure; 2. Daily small message service (SMS) over a one-month span; 3. An educational booklet on air pollution impacts.	1 month	Assigned to routine prenatal care
Bedran-Martins *et al* (2018)	Randomised evaluation of Anti-Poverty Government Programmes	Rural farmers living in high-drought areas (Brazil)	850	Adults (≥18 years) Age mean: 55 years)	*Bolsa Família (BF)*: state-sponsored cash transfer programme for farming households with a monthly income ≥1.5 monthly minimum wages, or low-income farming households in an area where an official declaration of drought emergency has been issued. *Rural Pension (RP)*: safety net for rural workers >60 (males) and >55 (females) provided they had worked >15 years and are associated with a rural labour union or association.	N/A—data compared with survey data from 15 years before the programme implementation	Urban households

(Continued.)

Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Binh *et al* (2020)	Field experiment, using people-centred risk communication	Flood-prone rural communities (Vietnam)	480	Adults (≥18 years)	Field experiment to assess 6 groups where informal and formal people-centred risk communication for flooding were allocated through an income-stratified sampling process: Control groups (A1) with and without (A2) wife participation; Informal (B1) (C1) and formal (B2) (C2) communication groups with and without wife's participation respectively. The risk communication message covered five issues: information about the risk (i.e. causes, probability, and impact), fear appeal (i.e. images recall the horror of the (2011) floods), pros and cons of structural flood defences, coping capacities, and flood personal experience.	N/A assessment done at the end of the intervention (groups B1, C1, B2, C2) and One week after the initial survey (groups A1 and A2)	Groups A1 and A2

(Continued.)

Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Davids et al (2022)	Environmental Impact assessment of WWWC programme interventions implemented in two low income, peri-urban communities	20 sites distributed along the Golokodo & Mbokodweni Rivers: Folweni (±urban) and Ezimbokodweni (rural-peri-urban), in Durban (South Africa)	126 (n = 60 intervention beneficiaries randomly selected; n = 60 random houses, n = 6 online surveys to stakeholders)	Adults (≥18 years)	WWWC initiative: Civic ecology programme grouping 6 environmental management interventions: (1) Solid waste management and removal: removal of waste from aquatic and terrestrial areas; (2) Recycling; waste collection and storage for recycling; (3) Invasive alien plant control: identification and control along rivers and streams; (4) Water quality monitoring: monthly biophysical monitoring of river water quality; (5) Community vegetable gardens: vegetable production (two gardens) using permaculture methods; (6) Community engagement: door-to-door community engagement, surveys & knowledge sharing.	N/A assessment done after 3 years interventions were undertaken	Randomly selected households in the same areas

(Continued.)

Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Duchelle *et al* (2017)	Randomised evaluation of REDD+ programme	Rural villages with reported forest clearing (Brazil, Peru, Cameroon, Tanzania, Indonesia, Vietnam)	4000 households/130 villages across 6 countries	Adults (≥18 years)	REDD+ initiatives aims to reduce emissions from deforestation across tropical countries. The authors assessed the impacts of REDD+ interventions (incentives vs. disincentives vs. a mixed portfolio of incentives and disincentives) on key safeguard-relevant indicators (i.e., tenure security, participation, and subjective Wellbeing), as well as on reported forest clearing on rural households.	N/A data was compared with survey data from 2 years after the programme implementation	Non-REDD+ rural villages
James *et al* (2020)	RCT	Community members living in high risk for extreme events in metropolitan Port-au-Prince (Haiti)	480	Adults (18–65 years, mean: 37 years)	3 day mental health integrated disaster preparedness group intervention. Day 1: discussions on mental health and psychosocial reactions to disaster-related stress & coping strategies. Day 2: disaster preparedness, facilitated discussions on links between common attributions for disasters (e.g., natural causes, God's will) and preparedness motivation. Days 2–3: practice on disaster and mental health related peer support through a 'mini disaster simulation' in which participants practice and demonstrate learned skills.	Baseline & Allocation (T1) assessment at 3 months (T2), and follow-up assessment 2 at 6 months (T3)	Wait-list

(Continued.)

Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Nunes *et al* (2021)	Mixed-methods assessment of socio-environmental impacts in the communities where the SAAs were implemented	21 riverside rural communities (Middle Solimões River region, Amazonas State) facing both seasonal floods and droughts (Brazil)	169 (Qualitative) 217 (Survey)	Adults (≥18 years)	Water Supply System (SAA) initiative implemented by the Mamirauá Sustainable Development Institute. The SAA uses photovoltaic solar energy, local timber resources, and users' workforce to capture water from the surface of rivers, pumping it to a central reservoir for pre-treatment (removal of coarse solids) and distribution by pipeline to households. Complementary actions, such as guidance to users on simplified home water treatment techniques (e.g., filtering and boiling water), improved the water quality.	Group 1: 5 communities with active SAA for 7–14 years; 14 communities with inactive SAA for 7–14 years. Group 2 (water with parasites +): 3 control communities, and 3 with active SAA between 7–14 years.	3 Non-beneficiaries rural communities
Weston *et al* (2015)	End-of-project evaluation of a FMNR project in Talensi, Ghana, evaluating on livelihoods[b] impact	Farmers and youth groups living in vulnerable rural communities in dryland zones of Talensi (Ghana)	400 households (104 intervention, 154 neighbouring, and 142 controls); 12 FGD	Adults (≥18 years) and youth groups	FMNR is a 3 year agroforestry project approach to arable land restoration and reforestation that seeks to reconcile sustained food production, conservation of soils, and protection of biodiversity. It involves selecting and protecting the most vigorous stems regrowing from live stumps of felled trees, pruning off all other stems, and pollarding the chosen stems to grow into straight trunks to achieve the regeneration of woody plant cover in farming and mixed land use areas.	4 years after project close	Comparison households, living outside the project area but within the same district, geo-climatic, ethnic, and economic zone

