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Co-designing maternal mental health interventions and implementation strategies under climate stress in Nigeria: a participatory workshop

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Background: Climate change is a risk multiplier in low- and middle-income countries, threatening maternal mental health and early childhood development. In Nigeria, environmental shocks intensify these risks, yet responses remain fragmented across sectors. Using a participatory implementation-science approach, this study co-designed a psychosocial intervention package and accompanying implementation strategies to protect maternal mental health under climate stress.
Methods: A full-day co-creation workshop was conducted in Enugu, Nigeria, involving 16 stakeholders (affected mothers, community health workers, community leaders, data collectors, and policymakers). Grounded in prior systematic review, national quantitative, and qualitative evidence, the workshop utilised participatory inquiry to map implementation determinants and the Expert Recommendations for Implementing Change (ERIC) taxonomy to select and categorise implementation strategies. Participants progressed through determinant mapping, appraisal of candidate components from Low-Intensity Psychological Interventions (LIPI) and WHO Problem Management Plus (PM+), delivery framework co-design, and strategy prioritisation via dot-voting.
Results: Stakeholders identified environmental shocks as key drivers of maternal anxiety, distress, and trauma. From eight candidate components, participants retained five for the preliminary Climate Adaptation and Psychosocial Support (CANOPY) candidate package: behavioural activation, cognitive restructuring, managing worries and problems, lifestyle, and strengthening social support. Three PM + components were discarded as duplicative, whereas strengthening social support was added to leverage existing community networks. Participants developed three preliminary delivery frameworks pairing psychosocial support with environmental protection. These frameworks represent proposed delivery

channels requiring further operational specification. Voting favoured immediate, actionable implementation strategies and frontline health-system strengthening over slower legislative and structural reforms.
Conclusion: Stakeholders pragmatically prioritised feasible, frontline community and health system strategies over structural policies. Prospective implementation of the CANOPY package would likely require addressing workforce shortages and stigma while leveraging informal social safety nets and faith-based structures. Voting outcomes are presented as exploratory participant preferences within the workshop, and prospective implementation of CANOPY is presented as a future step requiring further operationalisation and evaluation.

KEYWORDS
climate change adaptation, co-production, implementation science, low- and middle-income countries, perinatal mental health, problem management plus, Sub-Saharan Africa, task-sharing

1 Introduction

Climate change is one of the most significant global health threats of the 21 century, and its effects are felt most acutely in low- and middle-income countries (LMICs), where fragile health systems and limited infrastructure intersect with environmental stress (1, 2). Between 3.3 and 3.6 billion people now live in settings assessed as highly vulnerable to climate change, concentrated in Sub-Saharan Africa and South Asia (2). Nigeria is especially exposed: flooding in the south and drought and rising temperatures in the north are intensifying, compromising water security, agriculture, and livelihoods, and contributing to malnutrition, displacement, and disease (3, 4). The 2022 floods, the most severe in a decade, killed more than 600 people, displaced approximately 1.4 million, and affected 2.5 million (5). Flooding of this scale is now close to annual, with further fatal floods in 2024 and 2025.

Acting as a risk multiplier on an already heavy burden of communicable and non-communicable disease, climate change threatens national progress toward the Sustainable Development Goals, particularly SDG 3 (good health and well-being) and SDG 13 (climate action) (6), with women and young children among those most affected. As of late 2024, approximately 800,000 pregnant and breastfeeding women and 5.4 million children across six of the worst-affected northern states were at risk of acute malnutrition (7). Maternal and child mortality in Nigeria remains among the highest globally (8). It accounts for an estimated 28.3% of global maternal deaths, with a modelled maternal mortality ratio of 1,047 per 100,000 live births (9).

Within this context, maternal mental health is a critical but frequently overlooked pathway. Perinatal depression is common across LMICs, with a pooled prevalence of 24.7% reported from 589 studies in 51 countries, against a global pooled postpartum depression prevalence of 17.7%; studies from Nigeria, Sudan and Ethiopia report perinatal anxiety in 31 to 44% of women (10, 11). Climate-related shocks add psychological strain to already vulnerable households. Displacement, loss of homes and livelihoods, and chronic uncertainty are associated with increased maternal anxiety, depression, and post-traumatic stress (12, 13), which in turn can raise the risk of pregnancy complications and disrupt early bonding and responsive caregiving. Our prior work, using recent national evidence from Nigeria, found that higher daytime temperatures have been associated with child undernutrition, childhood fever, greater maternal postpartum distress, and reduced healthcare access (14), while qualitative accounts from flood-affected communities describe how flooding and extreme heat disrupt households, strain caregiving, and undermine maternal mental health and access to care. Because early childhood is a sensitive period for neurological, cognitive, and socio-emotional development, maternal distress and household disruption accompanying climate shocks can have lasting effects on children (15). These pathways are compounded by poverty in agrarian communities dependent on rain-fed farming, where crop and income loss limit access to nutrition and health care (16).

Effective responses to these challenges are not, in principle, lacking. Psychological interventions for perinatal depression delivered by non-specialist and lay health workers using task-sharing are effective, feasible, and acceptable in LMICs, and work best when embedded in routine maternal and child health care and extended to the wider family (17, 18). Yet such interventions remain under-scaled, and their implementation is constrained by workforce shortages, weak supervision, and limited contextual adaptation (18, 19). At the same time, climate and disaster responses in Nigeria and comparable settings are predominantly reactive and infrastructure- or relief-focused, and mental health and psychosocial support are routinely neglected within them (20). Crucially, comparative empirical evidence on local disaster governance from lower-middle-income settings, such as Indonesia, demonstrates that institutional capacity translates into disaster risk reduction performance through internal organisational routines and sustained multi-stakeholder collaboration rather than through resource possession alone (21). Furthermore, empirical evidence on preventive disaster governance in Indonesia reveals that the mere presence of multiple stakeholders remains insufficient when collaboration is *ad hoc*, event-driven, and restricted to post-disaster response (22). Effective pre-disaster risk reduction instead requires institutionalised collaborative forums, inclusive participation, and clear operational ground rules (22). In Nigeria, however, these operational and collaborative spheres remain disconnected, producing two largely parallel efforts: maternal mental health interventions that are not climate-informed, and climate adaptation and disaster responses that overlook mental health and early childhood development. A small number of studies have begun to bridge them, most notably a cluster-randomised trial in Uganda pairing a WHO low-intensity psychological package with climate-smart agriculture among refugee mothers (23), but these apply existing interventions to climate-affected populations rather than adapting intervention content to climate-specific

stressors. Few interventions address the intersection of climate stress, maternal mental health, and child development; fewer still are co-designed with the communities they are meant to serve; and implementation-ready evidence remains scarce in Nigeria (12).

Closing this gap requires more than further evidence of harm; it requires translating evidence into context-fit, implementable interventions. Participatory implementation science offers a means of doing so, bringing affected communities together with front-line and policy stakeholders to co-design interventions that reflect local realities and are more likely to be adopted and sustained. To this end, this study convened a participatory co-creation workshop with stakeholders drawn from Benue State, a north-central state subject to recurrent flooding along the Benue river system and to the agricultural disruption that accompanies rainfall variability, and the setting for the qualitative strand of the parent study. The workshop pursued two objectives. The first was to co-design a psychosocial intervention package for maternal mental health under climate stress, by appraising candidate intervention components with those expected to deliver and to receive them. The second was to identify and prioritise implementation strategies for delivering that package, using the Expert Recommendations for Implementing Change (ERIC) taxonomy (24, 25) to align stakeholder-identified bottlenecks with established strategies. In doing so, the study aimed to produce a locally grounded intervention package alongside *a priori*tised implementation plan, together with an account of the determinants likely to shape their adoption.