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Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Williams *et al* (2020)	RCT	High-altitude Aymara and Quechua indigenous resident users of traditional biomass stoves (Peru)	180 (90 intervention, 90 controls)	Adults 25–64 years (Mean: 37 years), non-pregnant women	Cardiopulmonary outcomes and Household Air Pollution (CHAP) RCT, which aimed to test the impact of a liquefied petroleum gas) (LPG) intervention on air quality and health outcomes. Intervention participants received a locally-produced LPG stove, free continuous LPG refills delivered directly to their home for one year, and behavioural training and reinforcement for LPG use.	N/A survey data collected at 1, 3, 6, 9, and 12 months after randomisation	Assigned to baseline cooking practices
Studies with quasi-experimental design							
Gori Maia *et al* (2021)	Quasi experimental study	Rural, smallholder family farmers in the Brazilian semiarid region of Sertão (Brazil)	100	Adults (Age not reported)	*MAIS*: is a set of agricultural production practices and technologies with specific goals to improve sheep milk and meat yields and climate resilience. The programme helps to support smallholder livestock and dairy farmers through both seasonal and longer-run climate variability by teaching farmers to grow extra, forage and manage herds appropriately, while also regenerating and protecting their natural capital assets in compliance with the Brazilian Forest Code [a].	N/A analyses used post-intervention cross-sectional data (2018) and a sub-sample pre-post panel dataset (2015 and 2018)	Non-MAIS farmers

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Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Gros *et al* (2019)	Quasi-experimental, mixed methods	Highly vulnerable, rural flood-prone communities in the Brahmaputra River basin before an early flood peak (Bangladesh)	1039 households	Adults ($\geqslant$18 years)	Forecast-based unconditional cash transfer in anticipation of extreme weather event on the target population of vulnerable households in 4 communities	N/A	Comparison communities (counterfactual)
Sunderlin *et al* (2018)	Quasi experimental study of REDD+ programme	Rural villages with reported forest clearing (Brazil, Peru, Cameroon, Tanzania, Indonesia)	3754 households/141 villages/countries	Adults ($\geqslant$18 years)	REDD+ initiatives aims to reduce emissions from deforestation across tropical countries. This study assessed the impacts of REDD+ interventions RFAC (restrictions on forest access and conversion) and TC (tenure clarification) on community subjective wellbeing perceived in rural households.	N/A data was compared with survey data from 2 years after the programme was implemented	Non-REDD+ rural villages
Studies with pilot/focused case studies design							
Kundo *et al* (2022)	Randomised evaluation of two Governmental programmes	15 villages. 6 from the Southwestern coastal and 9 from the Northwestern drought-prone zones (Bangladesh)	223	Adult women, males, and youth (Age not reported)	NJLIP: aims to build resilience to extreme weather shocks and stresses by integrating disaster risk reduction and climate change adaptation concerns with regular social assistance measures such as cash transfers ('adaptive' programme) or EGPP, a social protection programme ('conventional' programme).	N/A assessment was done years after programmes were implemented: 11 years (EGPP) and 4 years (NJLIP)	No control group

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Table 2. (Continued.)

Author, year	Design	Setting (Country)	Sample size	Population (Age)	Intervention	Follow-up assessment	Control group
Li *et al* (2021)	Pilot field experiment	Middle-aged and older people from a polluted urban community in Chengdu, Sichuan (China)	48	Adults (40–71 years)	Experimental setting with a pre-post walking intervention assessment at individual and environmental level, including real-time air quality index for the area. Two circular routes (1.6 km each) were set up in flat and illuminated walkways among the selected green space and urban area, which can be finished in ±20 min while monitored. An indoor checkpoint was established on each route for pre-and post-test measurements.	N/A pre-post assessment after experiment completion	N/A sample allocated to 4 walking groups: green areas (daytime/night-time) and urban areas (daytime/night-time)
McMichael *et al* (2021)	Qualitative multi-year evaluation of a governmental planned relocation programme	Indigenous coastal village residents (Fiji)	77–89	Adults (≥18 years, range: 20–84 years)	State-programmed planned relocation (defined as 'a solution-oriented measure, involving the State, in which a community is physically moved to another location and resettled permanently there'). Relocation ensured access to basic human rights including water, food, health, work, education, and a clean and healthy environment. Evaluation data collected over a five-year period using *talanoa* discussions (talking or telling stories without concealment), qualitative interviews with individuals and small groups, and observation of the built and 'natural' environment and everyday activities.	N/A data was collected in 4 time points over a 5 year period post relocation.	No control group

Table 3. Adaptation or mitigation and mental health & wellbeing assessments characteristics of the studies included in the review, grouped by study design ($n = 15$).