2 Materials and methods

2.1 Study design and setting

This study employed a participatory co-creation workshop design to develop context-specific implementation strategies to mitigate the impacts of climate change on maternal mental health and early childhood development in Nigeria. Nested within a broader mixed-methods implementation research project, the workshop sought to bridge the gap between empirical evidence regarding climate-related exposures, such as heat stress and rainfall variability, and the practical needs of affected communities. The design drew on principles of participatory implementation science, utilising the ERIC taxonomy (24, 25). ERIC was applied strictly as a taxonomy of 73 discrete implementation strategies organised into nine clusters to categorise and specify stakeholder-generated strategies, whilst local implementation determinants (barriers and facilitators) were identified through participatory diagnostic mapping. The workshop was conducted in Enugu, Nigeria, drawing representation from Benue State, a setting with high climate vulnerability. The analytical approach explicitly distinguished among four distinct objects: (1) implementation determinants or barriers/facilitators, representing multi-level contextual factors affecting delivery; (2) clinical and psychosocial intervention components, constituting the core therapeutic elements of the CANOPY package; (3) implementation strategies, defined strictly as methods or techniques (mapped to the ERIC taxonomy) used to promote the adoption and delivery of CANOPY; and (4) broader service-system, environmental, and public-policy interventions, encompassing macro-level structural, infrastructural, or legislative measures (such as river dredging or anti-stigma laws) that serve as vital contextual foundations but are analytically distinct from implementation strategies. To resolve conceptual ambiguity, three operational definitions were established for this study. First, regarding target population boundaries, the intervention focuses across the perinatal continuum, explicitly defined as pregnant women and postpartum mothers up to 12 months following childbirth, alongside their infants and young children. Second, 'climate stress' is operationalised as a compound exposure incorporating both acute hydrometeorological shocks (seasonal riverine flooding and emergency displacement) and chronic, slow-onset environmental pressures (extreme ambient daytime heat, rainfall unpredictability, and resultant agricultural and livelihood disruption). Third, psychological outcomes are explicitly conceptualised as non-clinical, transdiagnostic 'psychological distress' (characterised by situational anxiety, worry, emotional exhaustion, and demoralisation), rather than diagnosed clinical mental disorders; CANOPY is designed as a primary-care, task-shared psychosocial package rather than a specialised psychiatric intervention.

2.2 Conceptual framework and evidence base

The co-creation process was informed by complementary quantitative and qualitative evidence generated through the broader research programme. The quantitative evidence was derived from the previously published national cross-sectional study by Maharani et al. (14), which examined associations between ambient temperature, rainfall, and adverse maternal and child health outcomes in Nigeria. In addition, candidate psychosocial interventions were informed by an extensive systematic review conducted by our research team (registered on PROSPERO, CRD420261295747). Synthesising 48 peer-reviewed qualitative, quantitative, and intervention studies across 31 Sub-Saharan African countries from eight major databases, the review evaluated the impacts of climate exposures (extreme heat, drought, erratic rainfall, and flooding) on maternal physical and mental health and early childhood development. Crucially, the review identified an acute scarcity of evaluated mental health adaptation programmes and established that individual-level behavioural modifications consistently falter under severe climate shocks without structured psychosocial coping and community scaffolding. Furthermore, the synthesis highlighted that brief, task-shared cognitive and transdiagnostic problem-solving approaches delivered by non-specialists represent the most viable delivery model in resource-constrained environments, directly justifying the *a priori* appraisal of LIPI and WHO PM + as candidate foundations. These findings were complemented by qualitative evidence from focus group discussions and in-depth interviews exploring participants' experiences of climate-related stressors, psychological distress, livelihood disruption, and barriers to healthcare access. Findings relevant to the workshop objectives were synthesised into structured evidence briefs highlighting key climate-related vulnerabilities, contextual determinants, and potential areas for intervention. These briefs were presented during Phase 1 and used to contextualise participants' subsequent appraisal of the candidate psychosocial intervention components.

2.3 Participant recruitment and stakeholder sampling

Participants for the participatory co-creation workshop were recruited using a nested, purposive sampling strategy. The sampling frame comprised primary stakeholders who had previously taken

part in focus group discussions (FGDs) and in-depth interviews (IDIs) across the parent study's three target local government areas (LGAs) in Benue State, namely Makurdi, Gboko, and Otukpo. The 16 workshop participants were drawn across the three target LGAs: Otukpo ($n = 6$), Makurdi ($n = 5$), and Gboko ($n = 5$).

Recruitment prioritised sub-cohorts from the parent study, including affected mothers, data collectors, community primary healthcare workers and doctors, and community leaders. From this pool, individuals were selected by two members of the field research team (NIA and JJ) who had conducted the primary qualitative fieldwork. Candidate selection was conducted against two formal criteria, evaluated qualitatively through independent review of primary field notes, transcripts, and interviewer debriefing records: demonstrated contextual depth, evidenced by detailed accounts of local climate shocks, flood displacement, and care-seeking disruptions during parent study data collection; and interactive communicative capacity, operationalised as a willingness to engage constructively in peer dialogue and offer unprompted, spontaneous contributions during previous focus group discussions. Discrepancies in candidate suitability were resolved through consensus discussion without utilising a standardised scoring rubric.

Because eligibility was assessed partly on prior participation and demonstrated willingness to contribute spontaneously in previous group discussions, the sampling process may have favoured participants who were more familiar with the research team and more comfortable speaking in group settings. This may have introduced selection and social desirability bias and may have underrepresented quieter participants or individuals less willing or able to disclose psychosocial difficulties in group contexts. The pre-existing relationship arose from participants' involvement in the parent study. This familiarity supported recruitment of individuals with direct contextual knowledge of the study setting, but may also have influenced how participants interacted with facilitators or expressed views during the workshop.

A pragmatic sample of 16 participants was selected to provide representation across five stakeholder groups while enabling division into three small deliberative working groups for intensive discussion. All 16 invited stakeholders participated, with no refusals or dropouts. Specialised mental-health professionals (such as psychiatrists), emergency and disaster-management authorities (such as NEMA or SEMA), environmental actors, and civil-society organisations were not included in this workshop cohort. The recruitment deliberately focused on frontline primary healthcare actors, local community governance, and affected service users directly involved in primary care delivery and community coping. Affected mothers contributed direct lived experience of climate-related displacement, psychological distress and barriers to obtaining care. Research data collectors were included because their involvement in the parent study provided field-level knowledge of the study communities, recurrent concerns reported during data collection, and practical challenges related to engagement, disclosure and referral. They were included as contributors of contextual and implementation knowledge and were not treated as representatives of affected mothers or as substitutes for lived experience.

2.4 Workshop structure and sequential procedures

The co-creation workshop was conducted over a single full-day session in English, and no translation or interpretation was required. Although participants were drawn from Benue State, Enugu was selected for logistical reasons, including venue availability and coordination by the research team. Participants were supported to travel to the workshop. To support efficient and balanced contribution, procedures were structured across a sequential, four-phase trajectory (Figure 1) managed by four trained academic facilitators: NIA, a female medical sociologist with extensive qualitative research

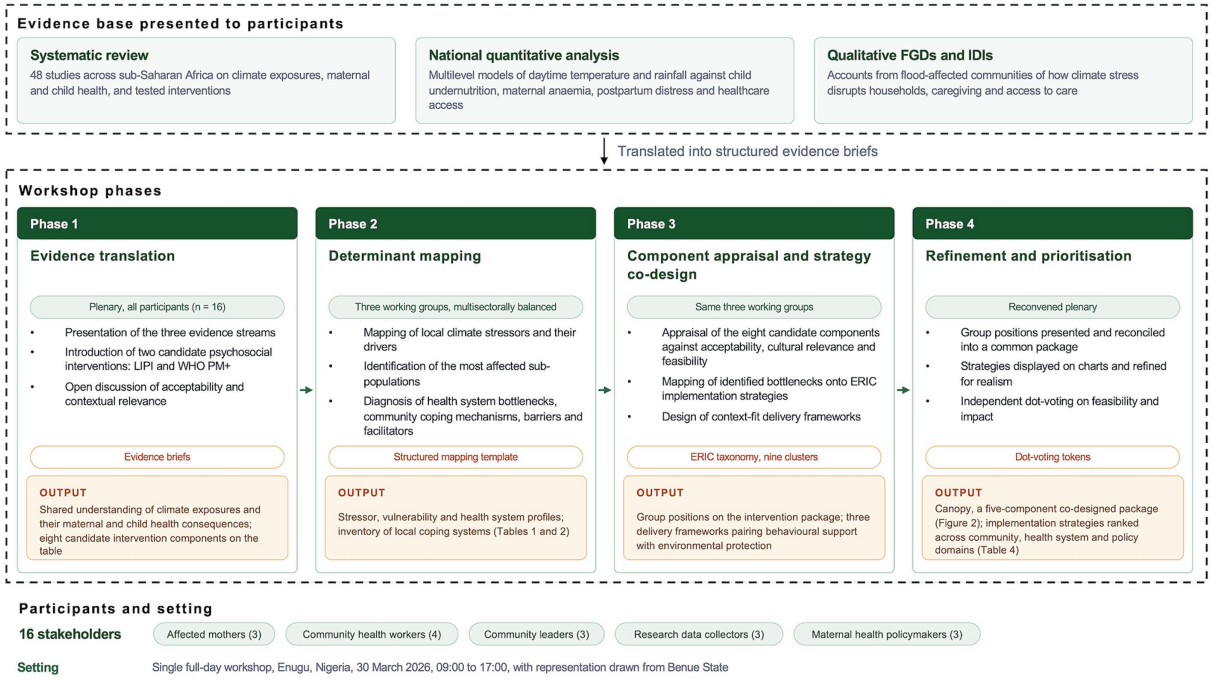


FIGURE 1
Design, evidence inputs, phase structure and outputs of the co-creation workshop.

experience; AM, a female public health physician and epidemiologist focusing on environmental health stressors; JM, a female health researcher specialising in inclusive mental health co-production; and JJ, a male medical sociologist with extensive experience in qualitative data collection. The four phases lasted approximately 60 min (Phase 1: Evidence Translation), 90 min (Phase 2: Determinant Mapping), 120 min (Phase 3: Strategy Mapping), and 45 min (Phase 4: Plenary Review and Dot-Voting), with scheduled breaks between phases. Participants were divided into three small working groups with multisectoral representation. Group allocation was undertaken by the facilitation team to distribute community and professional perspectives across the three groups and avoid concentration of a single stakeholder category within any one group. The stakeholder categories represented were affected mothers, community nurses/doctors, community leaders, research data collectors, and policymakers. Trained facilitators guided each group and encouraged contributions from participants across stakeholder categories to minimise professional or hierarchical dominance.

2.4.1 Phase 1: evidence translation

The full cohort ($N = 16$) met in a unified plenary session. Researchers presented integrated quantitative and qualitative data from the parent study, standardising the baseline technical understanding of climate-induced maternal and neurological vulnerabilities across all participants.

During this phase, participants reviewed two evidence-based psychosocial interventions suitable for integration into primary maternal healthcare: cognitive behaviour therapy-based Low-Intensity Psychological Intervention (LIPI) based on the NHS Talking Therapies model in England (26) and the World Health Organisation Problem Management Plus (PM+). Facilitators presented the key components, delivery approaches, and implementation considerations for each intervention, after which participants discussed their feasibility, acceptability, and contextual relevance within climate-vulnerable communities in Nigeria.

2.4.2 Phase 2: determinant mapping

Participants were split into three distinct working groups (Group 1, Group 2, and Group 3), each balanced for multisectoral representation. Guided by structured templates and a facilitator, each working group independently conducted diagnostic mapping of local implementation determinants, identifying climate stressors, vulnerable sub-populations, community facilitators, and structural health-system barriers.

2.4.3 Phase 3: strategy mapping

Operating within the same three working groups, participants mapped candidate solutions to the identified bottlenecks. Stakeholders distinguished between discrete implementation strategies to support CANOPY delivery (which were deductively categorised using canonical ERIC strategies) and broader service-system, environmental, and public-policy interventions (such as disaster relief and municipal infrastructure), synthesising these into three delivery framework architectures (HOPE, FLEXI, and LIPIS).

To ensure operational reproducibility and adherence to implementation-strategy reporting standards (27), candidate ERIC strategies prioritised by stakeholders were operationalised across seven canonical dimensions: actor, action, action target, temporality, dose/intensity, intended implementation outcome, and justification. Implementation determinants (barriers and facilitators) were examined independently of ERIC using an inductive socio-ecological perspective spanning individual, interpersonal, facility, and policy levels, reserving the ERIC taxonomy exclusively for strategy categorisation and specification.

2.4.4 Phase 4: plenary review and dot-voting

The working groups reconvened into a unified plenary session. All co-designed strategies were presented visually on charts. Voting was anonymous, and only aggregated strategy-level token totals were retained for analysis.

Each participant received 15 equal-value physical voting tokens. With 16 participants, the maximum available voting pool was 240 tokens. Participants reviewed the strategies generated by their assigned working group and independently allocated their tokens according to perceived feasibility, scalability and immediate community relevance. Participants undertook this appraisal heuristically based on experiential knowledge, without access to formal unit-costing data, fiscal expenditure projections, or standardised estimates of implementation effort. Participants could place more than one token on a strategy and were not required to use all 15 tokens. Voting produced 210 recorded tokens: 62 in Group 1, 75 in Group 2 and 73 in Group 3. Thus, 210 of the 240 available tokens were used (87.5%), while 30 remained unused. Scores represent aggregated token counts rather than numbers of participants. Participants evaluated all strategies generated within their assigned working group but did not vote on strategies generated by the other groups.

2.5 Candidate intervention components

Two brief psychosocial interventions were selected for appraisal by participants. Both are manualised, deliverable by trained non-specialists, and have an evidence base in low- and middle-income settings.

First, low-intensity psychological interventions (LIPI), which draw on cognitive behavioural principles and are adapted from the NHS Talking Therapies guidance and the Psychological Wellbeing Practitioner model used in England (26, 28) and previously adapted for delivery by non-specialist workers in Indonesia as part of our NIHR-funded Sustainable Treatment of Anxiety and Depression (STAND) programme (29), were presented as four components: behavioural activation, in which service users re-engage with enjoyable and necessary activities using a diary and graded task lists; cognitive restructuring, in which unhelpful thoughts are identified, examined against evidence and replaced with more realistic alternatives; managing worries and problems, using a scheduled worry period in which worries are gathered and focused then solutions are developed if possible; and lifestyle, addressing sleep quality, diet, physical activity, relaxation and hygiene (28, 30, 31).

Second, the World Health Organization's Problem Management Plus (PM+) is a brief transdiagnostic intervention for adults impaired by distress in communities affected by adversity, and was presented as its four constituent strategies: managing stress, delivered as a slow breathing exercise; managing problems, a seven-step structured problem-solving sequence; get going, keep doing, a behavioural

activation strategy; and strengthening social support, in which service users identify a trusted person, community organisation or support agency and plan contact in graded steps (32).

These two packages were selected as candidate foundations based on pragmatic task-sharing considerations, delivery feasibility, and clinical transdiagnostic utility in resource-constrained primary care. WHO PM + is an internationally validated, transdiagnostic package engineered specifically for adversity-affected populations, offering scalable tools deliverable by non-specialists without formal psychiatric training, whilst LIPI provided manualised cognitive-behavioural techniques previously adapted by members of our team for frontline task-sharing in low-resource contexts through the STAND programme. Together, they directly targeted the elevated psychological distress documented in our parent study. Highly specialised modalities, such as trauma-focused therapy or Eye Movement Desensitisation and Reprocessing, were deliberately excluded because their delivery requires protracted specialist training and clinical supervision that are unfeasible in rural Benue, where mental health specialists are absent. Similarly, while structured grief counselling and dedicated parenting programmes address important dimensions of bereavement and child development, they were omitted *a priori* to prevent excessive cognitive load on lay workers and avoid overburdening acutely distressed mothers with lengthy clinical curricula. However, pre-selecting LIPI and PM + established a researcher-bounded choice architecture that necessarily constrained the solution space. Methodologically, the exercise is therefore more accurately characterised as stakeholder appraisal, adaptation, and prioritisation within predefined boundaries, rather than unconstrained *de novo* intervention co-design. Facilitators explicitly informed participants that these candidate components served as adaptable building blocks rather than fixed protocols, and working groups were fully empowered to retain, reject, combine, or propose entirely new psychosocial components. In practice, while participants actively recombined components and introduced indigenous communal support networks (yielding the retained social support component), stakeholders did not propose completely novel psychotherapeutic modalities outside this architecture. All adaptations were deliberated in working groups and ratified during plenary consensus. Both LIPI and PM + are indicated for individuals experiencing elevated transdiagnostic distress in adversity-affected settings, requiring neither specialist assessment nor formal psychiatric diagnostic categorisation. Within the preliminary conceptualisation, cognitive restructuring and worry management were considered potentially relevant to antenatal anxiety and economic worry, while behavioural activation, lifestyle modification and mother-to-mother peer support were envisaged as potentially supporting postpartum coping and caregiving. These proposed functions do not constitute a finalised component-to-period allocation or clinical schedule and require further co-design.

The resulting package is referred to hereafter as the Climate Adaptation and Psychosocial Support (CANOPY). The name was proposed by the research team following the workshop for the purposes of reporting and onward development. Community validation of the name is planned as part of the adaptation phase.

2.6 Data collection and analytical approach

To ensure absolute transparency and reproducibility, qualitative data and quantitative prioritisation strands were managed and analysed via separate, distinct pipelines before integration.

2.6.1 Qualitative analysis

No audio recordings were made of the plenary or working-group discussions. The workshop was designed as a participatory brainstorming and co-design exercise to generate collective intervention components, implementation ideas and group decisions, rather than as an interview or focus-group study intended to produce a verbatim narrative dataset. The principal materials for analysis were the completed co-creation templates, determinant-mapping matrices, strategy-mapping charts and structured facilitator field notes. Voting records were analysed separately. These materials documented the issues raised, options considered and outputs agreed during the workshop; they were not treated as verbatim records of individual participants' speech.