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Studies with experimental design					
Araban *et al* (2017)	Comparison of two groups' mean scores with an independent *t*-test or a Mann Whitney U test	Score changes between Intervention and control groups: Perceived benefits 2.04 (4.16) $p = 0.003$; Self-efficacy 3.35 (3.34) $p = 0.0001$	Stage of behavioural change, perceived benefits, and self-efficacy in ↓ exposure to air pollution for pregnant vulnerable women	Significant group differences in terms of stages of change in self-efficacy, perceived benefits and practice regarding air pollution preventive behaviours at follow-up assessment ($P < 0.05$). At 1 month FU: Stages of change: Action 46 (86.8) intervention vs control 3 (5.9) $p < 0.001$	Educational intervention strategies based on a transtheoretical model can ↑ preventive behaviours in pregnant women and ↓ exposure to air pollution.
Bedran-Martins *et al* (2018)	Change of SWB and MQoL across 4 groups (Urban Pension (UP) Rural Pension (RP), Urban Bolsa Familia (UBF) Rural Bolsa Familia (RBF) using ANOVA	Change of SWB: RP 0.46 (1.10)UP 0.66 (1.56) RBF 0.27 (1.39) UBF 1.11 (1.11) F Test 3.48 (0.01) Change of perception of MQoL 1.25 (0.99) 0.89 (1.52) 0.73 (1.20) 0.46 (1.31) 3.78 (0.01)	UP and UBF had significantly higher levels of positive changes in their SWB. UBF expressed significantly lower levels of positive changes in perception of MQoL. RP had significantly higher levels of positive changes in MQoL.	Mixed. Improvement in perception of MQoL and SWB among some households, however, the persistence of extreme food insecurity allied to other unintended effects of cash transfer can actually not only offset but also worsen households' Wellbeing	Material gains in QoL promoted by social programs may not be sufficient to transform households' SWB perception, especially if they are vulnerable to drought. The relationship between MQoL and SWB is not linear and appears to be particularly affected by how households are affected by drought.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Binh *et al* (2020)	Principal-component factor method to classify protective measures into five groups of measures: structural, property, livelihood, emergency, and financial	Modest, for informal communication training participants	Fear feelings (FEAR) and structural measures 0.20 ($p = 0.043$), livelihoods measures 0.15 ($p = .032$), Emergency measures 0.12 ($P = 0.036$) and Self-efficacy structural measures (SE) 0.37 ($p = 0.041$) property measures 0.24 ($p = 0.045$), livelihoods measures 0.34 ($p = 0.041$) 0.36 ($p = 0.044$) and 0.33 ($p = 0.090$)	Risk perceptions and coping capacities > when respondent had better flood information. Formal risk communication not change people's perceived consequences, emergency mitigation intentions and had a modest impact on their risk perception. Informal risk communication performed better changing households' perception of consequences, fear feelings, and coping capacities associated with emergency measures. Household's mitigation intention seemed to depend on self-efficacy. Women's participation in flood-related intentions of households did not have significant differences.	Informal risk communication: perceived stronger feelings of flood threat and ↑ intentions to take property and financial measures. Formal risk communication: had lower feelings of flood threat, and much lower effect of fear feelings on mitigation intention. Better knowledge of flooding led to higher intentions to take additional mitigation measures. Households living farther from the main river and/or a nearby channel had weaker incentives to implement structural measures.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Davids et al (2022)	EIA to assess the impact significance of 37 ranked and scored outcomes from 6 interventions in terms of 5 impact assessment criteria. Authors used bipartite analysis to describe the pattern, and visualise the strengths of linkages, between the interventions and outcomes.	Outcomes' Impact significance (high $\geq$17, moderate $10\geq$ <17, or low <10) and Interventions' relative cumulative impact across ecological, socio-economic, and health categories (high impact = 10, moderate = 5 and low = 3). Relative cumulative impact factor: 1. Extent (E): spatial scale; 2. Magnitude degree (M); 3. Duration (D): time scale; 4. Reversibility (R) degree; and 5. Probability (P): of occurrence outcomes. Significance indicator is estimated by: $S = C$ $(E + M + D + R)/4) \times P$.	Improved QoL of beneficiaries, community members and external stakeholders (including funders, government, etc). Data collected in site visits (direct field observations & discussions with program beneficiaries), stakeholder engagement (surveys & interviews), a social-ecological workshop and specialist study reviews.	Interventions resulted in 37 outcomes (36 +, 1 -) compared through their impact assessment significance scores. The socio-economic outcomes were the greatest (21), followed by ecological (11) and health outcomes (6). Outcomes included access to education & training; $\uparrow$ QoL; $\uparrow$ terrestrial and aquatic ecosystems; $\uparrow$ in recreation and cultural uses of natural areas; $\downarrow$ health risks and $\uparrow$ nutrition. The $\uparrow\uparrow$ ecological outcomes were from invasive alien plant control and solid waste removal and water quality monitoring. The $\uparrow\uparrow$ health outcomes were from solid waste removal and vegetable gardens; the $\uparrow\uparrow$ social-economic outcomes were from the general operation of WWWC, solid waste removal, and invasive alien plant control.	Investments in natural areas can deliver not only enhancements in ecosystems and services, but also local community socioeconomic and health benefits. This study provides an intervention quantifying tool for practitioners to select optimal local management interventions, that can be aligned with desired outcomes related to specific community challenges and policy requirements.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Duchelle *et al* (2017)	Mixed effects models. For interventions effects on Wellbeing, the outcome was the relative, pairwise difference between intervention types using only Phase 2 data. For overall wellbeing outcomes to examine changes over time for households exposed to different intervention types, Phase 1 and Phase 2 data were used.	1. Significant score changes (Rank) of household-level averages (and SD) of wellbeing scores between groups of interventions at global/country level and 2. Significant changes in overall SWB scores (better off and worse off) over time at global level for those receiving or no interventions.	Reported change in overall household SWB when compared with two years prior. Proportion of households exposed to the different intervention types, including no interventions at all, that reported being better off and those that reported being worse off in Phases 1 and 2, and the evaluation of the effect of specific interventions on household wellbeing, using an average score from the Likert responses in phase 2.	**Globally:** + correlation with Wellbeing for all interventions (incentives, disincentives, both) at baseline. Phase 2: among households on disincentives↓ in the number of better off households and ↑ in those worse off. No changes amongst those receiving both (general worsening of Wellbeing due to disincentives was alleviated by addition of incentives) **Indonesia:** households on incentives were worse off at baseline. Wellbeing ↑ significantly on Phase 2. **Peru:** households on disincentives (with/without incentives) had no significant changes over time. **Tanzania:** disincentives households were less worse off over time, strengthening local land rights and increasing SWB.	Findings highlight the importance of ensuring that interventions designed to protect forests also benefit local people. Disincentives can have (−) impacts on smallholders' rights and Wellbeing, and possibly even more so when they effectively ↓ forest clearing, impacting local livelihoods. Incentives can alleviate the burden of disincentives, but the right balance is needed. Local perceptions of the social impacts of forest interventions must be prioritised in safeguards monitoring because individual farmers and communities across the tropics will ultimately make the collective difference in how forests are managed.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
James *et al* (2020)	Intention To Treat analysis to assess the main intervention effect analysis: the change in scales values in the intervention group relative to control from T1 to T2 or T1 to T3. Data were analysed in a three-level linear mixed effects model with fixed effects interactions of time point and intervention and random intercepts at community and participant level.	Intervention ↑ disaster preparedness (T1 to T2 4.18, $p < 0.001$ and T1 to T3 2.90, $p < 0.001$; ↓ symptoms of depression (T1 to T2 0.35 $p < 0.001$, T1 to T3 −0.21, $p < 0.01$), PTSD (T1 to T2 −0.46, $p < 0.001$ and T1 to T3 −0.28, $p < 0.01$), anxiety (T1 to T2 −0.27, $p < 0.001$ and T1 to T3 −0.15, $p < 0.05$), functional impairment (T1 to T2 −0.35, $p < 0.05$), and ↑ peer-based help-giving (T1 to T2 1.71, $p < 0.001$ and T1 to T3 1.37, $p > 0.001$) and disaster-focused help-seeking (T1 to T2 0.59 $p = 0.05$).	Depression cases evaluated with Zanmi Lasante Depression Symptom Inventory (ZLDSI); PTSD, with the Modified PTSD Symptom Scale (MPSS); Anxiety with the Beck Anxiety Inventory (BAI); functional impairment (Five items for women, four items for men, adapted from Kaiser *et al* (2013) and social cohesion (Five items, adapted from Sampson *et al* (1997).	The intervention was effective, ↑ disaster preparedness, ↓ depression associated symptoms, post-traumatic stress disorder, anxiety, functional impairment, and ↑ peer-based help-giving and help-seeking. There were no significant effects on MH related help-seeking. This may be due to the difficulty in interpreting this concept, despite it to capture even informal help-seeking not only formal MH services that are extremely limited and hard to access. The effect of the intervention on preparedness was mediated by mental health, and the effects on MH were mediated by preparedness.	This community-based MH-integrated disaster preparedness intervention was effective in improving MH and preparedness among community members vulnerable to environmental hazards