The workshop-generated qualitative materials were analysed using a hybrid inductive-deductive thematic synthesis approach. Two primary qualitative coders (NIA and JJ) independently reviewed the materials using a spreadsheet-based framework matrix. Rows represented stakeholder cadres and working groups, while columns captured deductive domains derived from the study objectives and implementation-strategy framework alongside inductive codes emerging from the workshop outputs. Deductive coding was applied to the strategy-mapping component using the operational definitions and canonical ERIC strategy taxonomy, while inductive coding captured emergent implementation determinants, contextual barriers, health-system bottlenecks and community coping or resilience mechanisms.

Coding decisions were subsequently compared between the two coders. Differences were discussed and resolved through consensus, with ambiguous categorisations referred to a senior investigator for adjudication. The coding framework was refined iteratively as context-specific concepts emerged. Facilitator notes, completed workshop templates, determinant-mapping matrices and strategy-mapping charts were compared to contextualise and triangulate interpretation of the collectively generated outputs.

Intercoder agreement was assessed through independent initial coding followed by systematic comparison and consensus resolution rather than through calculation of a statistical reliability coefficient. This approach reflected the exploratory, participatory purpose of the workshop and the focus on collectively generated co-design outputs. Because the process was structured around collective deliberation rather than producing an individually attributable transcript corpus, findings are reported as collectively generated thematic patterns and workshop outputs rather than as individual participant quotations.

2.6.2 Quantitative analysis

The quantitative prioritisation data generated during the Phase 4 dot-voting exercise were isolated from the narrative text. The physical tokens allocated to each distinct candidate implementation strategy and broader system-level action were aggregated and audited for entry errors by a data manager. These totals were transcribed into a structured spreadsheet and descriptively summarised using cumulative point scores and rank order. Following the voting exercise, proposed actions were summarised using their recorded token counts within each working group. Because participants evaluated actions generated within their assigned working groups, vote totals were treated as exploratory indicators of participant preferences rather

than as a single cross-group ranking or definitive prioritisation. No *post hoc* priority thresholds were applied.

2.7 Ethical considerations

Ethical approval for the parent project, under which this workshop was conducted, was granted by the University of Manchester Research Ethics Committee (Ref: 2026–25,211-45551) and the Benue State Ministry of Health and Human Services Research Ethics Committee, Nigeria (Ref: MOH/STA/204/I/199/2026). All participants provided written informed consent before participation. All methods were carried out in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. The study adhered to principles of voluntary participation, data confidentiality, and anonymity throughout. Participants were free to pause or withdraw from discussions if they experienced distress. No participant required referral during or after the workshop. Facilitators trained in psychological first aid were on site to provide immediate emotional support if required, and a local referral protocol to primary healthcare counselling services was in place.

3 Results

3.1 Determinant mapping and local vulnerability profiles

3.1.1 Climate stressors, vulnerable populations and health system bottlenecks

Across the three working groups, participants identified environmental degradation, flooding and displacement as the principal climate stressors affecting their communities (Table 1). Group 1 highlighted indiscriminate deforestation, poor refuse disposal in drainage channels, industrial pollution and failures of building regulation; group 2 focused on severe flooding and extreme weather events and the loss of livelihoods that followed; group 3 emphasised unplanned displacement and exposure to climate-driven disease threats. Participants described these shocks as contributing to food insecurity, damage to local infrastructure, and loss of household livelihoods.

Across groups, stakeholders considered women, particularly pregnant and nursing mothers, and young children to bear a disproportionate share of this burden. Group 2 additionally identified older people, people with disabilities and the poorest households as disproportionately affected. As summarised in Table 1, stakeholders linked these climate exposures to a range of mental health impacts, describing the intersection of displacement and economic instability as contributing to anxiety, low mood, loss of interest or motivation, sleep problems, mood changes, physical exhaustion and, in some accounts, thoughts of self-harm.

Because these psychological impacts were captured through qualitative stakeholder inquiry rather than standardised diagnostic screening tools or clinical psychiatric interviews, they represent self-reported emotional and psychological distress (such as situational anxiety, fatigue, and demoralisation) rather than formal clinical diagnoses.

Participants also noted potential effects on early childhood development, describing how maternal stress and postpartum distress could disrupt early bonding and responsive caregiving, while climate-related agricultural failures contribute to household poverty and childhood stunting.

Each group also mapped the health system constraints they encountered during and after climate events. These included severe staff shortages and poor funding (group 1), damaged facility access roads, emergency surges exceeding clinical capacity and loss of equipment (group 2), and stockouts of drugs and diagnostics, absent personal protective equipment and weak facility management (group 3).

3.1.2 Barriers and facilitators

3.1.2.1 Structural, institutional, and socio-cultural barriers

Stakeholders grouped the main obstacles to effective intervention into three domains. First, infrastructure and resource deficits: Groups 2 and 3 identified impassable or destroyed facility access roads and limited electricity that cut vulnerable perinatal populations off from care during climate crises, compounded by limited institutional funding and resource mobilisation (Table 2).

TABLE 1 Stakeholder mapping of climate stressors, drivers, and psychological impacts.

Working group	Primary climate stressors and drivers	Most vulnerable populations	Stakeholder-described mental health impacts	Structural health system challenges
Group 1	Deforestation, poor refuse dumping, drainage blocks, industrial pollution, and building regulation failures	Women and Children	Anxiety, low mood, irritability, thoughts of self-harm, sleep problems	Lack of healthcare access, severe staff shortages, flood-related infrastructure damage, and poor funding
Group 2	Loss of livelihood from damage, extreme flooding, food insecurity, and lack of prevention measures	Pregnant/nursing mothers, children, older adults, the less privileged, and people with disabilities	Loss of interest or motivation, anxiety, low mood	Damaged facility access roads, emergency surges exceeding clinical capacity, equipment loss
Group 3	Unplanned relocation, exposure to climate-driven disease threats, and loss of livelihoods	All family members, with specific emphasis on Mothers	Anxiety, low mood, symptoms of Post-Traumatic Stress Disorder (PTSD), mood changes, physical exhaustion, fatigue	Poor staffing, lack of personal protective equipment (PPE), drug and diagnostic stockouts, weak management, limited finance

Second, knowledge gaps: limited public awareness of both environmental protection measures and the legitimacy of mental health conditions was reported, allowing climate stressors to be misunderstood or overlooked at the community level. Third, socio-cultural barriers and institutional distrust: cultural beliefs and stigma around mental health care restrict care-seeking. At the same time, group 3 noted that distrust of formal health systems and a perceived lack of government commitment led some communities to disengage from public health initiatives (Table 2).

3.1.2.2 Local coping systems and implementation facilitators

Stakeholders described how communities draw on informal networks to cushion environmental shocks, identifying these as facilitators that could be leveraged. Informal financial and support networks included peer groups, communal living arrangements, and practical and emotional support from relatives, neighbours, and friends, including pooling and distributing emergency relief, clothing, food, and temporary housing. Faith-based and community-led mobilisation featured trusted religious institutions and local philanthropists providing donations, communal food banks, and religious facilities for emergency shelter, alongside youth volunteering systems supporting local development and disaster response. Grassroots health-delivery channels were used to bypass impassable roads and facility bottlenecks. Examples included town announcers, village and religious leaders, community mobilisers, Ward Development Committees, Community Health Influencers, Promoters, and Services (CHIPS) agents, community volunteers, and mobile health outreaches with temporary health outposts established in high-risk or hard-to-reach communities.

3.1.2.3 Maladaptive coping mechanisms

Stakeholders also noted that when informal support structures are overwhelmed and formal support does not materialise, harmful coping can emerge. Group 1 reported that displaced and economically distressed individuals sometimes turn to harmful coping strategies for immediate survival, including increased smoking, alcohol use, and transactional sex.

3.2 The co-designed CANOPY package

Working within their three groups, participants appraised the four LIPI components and the four PM + components presented during evidence translation, and each group presented its agreed position in plenary (Figure 2).

Appraisal centred on participant perceptions of functional overlap between the two source interventions rather than formal clinical equivalence determinations. Specifically, participants perceived three PM + components to duplicate techniques encompassed within LIPI. Lay health workers and community stakeholders viewed PM + "managing stress" (a dedicated slow-breathing exercise) as functionally subsumed under LIPI's broader lifestyle component, which incorporates relaxation alongside sleep, diet, and physical activity, despite clear clinical differences between a targeted physiological de-arousal technique and general lifestyle advice. Similarly, participants judged PM + "managing problems" (a structured, seven-step problem-solving sequence) to be encompassed by LIPI's "managing worries and problems" (a scheduled worry intervention where solution generation is optional). Finally, PM + "get going, keep doing" was viewed as equivalent to LIPI behavioural activation. Based on

TABLE 2 Stakeholder classification of local coping systems, implementation barriers, and facilitators across target communities.

Working group	Community coping mechanisms and resources	Barriers identified	Facilitators identified	Maladaptive coping reported
Group 1	• Community volunteers educating affected people about coping • Temporary residential health outpost • Social support from relatives, neighbours and friends, including relief materials, food and possible housing • Relief materials provided by religious organisations • Community health outreach	• Cultural barriers • Limited healthcare access • Policy gaps • Economic barriers	• Leveraging community support groups	• Smoking • Alcohol use • Transactional sex
Group 2	• Formation of support groups • Communal living • Religious institutions • Voluntary donations from philanthropists	• Knowledge gaps • Lack of support networks • Lack of government policies • Infrastructure deficits, including lack of electricity and poor roads • Cultural beliefs	• Improved education • Existing social support • Proper town planning	Not separately documented in the source table
Group 3	• Peer groups • Support groups • Mobilisation and establishment of a youth volunteering system • Village savings/loan associations • Food banks • Community development projects	• Ignorance/knowledge gaps • Distrust • Lack of resources and poor resource mobilisation	• Community engagement, involvement and participation	Not separately documented in the source table

this stakeholder appraisal, the four LIPI components were retained, and these three PM + components were not carried forward as separate manualised modules.

The exception was PM + "strengthening social support," which participants identified as having no equivalent within LIPI and agreed should be added. The rationale given corresponded closely to the coping mechanisms mapped in the preceding phase (Table 2), in which all three groups independently identified informal networks as the primary means by which households absorb climate shocks. Participants considered that an intervention which did not work through these existing relationships would be poorly matched to how support is actually sought and provided in these communities, particularly during displacement, when formal services are least reachable.

The resulting package, CANOPY, therefore comprises five components: behavioural activation, cognitive restructuring, managing worries and problems, lifestyle, and strengthening social support. Four are adapted from low-intensity psychological interventions and one from PM+. In this candidate configuration, the retained "managing worries and problems" component remains the LIPI approach presented during the workshop, in which solution generation is optional; PM + 's distinct seven-step structured problem-solving sequence was not retained as a separate component. This decision reflected participants' perceptions of functional overlap and should not be interpreted as establishing therapeutic equivalence. Whether structured problem-solving should be incorporated into subsequent CANOPY development, either within an adapted existing component or as a distinct module, remains to be assessed.

The three delivery models generated during workshop deliberations, designated as HOPE, FLEXI and LIPIS, are complementary, context-responsive delivery-channel concepts rather than competing alternatives. Stakeholders envisaged a proposed, tiered architecture responsive to environmental conditions: HOPE was envisaged as a facility-anchored channel during non-flood periods; FLEXI was proposed as an adaptive mobile-outreach channel during acute flood displacement; and LIPIS was envisaged as a year-round, community-anchored peer-support channel. Supplementary Table S1 summarises the proposed characteristics of the three channels, including delivery actors, training considerations and clinical settings where these were specified. These remain preliminary concepts rather than fully specified or validated service models.

3.3 Strategy mapping and contextual framework architecture

Operating within their thematic teams, participants used the ERIC taxonomy to co-design three multisectoral intervention frameworks. Each framework paired CANOPY components with context-specific implementation strategies, underpinned by broader environmental and structural protections (Table 3). The HOPE (*Shima Veren Kaghen*) framework was designed around positive behavioural change and activation, using the retained behavioural-activation component to help distressed mothers re-engage in healthy, productive and culturally appropriate everyday activities to support mood and restore a sense of agency.

The FLEXI (Flooding and Extreme Weather Intervention) framework focused on structural flexibility and environmental safety, establishing alternative delivery architectures, such as temporary health outposts, to circumvent impassable roads and physical health facility capacity surges during flood events. The LIPIS (Local Impact Psychological Intervention Strategies) framework integrated focused cognitive techniques delivered outside conventional psychiatric facilities, aiming to identify and redirect unhelpful or distressing thought patterns linked to environmental asset loss or displacement by leveraging trusted spiritual, traditional, and community leaders to redirect misconceptions. All three proposed frameworks emphasised social support and lifestyle-related activities, including mother-to-mother support groups, group storytelling, vocational skills training,

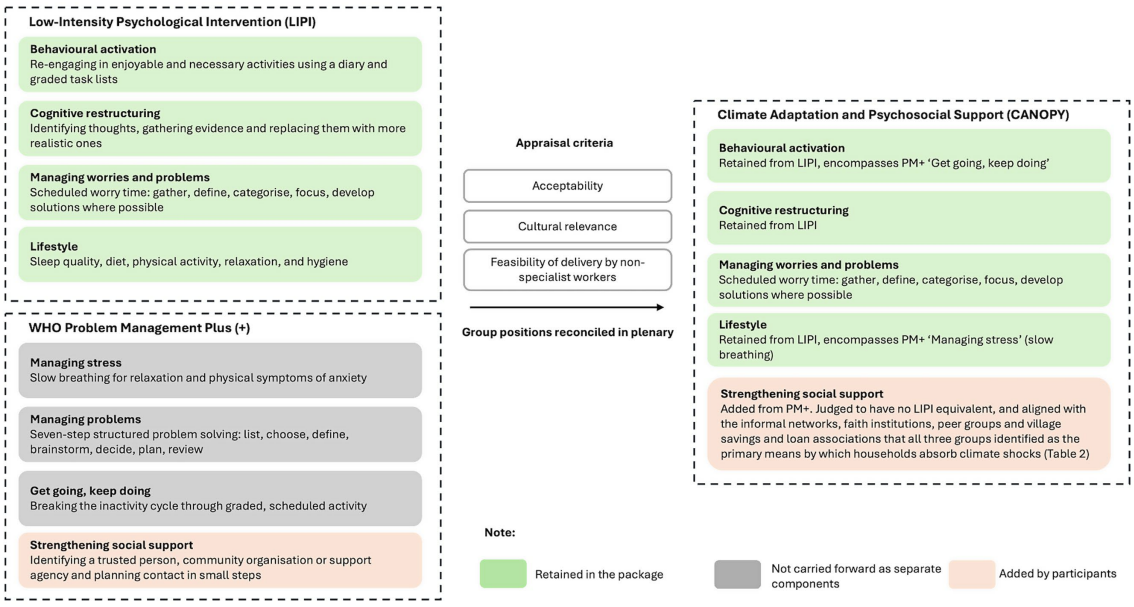


FIGURE 2
Appraisal of eight candidate intervention components and composition of the co-designed Climate Adaptation and Psychosocial Support (CANOPY) package.

TABLE 3 Group-specific implementation crosswalk of stakeholder-generated actions, workshop-identified determinants, and ERIC classification.

Group	Stakeholder-generated action	Tokens allocated	Workshop-identified determinant/problem addressed	Analytical classification	Canonical ERIC strategy, where applicable	Analytical rationale
Group 1	Awareness and sensitisation of community members	9	Knowledge gaps/ignorance; cultural barriers	ERIC implementation strategy	Conduct educational meetings	A discrete community education activity intended to address knowledge gaps and increase awareness relevant to implementation
Group 1	Training and retraining of community volunteers on mental health	6	Shortage of healthcare workers; limited implementation capacity	ERIC implementation strategy	Conduct ongoing training	Builds the capacity of an existing community workforce to support delivery of CANOPY-related activities
Group 1	Stakeholder engagement and community dialogue	12	Cultural barriers; limited community engagement	ERIC implementation strategy	Conduct local consensus discussions	Provides a structured mechanism for engaging community and implementation stakeholders around delivery
Group 1	Resource mobilisation	9	Poor funding; economic barriers	ERIC implementation strategy	Access new funding	Seeks additional resources needed to support implementation activities
Group 1	Active routine M&E supervision	6	Health-system management and monitoring gaps	ERIC implementation strategy	Audit and provide feedback	Establishes routine monitoring and feedback to support iterative improvement of implementation activities
Group 1	Strengthen health facility structure	10	Facility damage; poor access to healthcare	Potential ERIC implementation strategy; scope-dependent	Change physical structure and equipment, if explicitly directed at enabling CANOPY delivery	If the action specifically involves modifying facilities or equipment to accommodate CANOPY, the ERIC mapping is appropriate. As phrased in the workshop output, it may also refer to broader health-system infrastructure strengthening rather than an intervention-specific adaptation
Group 1	Stocking and availability of necessary drugs and infrastructure	2	Limited healthcare access; infrastructure damage; poor funding	Broader health-system/resource action	Not mapped to a discrete ERIC strategy	Combines commodity provision and infrastructure support and therefore represents broader system readiness rather than one discrete implementation technique
Group 1	Screening of mental-health disorders	3	Mental-health identification/service gap	Clinical/service intervention	Not mapped to a discrete ERIC strategy	Screening is a clinical/service activity rather than, by itself, an implementation strategy for promoting CANOPY adoption
Group 1	Increase healthcare workers/workforce	5	Shortage of healthcare workers	Broader workforce-system action	Not mapped to a discrete ERIC strategy	Workforce expansion is a system-level staffing intervention rather than a discrete implementation technique
Group 2	Mobilisation and stakeholder engagement	21	Lack of support networks; limited government/community coordination	ERIC implementation strategy	Build a coalition	Builds relationships among actors required to support implementation and community participation
Group 2	Community-based support network	15	Lack of support network	ERIC implementation strategy	Promote network weaving	Strengthens existing interpersonal and community relationships that can facilitate engagement and continuity of support
Group 2	Integrate mental-health services into health programmes and emergency response	19	Emergency surges exceeding facility capacity; limited integration	Broader health-system integration action	Not mapped to a discrete ERIC strategy	Represents system-level integration across routine programmes and emergency response rather than a single ERIC implementation technique