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Nunes *et al* (2021)	Mixed methods evaluation of health and Wellbeing. Data was collected through 19 FGDs, 19 Semi-structured interviews, 217 questionnaires, 393 parasitological examinations and 33 analysis of water quality.	In communities with active SAA: benefits in work dynamics, house cleaning and personal hygiene (more comfort, privacy and safety to showering indoors) 55% reported more time for women to do additional income-generating activities, rest or leisure. 11% reported benefits in avoiding weight-carrying (water, bowls and clothes) from the riverbank to the households, and a ↓ in related back pain among those collecting the water.	SWB and impacts on household/domestic infrastructure.	The SAAs had impacts ↑ comfort, privacy and ↓ of the time employed in domestic activities (e.g. fetching water in the river or washing clothes, having an indoor toilet) related to ↑in life conditions, and ↓ in the risk of accidents related to going to the riverbank, from a wellbeing point of view. It did not have a reduction of parasitosis prevalence.	In general, in communities with active SAA, the Quality of tap water presented median better results than water from the river (e.g., the turbidity parameters) but could not supply drinking water due to parasitosis prevalence and did not lessen the health risks due to inadequate disposal of human waste. Despite this, the SAAs hold social impacts related to the comfort of domestic tasks and privacy for personal hygiene and represents an improvement in the living conditions of the communities.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Weston *et al* (2015)	SROI analysis interpret social and environmental variables and economic value creation using estimated proxy monetary values. Additionally, qualitative, and quantitative outcome changes were collected with the project's primary stakeholders	Proxy financial values among intervention stakeholders increased in 100% comparing outcomes at the end of project (Year 3) with 4 years after project close (Year 7) for: Increased optimism towards future, Enhanced leadership roles (especially for women) and community solidarity	Psychosocial wellbeing outcomes, individual and community aggregated livelihood impact	SROI which entails conceptualising proxy monetary values for social benefits of an initiative and allowing to determine individual and aggregate values of perceived changes on households' livelihoods from adopting FMNR (1) ↑ increased assets in the form of tree stocks and ↑ livestock; (2) ↑ wild resources (especially wild foods and construction inputs) for household consumption and sale and associated dietary health benefits; (3) ↑ psychosocial Wellbeing related to having a pleasing and comfortable community and work environment, ↑ leadership capacity of FMNR group members, and a more positive outlook; and (4) improved soil fertility and crop yields.	FMNR project is a field and forest restoration technique, that is also an embodiment of rural landscape management that empowers land users and creates space for ecological dynamics to restore soil and natural resources.
Williams *et al* (2020)	Mixed methods. 1. Intention to treat analysis: Two-tailed *t*-tests to compare differences in time spent collecting fuel between participants. 2. Thematic analysis on Qualitative interviews data collected from a sub sample.	Qualitative interviews found that adoption of LPG improved participants' QoL. Women appreciated that they could sleep more and that they and their families could consume more hot meals.	Perceived QoL through saved time that can be dedicated to leisure, rest, and income generation activities	Quantitative evidence of temperature-based stove use monitors, supported by self-reported survey data, that cooking with LPG can save significant time compared to cooking with biomass fuels, up to 5.8 h saved per week. Participants perceived this time savings as a positive change	Use of LPG may provide benefits beyond potential improvements to air quality and health that can be integrated into LPG promotion efforts. By quantifying the impact of LPG on time, this study provides evidence for one of the most promoted benefits of LPG.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Studies with quasi-experimental design					
Gori Maia *et al* (2021)	Difference-in-difference (DID) estimators; Two-stage regression estimators; and methods derived from the propensity score (PS)	SWB OLS estimates on satisfaction: Income (0.270, $p < 0.001$) work (0.324 $p < 0.001$) and life (0.233 $p < 0.01$). Food satisfaction was NS. The annual average farm income of MAIS farmers was 95% higher than non-MAIS farmers.	Measures of economic welfare and SWB (Income & Wellbeing—Farm income, Income, food, work, and life satisfaction).	MAIS farmers (survey 2018) reported their perceptions on variations in the income sufficiency (22% points ↑), quality of work (30% points ↑), and Quality of life in general (16 % points↑). No significant difference on the variation in the quantity of food satisfaction in the last 2 years. This may be because the program prioritised cash crop productions (milk and sheep meat) rather than the food sufficiency of impoverished farmers.	1st study to evaluate the impacts of a climate resilience program in the Brazilian semiarid region, where family farmers have historically suffered from recurrent and prolonged droughts that have worsened in the last decades. Simple farm management strategies may be an effective tool for building resilience into rural agricultural systems.