(Continued)

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TABLE 3 (Continued)

Group	Stakeholder-generated action	Tokens allocated	Workshop-identified determinant/problem addressed	Analytical classification	Canonical ERIC strategy, where applicable	Analytical rationale
Group 2	Strengthen structural and human resources	9	Damaged facilities; inadequate human resources	Broader health-system action	Not mapped to a discrete ERIC strategy	Combines infrastructure and workforce strengthening at system level
Group 2	Legislation against mental-health stigmatisation	0	Cultural barriers; lack of supportive government policy	Broader public-policy intervention	Not mapped to a discrete ERIC strategy	Represents statutory and structural reform rather than a discrete strategy for implementing CANOPY
Group 2	Government-facilitated social intervention programmes	7	Livelihood loss; displacement; food insecurity; limited government intervention	Broader social-policy/system intervention	Not mapped to a discrete ERIC strategy	Addresses social protection and wider government support beyond implementation of the psychosocial intervention itself
Group 2	Integration of mental-health indicators into IDSR	4	Health-information and surveillance gap	ERIC implementation strategy	Change record systems	Modifies information systems and reporting processes to support routine mental-health information within implementation workflows
Group 3	Intensify awareness	8	Knowledge gap/ignorance	ERIC implementation strategy	Conduct educational meetings	Represents a community-level educational activity addressing identified knowledge gaps
Group 3	Improve community mobilisation	23	Distrust; poor resource mobilisation/community participation	ERIC implementation strategy	Build a coalition	Mobilises community and implementation actors around delivery and participation
Group 3	Encourage resource mobilisation	6	Lack of resources; poor resource mobilisation	ERIC implementation strategy	Access new funding	Seeks additional financial resources to support implementation
Group 3	Improved healthcare management system	9	Poor facility management	Broader health-system intervention	Not mapped to a discrete ERIC strategy	Too broadly specified to map reliably to a single canonical ERIC technique without further operational definition
Group 3	Improved healthcare facility funding	6	Lack of financing	ERIC implementation strategy	Access new funding	Addresses availability of financial resources needed to support implementation capacity
Group 3	Employment/redeployment of healthcare workers	1	Poor staffing; lack of personnel	Broader workforce-system intervention	Not mapped to a discrete ERIC strategy	Concerns recruitment or redistribution of the health workforce at system level
Group 3	Provision of PPE	3	Lack of PPE; occupational hazard	Broader health-system/resource intervention	Not mapped to a discrete ERIC strategy	Represents occupational safety and resource readiness rather than an adoption or delivery strategy for CANOPY
Group 3	Establishment of alternative temporary flood shelters	6	Unplanned relocation; basic shelter needs during flooding	Broader disaster-response intervention	Not mapped to a discrete ERIC strategy	Addresses humanitarian shelter and disaster protection rather than implementation of the psychosocial intervention
Group 3	Dredging of river paths	6	Flooding and environmental/infrastructure risk	Broader environmental/infrastructure intervention	Not mapped to a discrete ERIC strategy	Addresses the underlying environmental hazard and access infrastructure rather than implementation of CANOPY
Group 3	Continuous needs assessment	5	Need for ongoing assessment of implementation needs	ERIC implementation strategy	Conduct local needs assessment	Supports iterative identification of changing implementation needs and local barriers

Token allocations are aggregated physical votes, not numbers of participants. Each participant received 15 tokens; 210 of 240 available tokens were used (Group 1: 62; Group 2: 75; Group 3: 73). Participants voted on actions generated within their assigned working group, so totals are not a single cross-group ranking or evidence of community-wide consensus. Canonical ERIC labels are used where an action could be mapped to a discrete implementation strategy (24). Broader clinical/service, workforce, health-system, social-policy, disaster-response and environmental actions are classified separately where they are not, as phrased, discrete ERIC implementation strategies. "Strengthen health facility structure" is classified as a potential implementation strategy because its categorisation depends on whether physical modifications specifically enable CANOPY delivery or reflect general facility strengthening.

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relaxation exercises and couples' workshops. These activities were described within the broader delivery-framework concepts and should not be interpreted as additional core therapeutic components beyond the five-component CANOPY candidate set.

Stakeholders operationally specified the prioritised strategies to fit local delivery constraints (Supplementary Table S2). Primary healthcare supervisors and Ward Development Committees were identified as core implementation-support actors for non-specialist training and community consensus activities. Temporally, stakeholders specified that workforce training and community sensitisation via town announcers must precede anticipated flood seasons, whereas mother-to-mother peer support groups and integrated ANC screening were designed as ongoing or year-round activities. These operational parameters targeted implementation outcomes of acceptability, adoption fidelity, and service penetration across rural primary healthcare facilities.

These specifications relate to the proposed implementation strategies and their intended delivery arrangements; they do not establish a complete clinical delivery protocol for CANOPY. In particular, specifying actors for implementation activities does not imply that a delivery agent, individual or group format, session dose, language or materials were agreed for every therapeutic component. These component-level arrangements remain to be determined during subsequent intervention development.

3.4 Independent dot-voting and ERIC strategy prioritisation

Participants independently allocated physical voting tokens to the implementation strategies and broader system-level or policy actions generated within their assigned working groups. Each participant received 15 equal-value tokens, giving a maximum pool of 240 tokens across the 16 participants. In total, 210 tokens were used, comprising 62 in Group 1, 75 in Group 2 and 73 in Group 3. Participants could allocate multiple tokens to the same action and were not required to use all 15 tokens. Because participants evaluated actions generated within their assigned working group rather than voting across a common list, the resulting counts represent group-specific participant preferences and are not directly interpretable as a single cross-group ranking or organisational consensus.

In Group 1, stakeholder engagement and community dialogue received the largest vote total (12), followed by strengthening health-facility structure (10), awareness and sensitisation (9), resource mobilisation (9), training and retraining of community volunteers (6), active routine M&E supervision (6), increasing the health workforce (5), screening for mental-health disorders (3), and stocking necessary drugs and infrastructure (2). In Group 2, mobilisation and stakeholder engagement received 21 votes, followed by integration of mental-health services into health programmes and emergency response (19), community-based support networks (15), strengthening structural and human resources (9), government-facilitated social intervention programmes (7), integration of mental-health indicators into IDSR (4), and legislation against mental-health stigmatisation (0). In Group 3, improving community mobilisation received the largest vote total (23), followed by improved healthcare management systems (9), intensified awareness (8), encouragement of resource mobilisation (6), improved healthcare facility funding (6), establishment of alternative temporary flood shelters (6), dredging of river paths (6), continuous needs assessment (5), provision of PPE (3), and employment/redeployment of healthcare workers (1).

4 Discussion

This study used a participatory co-creation workshop to translate evidence on climate-related risks to maternal mental health and early childhood development in Nigeria into context-fit intervention content and prioritised implementation strategies. Bringing together affected mothers, community health workers, community leaders, research data collectors and policymakers, the workshop identified local drivers and consequences of climate stress, developed a five-component candidate psychosocial set (CANOPY), conceptualised three potential delivery channels, and mapped candidate implementation strategies to the ERIC taxonomy. Two findings stand out: participants consolidated rather than accumulated intervention content, adding one component that reflected locally identified coping resources; and, despite identifying stigma and policy gaps as pervasive barriers, they directed their votes toward immediately actionable community and health-system strategies.

4.1 The co-designed intervention

The appraisal of candidate components produced a package smaller than the sum of its inputs. Presented with eight components from two interventions, participants retained five, judging three PM + components to duplicate techniques already available within LIPI. This is a consolidating rather than accumulating logic, and it runs against a common assumption in adaptation work that stakeholder involvement expands intervention content. Participants were attentive to burden: each retained component had to earn its place against the time of a non-specialist worker and the attention of a distressed mother.