Gros *et al* (2019)	Logistic regression analysis of household surveys and qualitative data analysis	FbF-assisted households experience less psychosocial distress than non-FbF-assisted households in the aftermath of the flood.	Psychosocial distress (feelings of unhappiness, being miserable, anxious or depressed)	The survey data show that households who did not receive FbF assistance felt miserable or unhappy significantly more frequently after the flood than the intervention group who received cash assistance. Similarly, FbF-assisted households were significantly less likely to have felt anxious or depressed in the last seven days before the survey (29% vs. 43%)	The FbF cash transfer increased the regularity and Quality of beneficiary households' food intake, reduced the need to take out high-interest loans and appears to have reduced psychosocial stress in the aftermath of the flood. The intervention may have also prevented households from having to make destitution sales of valuable assets when compared to similarly affected households.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Sunderlin *et al* (2018)	Difference-in-difference (DID) estimators; Counterfactual analysis and local perceptions of the drivers of observed changes and the effects of REDD+ activities on Wellbeing among intervention and control villages and households.	In analysing the wellbeing effect of tenure-related interventions, the perceived effects were classified at the village level (negative, neutral, positive) by country, and by type of intervention (RFAC alone, TC alone, and the aggregated RFAC and TC).	Perceived effect of tenure related interventions on community wellbeing at the village and household levels	**All countries:** net positive view at the village level + (16.7% of villages had a negative view, 55.1% a neutral view, and 28.3% a positive view) and at the household level (18.6% holding a negative view, 35.5% a neutral view, and 46.0% a positive view). Respondents from **Cameroon, Tanzania,** and **Indonesia** have a net positive evaluation of the wellbeing impact of tenure-related interventions with a tendency toward a higher share of non-negative responses, whereas **Brazil** and **Peru** have a net negative evaluation, with fewer villages reporting positive responses (In Peru, the reasons for higher tenure insecurity have largely to do with 'problems with or fear/distrust of government authorities' and 'natural conditions are poor/pose risk'.)	The results suggest a somewhat less positive evaluation of the impact of restrictions on RFAC than TC interventions, both at the village and household level, especially in Brazil and in Peru, where also TC interventions had a negative evaluation at the village level. In Cameroon and Tanzania this was not significant at the village level. The importance of national-level action to successfully restrain the 'BAU-Business as usual' interests that continue to have the upper hand in tropical land use decisions is crucial on the achievement of REDD+. The role played by companies and by governments is central, and concerted efforts by civil society may be needed to bring about change.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Studies with pilot/focused case studies design					
Kundo et al (2022)	Thematic content analysis. Data validity was achieved through triangulation of data collected through FGD, LHI and KII to women, men and youth beneficiaries, and national and local officials.	N/A Program effectiveness was not reported. Rather, authors assessed the interviewees' vulnerabilities and resilience capacities and the contribution of the programmes to their desired self-reported wellbeing indicators	Self-reported wellbeing indicators, resilience, and vulnerability	Mixed. Perceived EGPP & NJLIP effectiveness varies across regions due to socio-economic and political factors. EGPPs are prioritised by local political actors without community consultation. Both fail to address structural barriers for gender equity (e.g., women ↑ livelihoods). NJLIP contributed modestly to long-term capacities to deal with climatic stresses. Outcomes of material Wellbeing (e.g., food consumption, expenditure) provide immediate poverty relief but fail to clear precarity or debt. Psychosocial Wellbeing (aspirations, confidence, purpose of life views) were not improved.	Repeated and predictable public works programmes reduce distress migration and improve food security and resilience capacities to deal with climatic stresses. Outcomes compared with one-off short-term programmes. Multipronged adaptive programmes that explicitly integrate climate change concerns perform better than conventional programmes. Cash programmes that fail to incorporate climate risk reduction in their design have ↓ potentiality to build resilience or enable households' preparedness for facing adverse climatic events.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
Li *et al* (2021)	Two-way ANOVA to determine the effects of time and location. Fisher's exact test and the Chi-squared test to check the preferred difference between the two walking environments.	The median score of PANAS-positive ↑ significantly after daytime green walking ($p = 0.03$) and nighttime urban walking ($p = 0.046$). The median score of Vigour ↑ significantly after daytime green walking ($p = 0.034$) and nighttime urban walking ($p = 0.024$). In daytime, the PRS score in green walking was significantly > than urban walking ($p < 0.001$). In the urban walking, the PRS score in nighttime was significantly > than daytime walking ($p = 0.037$).	Positive and negative emotions (PANAS), Six subscales of mood (POMS assessing Tension or anxiety (T), anger or hostility (A), fatigue (F), depression or dejection (D), Vigour (V), and confusion or bewilderment), perceived restorativeness of environment (PRS) and properties of the environments that contributed to the restorative outcomes (ROS)	Blood pressure (SBR, DBP, and MAP), and some psychological parameters (PANAS-positive and POMS-Vigour) demonstrated reduction after the daytime urban walking. The nighttime urban walking was associated with significant improvements in moods (PANAS-positive, POMS-vigour, and POMS-TMD) and blood pressure (SBP and MAP). In addition, the nighttime PRS score of the urban area was significantly higher than the daytime counterpart.	Daytime green environments are advantageous to mental relaxation and can help to lower blood pressure, while the urban environments are negatively associated with walking exercise and may attenuate positive effects of physical activities. The psychological influences may be subtle during the nighttime green walking, and nighttime walking in both urban areas and green spaces may provide similar benefits. Considering the limitations of the present study, we would recommend the urban citizens start nighttime green walking after work, and nighttime urban walking is also advisable when the air is less polluted.

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Table 3. (Continued.)

Author, year	Analysis	Effectiveness of the strategy/program	Indicator of interest	Key findings	Implications & remarks
McMichael *et al* (2021)	Thematic content analysis. Data validity was achieved through triangulation of *tanaloa* data, individual and small groups interviews and interactive mobile interviews	N/A Program effectiveness was not reported. Rather, villagers relocated in the state program reported health and wellbeing benefits and challenges following planned relocation.	Disrupted place attachment, mental Wellbeing	Key facilitators for good health and wellbeing (movement away from environmental risks to health, livelihoods diversification) and challenges and risks (disruption of culture and place attachment, communal laws, ↓ mental Wellbeing). These determinants are also mediated by wider processes of sociocultural change that operate at the local, national, and global levels. Reported health risks—i.e, altered diet, increased consumption of alcohol and tobacco—were understood to be the result of diminished traditional values and practices.	These results highlight the need for context-specific planning and adaptation programs that include meaningful involvement of community members in ongoing decision making, and call for an understanding of diverse social determinants of health that emerge and evolve in contexts of planned relocation.

SWB: subjective wellbeing; MQoL: material quality of life; UP: urban pension; RP: rural pension; UBF: urban Bolsa Familia; RBF: rural Bolsa Familia; EIA: environmental impact assessment; FGD: focus group discussion, LHI: life history interview; KII: key informant interview; EGPP: Employment Generation Programme for the Poorest; NJLIP: Nuton Jibon livelihood Improvement Project; PANAS: positive and negative affect schedule; PRS: perceived restorativeness scale; POMS: mood states questionnaire; ROS: restorative outcome scale; RFAC: restrictions on forest access and control; TC: tenure clarification; SAA: water supply system; LPG: liquefied petroleum gas; QoL: quality of life; FbF: forecast-based cash transfer; SROI: social return on investment.

and life satisfaction. The study led by James *et al* [54] showed positive effects of the intervention on disaster preparedness and mental health outcomes, such as depression, trauma, anxiety, and functional impairment, as well as social outcomes, such as help-giving and help-seeking behaviours. However, despite the positive effects found in the studies mentioned, the specific effect sizes values across the studies were not reported, making it difficult to assess the magnitude of the improvements and the significance of these changes. Additionally, confirming the long-term effects of these interventions is challenging due to the varied evaluation periods and availability of post-intervention assessments. For example, five studies [55, 57, 63, 65, 66] did not report conducting follow-up assessments, and the remaining ten did. However, their timelines ranged from one-month follow-up evaluation post-intervention [53] to 15 years [56], as in the study led by Bedran-Martins.

On the other hand, there were studies with mixed or non-significant changes among intervention participants. For instance, Duchelle's randomised evaluation of the anti-deforestation multi-country program [58] found mixed effects of specific intervention components across countries, highlighting the importance of local factors in real-life conditions and the need to prioritise meeting communities' needs. Additionally, qualitative evaluations conducted by Kundo *et al* [64] of two governmental programs for communities at high-risk for short and long-term climatic stressors and McMichael and Powell [28] on the longitudinal assessment of a relocated community due to coastal erosion and sea-level rise provided valuable insights into the intervention participants'perspectives but also obtained mixed results in terms of the perceived effectiveness and improvements that these strategies brought across regions. These findings highlight sociocultural, socioeconomic, and political factors' role in wellbeing indicators and emphasise the need to involve target communities into context-specific participatory design planning meaningfully.