However, reducing the number of intervention components should not be interpreted as evidence that the retained worry-management technique can substitute clinically for structured problem-solving. For mothers experiencing displacement, livelihood loss, food insecurity or disrupted access to essential services, distress may be closely linked to concrete problems that require the identification of feasible options, planning and action. Worry management may support emotional coping, but it may be insufficient on its own when practical problems require structured support or assistance navigating available services. Moreover, psychosocial techniques alone cannot resolve material deprivation or substitute for essential relief and social services. Subsequent intervention development should therefore assess, in collaboration with mothers and prospective delivery stakeholders, whether and how structured problem-solving could be incorporated into CANOPY, either within the existing component or as a distinct module. The workshop generated a candidate intervention configuration; it did not resolve this clinical design question.

The substantive finding is what they added. Strengthening social support was the only candidate component without a LIPI equivalent, and it was also the one that corresponded most directly to what participants had described in the preceding phase. All three groups had independently identified informal networks, peer groups, faith institutions, communal living arrangements and village savings and loan associations as the primary means by which households absorb

climate shocks (Table 2). They reasoned that an intervention which did not work through these relationships would be poorly matched to how support is actually sought and given, particularly during displacement, when formal services are least reachable. The component participants added was therefore not an arbitrary preference but a direct read-across from their own determinant mapping. While empirical trials directly comparing top-down and co-designed adaptation pathways are lacking, stakeholder prioritisation in this workshop suggests that conventional manual adaptation might not have identified the central role of communal informal networks as readily. We frame this observation as a hypothesis warranting systematic comparative evaluation rather than a definitive claim regarding participatory superiority.

4.2 Prioritisation under constraint

Stigma and policy gaps were identified as pervasive barriers across all three working groups (Table 2), yet macro-level policy proposals addressing them received relatively little support within the group-specific voting exercises. Legislation against stigmatisation was raised during co-design but received no votes in Group 2. Rather than treating the voting exercise as a single cross-group ranking, the results are interpreted as exploratory participant preferences within each working group. In Group 1, stakeholder engagement and community dialogue received the largest number of votes (12), followed by strengthening health-facility structure (10), awareness and sensitisation (9), and resource mobilisation (9). In Group 2, mobilisation and stakeholder engagement received 21 votes, followed by integration of mental-health services into health programmes and emergency response (19) and community-based support networks (15). In Group 3, improving community mobilisation received 23 votes, followed by improved healthcare management systems (9) and intensified awareness (8).

This apparent disconnect does not mean policy and anti-stigma legislation were viewed as unimportant; rather, it may reflect a pragmatic preference for actions perceived as more immediately actionable within participants' local implementation environments. Because participants voted on actions generated within their assigned working groups, the resulting counts cannot be interpreted as a single hierarchy of stakeholder priorities across the full cohort. Facing a finite number of tokens, frontline health workers, community leaders, and, notably, the affected mothers themselves selected actions that they perceived to be feasible, scalable, and immediately relevant; these dimensions were not scored separately. The relatively low or zero voting received by some structural actions should therefore be interpreted cautiously and should not be taken as evidence that participants considered them unimportant.

For example, although legislation against mental-health stigmatisation received no votes in Group 2, participants in the same group assigned 21 votes to mobilisation and stakeholder engagement and 15 votes to community-based support networks, indicating stronger expressed preference for community- and relationship-based actions within that voting context. Similarly, the 19 votes assigned in Group 2 to integration of mental-health services into health programmes and emergency response indicate a preference for system integration, whereas the separate proposal to integrate mental-health indicators into IDSR received four votes. These were distinct stakeholder-generated actions and should not be treated as equivalent strategies.

This pragmatic tendency mirrors comparative findings from urban landslide mitigation in Sawahlunto, Indonesia, which demonstrate that multi-stakeholder collaboration frequently falters when restricted to reactive, crisis-driven coordination rather than institutionalised preventive routines (22). In the present workshop, the voting pattern similarly suggests that participants tended to favour actions that could be enacted through existing community and health-system structures, although the exercise did not assess implementation outcomes or establish that these actions would be more effective than longer-term structural interventions.

The low vote tallies allocated to macro-level structural and environmental strategies, such as anti-stigma legislation (0 votes in Group 2) or river channel dredging (6 votes in Group 3), must not be interpreted as evidence that stakeholders viewed structural protection as unimportant. Rather, this distribution may reflect the immediate-action orientation of a constrained token-voting exercise, in which participants selected among locally generated options without formal economic costing or separate scoring of feasibility, scalability, and anticipated impact. The prioritisation should therefore be read as a statement about participant preferences within the workshop and their perceived immediate tractability, rather than overall policy importance. Longer-term structural, legislative and environmental measures therefore remain relevant to the broader implementation context and require separate assessment through appropriate policy, technical and economic processes.

4.3 Relationship to existing evidence

CANOPY aligns with a growing evidence base on low-resource, task-shared maternal mental health care. It's behavioural and cognitive components, and the peer-led mother-to-mother support through which participants proposed to deliver them, mirror approaches shown to be effective, feasible, and acceptable when delivered by non-specialist and lay workers within routine maternal and child health services in LMICs. By embedding these within community structures rather than specialist facilities, the frameworks reflect the reality that, in settings such as Benue, frontline and community actors are the realistic point of delivery.

A small number of studies have begun to address climate adaptation and maternal mental health together, most directly a cluster-randomised trial in Uganda combining a WHO low-intensity psychological package with climate-smart agriculture among refugee mothers (23). That work applies an existing manualised intervention to a climate-affected population. The present study differs by adapting intervention content to the population and treating the local architecture of informal support as intervention material rather than context.

Stakeholders' accounts of how climate stress harms maternal mental health and child development are consistent with established pathways and with recent Nigerian evidence. Displacement, livelihood loss, food insecurity, and disrupted care are recognised psychosocial stressors linked to maternal anxiety, depression, and post-traumatic stress, and maternal distress can, in turn, affect early bonding, responsive caregiving, and child development. National data link higher temperatures to child undernutrition, fever, greater postpartum distress, and reduced healthcare access, while qualitative work in flood-affected communities, documented in another article that is under review, shows how these stressors disrupt households and caregiving. The workshop's contribution is not to re-establish these

pathways but to translate them into actionable, locally grounded strategies.

4.4 Barriers and community assets

Prospective implementation of CANOPY in practice would require navigating severe structural bottlenecks mapped within the formal Primary Healthcare (PHC) framework. Stakeholders identified critical barriers, including severe frontline healthcare staffing shortages, recurrent stockouts of essential medicines and basic healthcare commodities, the lack of routine maternal mental health indicators within primary care and the Integrated Disease Surveillance and Response (IDSR) reporting workflows, and limited facility funding, all of which are compounded by deep-seated social stigma, institutional distrust, and physically impassable rural roads during extreme weather.

Crucially, stakeholders described substantial community assets that can cushion these shocks. Informal social safety nets, communal living arrangements, village savings and loan associations, faith-based and philanthropic networks, peer support, and grassroots health-delivery channels (such as town announcers and youth volunteering networks) can serve as vital implementation facilitators if they are formally recognised and resourced. The interplay between these barriers and facilitators is itself a major implementation finding: interventions at the intersection of climate and health are far more likely to succeed where they actively build on trusted community structures rather than rely solely on a stretched, underfunded formal health system. This dynamic aligns directly with comparative disaster-governance findings from West Sumatra, Indonesia, which empirically demonstrate that institutional capacity functions as a latent potential requiring conversion through operational routines and cross-boundary collaborative networks (21). In rural Nigerian settings where formal health facilities face severe fiscal and staffing constraints, treating informal community support structures and primary healthcare centres as complementary collaborative mechanisms provides a practical pathway to operationalise psychosocial care under environmental stress. That this same infrastructure supplied both the delivery mechanism and the one component participants added to the package underlines the point.

4.5 Implications for policy and practice

While broader governance literature highlights that environmental and health portfolios in Nigeria frequently operate within separate institutional silos, our workshop captured how these macro-level divisions are experienced on the ground by frontline stakeholders. Without evaluating the institutional functioning of federal bodies directly, stakeholder accounts illustrated how operational fragmentation manifests locally as uncoordinated disaster relief and omitted mental healthcare, underscoring the practical necessity of cross-sectoral coordination between environmental risk reduction and maternal health programming. Comparative findings from Indonesian disaster governance underline that political commitment and budget allocations act primarily as baseline enabling conditions, which fail to improve outcomes unless deliberately anchored in shared organisational routines and institutionalised inter-agency coordination (21). Complementing this insight, empirical research from Sawahlunto highlights that shifting from reactive coordination to genuine preventive governance demands deliberate institutional design: transitioning from formal, inactive meetings to routine risk-based deliberative arenas, establishing binding pre-disaster operational rules across sectors, and fostering participatory transparency (22). For maternal mental health programming in climate-vulnerable Nigerian communities, these comparative lessons underscore that bridging disaster-management agencies (NEMA and SEMA) and primary healthcare systems cannot remain an *ad hoc* emergency arrangement, but requires institutionalised joint planning protocols and routine inter-agency review mechanisms operationalised before seasonal flood onset (22). Practically, drawing on stakeholder deliberations and our analytical mapping, several tentative policy proposals emerge for further institutional feasibility appraisal rather than as empirically demonstrated policy solutions. First, maternal mental health indicators could be explored for progressive integration into the National Health Management Information System and routine IDSR reporting workflows. Second, standardised psychological screening could be assessed for potential inclusion within the service packages supported by the Basic Health Care Provision Fund at primary healthcare level. Third, disaster-management agencies, such as NEMA and SEMA, could examine the feasibility of designating protected safe spaces for pregnant and lactating women during flood displacement and collaborating with frontline community health workers trained in basic psychological first aid. Finally, local government authorities could evaluate modest co-financing mechanisms to formalise and sustain community-anchored mother-to-mother peer support networks.

4.6 Limitations

Our study has several limitations. The workshop involved a small number of participants in a single setting, so the findings reflect local priorities rather than a national consensus. Participants were recruited from those who had previously taken part in focus groups and interviews within the parent study, and were selected partly for active contribution in group settings. These recruitment procedures introduce several important sources of bias that must be explicitly acknowledged. Because participants were purposively recruited from the parent study cohort, pre-existing relationships with field researchers shaped the deliberative dynamic in complex ways. While established rapport helped overcome initial hesitancy regarding sensitive mental health discussions, it inevitably introduced social desirability bias and subtle relational deference. Having previously engaged with the research team during interviews and focus groups, participants were familiar with the broad project aims and may have felt interpersonal pressure to validate the proposed psychosocial frameworks rather than interrogate their underlying assumptions. This familiarity could have fostered uncritical consensus, where community members and frontline workers deferred to perceived academic authority or aligned their contributions with perceived researcher expectations, potentially muting dissenting perspectives or alternative local priorities. Furthermore, prioritising participants who exhibited spontaneous contribution in prior focus groups created a vocalness bias that likely excluded quieter, more socially withdrawn community members, particularly mothers experiencing severe perinatal depression or debilitating trauma who are least able to vocalise distress in public arenas. In addition, assessing candidate suitability through qualitative field notes rather than validated screening rubrics leaves selection open to subjective researcher interpretation. Whilst a cohort of 16 participants

is operationally well suited for participatory co-design dynamics, it remains an exploratory qualitative sample that cannot capture the full demographic and experiential heterogeneity of climate-vulnerable communities across Nigeria. Furthermore, the stakeholder group lacked multisectoral representation from psychiatric specialists, emergency and disaster-management authorities (NEMA and SEMA), environmental agencies, and civil-society organisations. Consequently, while the prioritised strategies capture authentic frontline primary care and grassroots realities, they omit direct operational appraisal from disaster response and environmental governance actors. The dot-voting exercise entails several methodological constraints that require cautious interpretation. Conducted among 16 participants, the resulting tallies capture exploratory participant preferences within a specific workshop cohort rather than definitive institutional, organisational, or community-wide consensus. Furthermore, because candidate strategies were displayed visually on wall charts, visual salience, spatial arrangement, and presentation formatting may have exerted subtle framing effects on individual voting behaviour. Participants also appraised candidate actions heuristically without access to objective economic evaluation data, unit costs, or technical estimates of implementation effort, which might have altered feasibility appraisals. Dot-voting inherently disadvantages longer-term structural and legislative interventions, such as municipal flood mitigation or anti-stigma statutes, which scored poorly because participants prioritised immediately tangible frontline workflows, an artefact of short-term heuristic choice rather than an objective indictment of structural policy value. Disaggregating these analytically distinct dimensions using structured multi-criteria decision analysis alongside economic costing remains an objective for subsequent intervention validation.

An additional reporting limitation is that no audio recordings or verbatim transcripts were made of the workshop discussions. Documentation was designed to capture collective deliberations and outputs through facilitator notes, completed templates, determinant-mapping matrices and strategy-mapping charts, rather than speaker-attributed verbatim speech. Consequently, the Results report themes and decisions synthesised from these materials without direct participant quotations.

Three limitations concern the package itself. First, participants specified content but not delivery: the delivery agent, individual or group format, number of sessions, language and materials were not agreed. Consequently, CANOPY remains an adaptable candidate component set rather than a ready-to-use clinical manual. Although the workshop generated proposed delivery frameworks and specified selected implementation strategies, the intervention and its delivery arrangements require further operationalisation, stakeholder review, feasibility assessment and field testing.

A further limitation concerns the framing effect imposed by preselecting LIPI and PM + as the primary candidate foundations. By establishing a researcher-bounded choice architecture, the workshop necessarily constrained the deliberative space within which stakeholders operated, potentially fostering an anchoring bias toward the presented cognitive-behavioural and problem-solving modalities. The research team's prior methodological involvement with the STAND programme in Indonesia may have introduced an implicit institutional preference for LIPI-derived components, inadvertently steering focus toward familiar individual-level tools. Although participants were explicitly empowered to reject or propose novel components, pre-specifying this architecture meant stakeholders were not invited to appraise alternative, regionally validated task-shared packages (such as the Friendship Bench) or other clinically salient strategies, notably trauma-focused stabilisation for flood survivors, dedicated grief and bereavement counselling for infant or livelihood loss, and structured parenting skills for early child development. While these components were omitted a priori to safeguard task-sharing feasibility and prevent lay worker overload, their exclusion pre-empted stakeholder dialogue regarding their contextual value, highlighting the need for broader component appraisal during subsequent participatory adaptation cycles. A third clinical limitation concerns the consequences of stakeholders retaining LIPI's 'managing worries and problems' over the structured seven-step problem-solving protocol of PM+. Because determinant mapping revealed that acute, tangible adversities (such as destroyed crops, lost livelihoods, and washed-out roads) represent the primary drivers of distress, prioritising a cognitive worry-scheduling technique where practical solution generation remains optional carries distinct clinical risks. While effective for hypothetical, repetitive catastrophic thinking, scheduled worry protocols may prove inadequate for concrete, climate-induced material deprivation. The workshop did not establish therapeutic interchangeability between worry management and structured problem-solving; therefore, participants' perceived overlap should not be interpreted as evidence that one technique can replace the other. Subsequent intervention development should assess whether and how structured, instrumental problem-solving could be incorporated, so that the refined package can better address practical problem resolution alongside emotional coping where appropriate.

CANOPY was also appraised by maternal health stakeholders against the needs of pregnant and postpartum women up to 12 months following childbirth, alongside their infants and young children. Its acceptability and relevance to other populations affected by climate stress, including men, older adults and displaced households, have not been assessed. Finally, findings were not returned to participants for verification, and neither the package nor the prioritised strategies have yet been implemented or evaluated; their feasibility, acceptability, and effectiveness in practice remain to be tested.

5 Conclusion

Climate change in Nigeria affects maternal mental health and early childhood development through interacting environmental, economic, and social pathways that current siloed responses are poorly equipped to address. Through participatory co-creation, this study produced a set of locally grounded, stakeholder-prioritised candidate implementation strategies requiring further operational specification, feasibility assessment, and prospective evaluation, showing that stakeholders pragmatically favour immediate, frontline community and clinic actions over longer-term structural reform. Integrating maternal mental health into climate adaptation and disaster response, and building on existing community structures, offers a practical path forward. The next step is to refine and operationally specify the candidate intervention and its proposed delivery frameworks in partnership with the communities that shaped them, agree on component-level delivery arrangements, assess feasibility and acceptability, and subsequently evaluate the package and its implementation strategies in practice.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The University of Manchester Research Ethics Committee (Ref: 2026–25,211-45551) and the Benue State Ministry of Health and Human Services Research Ethics Committee, Nigeria (Ref: MOH/STA/204/I/199/2026). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NI-A: Methodology, Writing – original draft, Investigation, Supervision. NE: Writing – original draft. JJ: Data curation, Writing – original draft. DA: Writing – review & editing. IO: Writing – review & editing. RR: Writing – review & editing. ZM: Writing – review & editing. TL: Writing – review & editing. MT: Writing – review & editing. EE: Writing – review & editing. AB: Writing – review & editing. JM: Writing – review & editing, Investigation, Conceptualization, Supervision, Project administration, Methodology. AM: Methodology, Investigation, Supervision, Conceptualization, Writing – review & editing, Project administration.

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Conflict of interest

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The author AM declared that they were an editorial board member of Frontiers at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2026.1952665/full#supplementary-material

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