4. Discussion

This systematic review summarises the existing evidence on the effects of climate change mitigation and adaptation strategies on mental health and wellbeing outcomes among adult populations living in LMICs. Most included studies focused on adaptation interventions, with only a few examining mitigation programmes. There was limited evidence on the effects of climate action on common mental disorders. Furthermore, no studies assessed the linkages between mental health variables and mitigation programmes.

The study designs, types of intervention, and their active components varied widely across studies, reflecting the diverse range of strategies being implemented, the different climatic hazards being addressed, and the various assessment tools and approaches used to measure mental health and wellbeing outcomes.

Factors significantly associated with wellbeing outcomes ranged broadly between studies, but most findings highlighted the critical role of contextual and sociocultural factors in achieving beneficial effects. For example, there was a consistent link between cash transfer programmes and integrated interventions that strengthen community ties and improve material living conditions or wellbeing. This findings aligns with the broader literature on underserved communities and climatic events [73] and external stressors [74]. However, while cash transfers programs, especially unconditioned ones can increase participant's wellbeing levels by helping them meet their basic needs, they may require an integrated approach to achieve longer-term wellbeing effects, as reported elsewhere [75]. Evaluations of anti-poverty governmental programs [56, 64] implemented in underserved communities and multi-country anti-deforestation programs [58, 62] highlighted the need for tailored community protective measures that go beyond providing access to cash funds for high-risk groups affected by climatic stressors.

Notably, none of the included studies reported on additional related mental health topics, such as forced migration, gender-based violence, or substance use. The limited evidence in this area may be attributed to mental health not being a primary focus of evaluations of climate change mitigation and adaptation strategies in LMICs [76] and the lack of validated scales and tools for measuring these outcomes in co-benefits studies in LMICs [77].

The reporting of gender-disaggregated data across the included studies was scarce. Women, who often experience higher rates of mental conditions, primarily due to depression [78], are disproportionately affected by the impacts of climate change [79]. Given that nine out of the 15 included studies assessed populations living in high-risk areas for cyclical extreme weather events, the lack of reported outcomes with gender-differentiated data is concerning considering the increased economic pressures faced by female beneficiaries of climate mitigation and adaption programmes. Women often become heads of households after extreme weather events [80], experience displacement [81], partner's economic migration or endure gender-based violence [82], all of which have well-documented mental health consequences [13]. Ensuring equal inclusion in leadership and decision-making of women and minorities, especially those belonging to Indigenous groups in high-risk areas for climatic stressors, is crucial to address their mental

and wellbeing needs while incorporating their unique knowledge of ecosystem handling and protection.

Improvement in quality of life [55–57, 60] and perceived wellbeing [28, 53, 56, 58–62, 64] were the two most commonly reported positive outcomes across the strategies, with fewer studies reporting decreased psychosocial distress, self-efficacy and resilience. This finding broadly resonates with the more extensive evidence base on co-benefits amongst high-risk communities affected by climatic hazards in LMICs [16].

The relationship between the co-benefits of adaptation and mitigation strategies and mental health outcomes among LMIC populations is still largely unknown, with limited quantitative research to date. Two studies that measured mental health outcomes quantitatively were also limited by methodological constraints in conducting research in humanitarian settings. One study [54] conducted 3 day mental health integrated disaster preparedness group intervention, used validated scales and conducted follow-up assessments three and six months after the study. The other study [63] provided unconditional cash transfers in anticipation of extreme weather events, used a survey with a shortened version of a standardised scale, and did not report a follow-up assessment, limiting the understanding of the temporal relationship between these strategies and the possible mental health co-benefits they bring to beneficiaries and communities.

The countries and regions identified as having extensive exposure to climate change hazards are primarily located in the tropics and subtropics [83]. With large regions affected by climate change hazards, Brazil has the largest population exposed to wet-bulb temperatures of 30 °C and above [84]. This review's findings align with this evidence, as 5 out of 15 studies were conducted in Brazil. Peru and Indonesia were the next most common countries, with three studies each.

Most studies (12 out of 15) were implemented in rural or peri-urban villages located in various settings and exposed to different environmental threats, providing a clearer understanding of where these strategies can potentially have an impact. However, various methods were used to measure the most frequent wellbeing outcomes, and most studies did not report their translation process or validation of the surveys or tools used for individual data collection, which may weaken the reliability of the findings. Future research should incorporate validated tools to provide more accurate data on the impact of these strategies. The absence of widespread formal evaluations of these strategies 'mental health and wellbeing outcomes limits policymakers' ability to make informed decisions considering the holistic impact of climate change mitigation and adaptation strategies at both population and individual levels.

Despite the increase in recent evidence on the threats of climatic hazards and their impacts on health and wellbeing, global estimates and projections often need to be revised at regional and local levels. Higher temperatures and various extreme weather events may have different effects in different areas. However, social vulnerability factors and individual susceptibilities mediate their local impact on human populations, such as the marginalisation of certain groups like Indigenous People, lack of communication and support features for rural villages, poorly planned urban and peri-urban characteristics, and high prevalence of comorbidities. These factors tend to increase the risk of adverse health outcomes within populations [8, 10].

4.1. Strengths and limitations

The strengths of this review lie in the comprehensiveness of the search strategy and the rigorous inclusion criteria used. We included controlled, quasi-experimental, and pilot studies and focused case studies that reported on the impact of climate change mitigation and adaptation strategies on mental health and wellbeing outcomes. Also, only one included study [54] directly focused on mental health outcomes rather than assessing mental health as a secondary benefit of other climate adaptation activities. This aligns with the broader lack of research examining mental health as a primary outcome in climate change intervention studies [7, 85, 86]. The shortage of studies focused specifically on mental health measures highlights a key gap in the evidence base and underscores the need for future intervention studies to deliberately incorporate and prioritise validated mental health assessments. The limited number of studies that met the inclusion criteria underscores the need for further research in this area.

Nevertheless, as awareness of the potential mental health and wellbeing co-benefits of mitigation and adaptation efforts increases, these aspects are expected to be more deliberately considered to augment population benefits. However, more research is needed to strengthen this review's relatively weak evidence base. Our restriction to adult populations may have omitted overarching evidence across the lifespan. However, this approach is justified since most participants and beneficiaries of these strategies and programs are adults. Additionally, four studies included subpopulations with increased vulnerability to risk factors, such as older adults [66], youth [59, 64], indigenous women [55] and pregnant women [53].

This review included published peer-reviewed studies reporting quantitative and qualitative outcomes in English and Portuguese. Data extraction was completed by a single author, which introduces the potential for selection and extraction bias. However, this bias is mitigated by oversight and discussion with a second author during the screening, data extraction

and quality appraisal processes. Future review should also consider including grey literature for a more comprehensive search in this area. Due to the heterogeneity of outcomes, conducting meta-analysis or meta-synthesis of quantitative and qualitative studies was impossible, thereby preventing the pooling of results.

4.2. Future research recommendations

Further research should focus on collecting more data targeting local population groups with heightened vulnerabilities. This will contribute to a more comprehensive understanding of the cross-cultural impacts of these strategies. Detailed and country-specific evaluation analyses and focused data on the most affected groups are needed to inform policymakers, the public, and key stakeholders. Additionally, joint co-design of targeted interventions with the communities at the forefront of adaptation efforts, ensuring research equity and inclusion, is crucial to understand better the magnitude of climate change impacts on population health and wellbeing and to identify and leverage the protective factors of mitigation and adaptation programs. More attention and efforts should be directed towards the potential negative impacts of implemented mitigation and adaptation strategies, such as displacement through relocation [64] and loss of livelihoods [58]. This can be achieved by more frequent and better measurement of mental health outcomes, considering such potential negative impacts, and ensuring that they are minimised with strong, culturally sensitive co-produced, and participatory local adaptation measures. We have included studies that have assessed mental health and wellbeing outcomes at the individual level but there are also social-ecological level factors with an undeniable influence at both the individual and the community level, which should be explored accordingly. Furthermore, strategies should also ensure that affected communities are adequately compensated for economic and material losses and empowered to face the effects of climate change.

It is crucial to recognise that populations living in LMICs are among the most vulnerable and neglected groups, often lacking support from their governments. They have been forced to be at the forefront of adaptation activities, with little or no engagement from local authorities. Therefore, their needs, vulnerabilities and contextual factors must be considered when scaling up multisectoral approaches that harness the co-benefits of these strategies to alleviate the burden on their mental health and wellbeing.

Addressing these potential co-benefits for populations living in LMICs requires a holistic and transdisciplinary approach. It is essential to consider the specific needs and vulnerabilities of target population groups, including those living with disabilities, women, the elderly, and youth, living in high-risk areas for climatic events and environmental

hazards in LMICs. This consideration ensures that these strategies are practical, equitable and capable of bringing population-wide indirect effects that positively impact sustainable development, poverty reduction and wellbeing in these countries, although more evidence is still needed.

Our findings should be interpreted with caution due to the possibility of reporting and publication bias. Additionally, the small number of studies, the lack of specific size values reported, and the heterogeneity of the study designs and populations make it challenging to draw firm conclusions. Further research is needed to fully understand the potential co-benefits of these strategies for mental health and wellbeing in LMIC settings.

The results of this review underscore the need for greater attention to the psychosocial impact of climate change mitigation and adaptation strategies, both in terms of measuring mental health and wellbeing as outcomes, and in designing interventions. The concurrent global climate and mental health crises require the prioritisation of evidence-based policies that prioritise the mental health and wellbeing of the population. Such policies should promote preparedness, resilience, and recovery facing climate change effects, foster social cohesion and community engagement, and empower individuals and communities in LMICs.

5. Conclusion

This review identified limited and disparate evidence regarding the effects of climate change mitigation and adaptation strategies on mental health and wellbeing in LMICs. Despite the widespread implementation of programming in this area, formal evaluations that measure these critical outcomes are lacking. Given the current global climate and mental health crises, this scarcity of evidence represents a missed opportunity to address significant long-term problems for population mental health and wellbeing. Urgent research is needed to explore how these interventions work and how to better address mental health responses, considering local factors and adopting a transdisciplinary approach at all levels to facilitate the translation of findings into policy and action.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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Conflict of interest

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Credit author statement

Elaine C Flores/Alan D Dangour: Conceptualization, Methodology. Elaine C Flores/Laura J Brown: Data collection; Elaine C Flores: Analysis, Writing, Original draft preparation, and Editing. Laura J Brown/Ritsuko Kakuma/Julian Eaton/Alan D Dangour: Analysis, Writing- Reviewing, and Editing.

ORCID iD

Elaine C Flores ⓘ https://orcid.org/0000-0002-6195-9595

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