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SCIENCE FOR A FOOD-SECURE FUTURE

A Review of climate variability and extreme weather impacts on diets and nutritional status among marginalized agri-food system workers and micro-, small- and medium-sized enterprises in LMICs

Project Inception Report

Contents

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Executive Summary

Agri-food system actors, including micro-, small- and medium- sized enterprises (MSMEs), produce, process, transport and sell a significant share of the world's food, yet these often informal sector actors remain among the most food insecure and climate-vulnerable. In low- and middle-income countries (LMICs), climate stressors such as heat, erratic rainfall, droughts, floods, and ecosystem shifts are already undermining crops, livestock, and fisheries, threatening livelihoods, nutrition, and health. These impacts fall most heavily on marginalized groups—especially women farmers and Indigenous Peoples—who face structural inequalities in access to resources, information, and decision-making, despite their central roles in food security and ecological stewardship.

While evidence linking climate change to a range of health outcomes is growing, existing reviews are often narrow in scope, geographically limited, or focused on broad vulnerable populations rather than MSMEs specifically. No review to date synthesizes climate-related food and nutrition security impacts on MSMEs with an explicit focus on gender and Indigenous communities. The proposed review will address this need by consolidating evidence on how climate change and variability affect MSME actors in the agri-food system and by informing more inclusive, effective adaptation and food-system transformation strategies.

Our primary research questions are:

- **RQ1**: What is the impact of climate variability and extreme weather on the physical and economic access of nutritious food for marginalized agri-food system workers and MSMEs?
- **RQ2**: What is the impact of climate variability and extreme weather on the diet quality and diversity of marginalized agri-food system workers and MSMEs?
- **RQ3**: What is the impact of climate variability and extreme weather on the nutritional status (e.g., anthropometry and micronutrient deficiencies) of marginalized agri-food system workers and MSMEs?

Proposed scope and objectives

The review will examine the impacts of climate change on diets and nutrition-related outcomes within the last 25 years, with a particular focus on agri-food system workers and MSMEs, especially women, Indigenous Peoples, and other marginalized communities in LMICs facing intersecting social exclusion.

Expected outputs

- A robust and detailed protocol, which outlines a comprehensive plan to conduct and report the systematic review. The protocol will be made publicly available (e.g., PROSPERO or Open Science Framework).
- Evidence will be synthesized for submission to a high impact peer-reviewed journal.
- PowerPoint presentation summarizing all outputs (protocols, systematic maps, systematic review) and key findings and takeaways for a lay audience

Background and Rationale

Agri-food system actors, including MSMEs, produce, process, transport and sell a significant share of the world's food, yet they remain among the most food insecure (Reardon, 2015). Around the world, MSMEs constitute about 90 percent of all businesses and generate between 60 and 70 percent of employment, and are key sources of income for women, young people, and vulnerable groups (UN, 2025).

In low and middle-income countries (LMICs), where agriculture is often rainfed and labor-intensive, climate stressors—rising temperatures, erratic rainfall, droughts, and floods—are already reducing crop yields and threatening rural livelihoods (Khatri et al., 2024). Livestock keepers face water scarcity, heat stress, and disease outbreaks, while small-scale fishers confront shifting ecosystems and declining stocks due to warming waters and extreme weather. These disruptions jeopardize livelihoods, with cascading effects along the agri-food value chain, especially among marginalized groups (IPCC, 2022). Women farmers, Indigenous Peoples, and other vulnerable communities often make up this informal sector and disproportionately bear the burden due to entrenched inequalities in access to land, capital, information, and decision-making power (GermanWatch, 2025).

Understanding how climate change affects the well-being of these groups is critical for building equitable, effective climate adaptation and food system transformation strategies. Women and Indigenous Peoples are not only more exposed to climate-related shocks, but also often hold key knowledge systems and play central roles in household food security and ecosystem stewardship. Overlooking their specific vulnerabilities, capacities, and constraints risks reinforcing inequality and undermining resilience.

A growing body of evidence exposes climate and health linkages. Lawrance et al. (2022) reviewed evidence on climate change's impacts on mental health. Rocque et al. (2021) provided the first broad overview of previous systematic reviews on climate-related health impacts (but found limited meta-analytic evidence). However, many systematic reviews remain regionally specific, limiting broader generalizability: Zenda (2024) focuses on smallholders in South Africa; Linh Tran et al. (2023) examine health impacts in Vietnam; Acosta et al. (2024) address climate-related health risks in the Sahel. Furthermore, while several reviews consider vulnerable population more broadly (e.g., Desai and Zhang's (2021) scoping review on women's health; Khine and Langkulsen's (2023) systematic review on health implications among vulnerable population in South Africa; Ngcamu's (2023) review focused on vulnerable groups in the Global South), none address smallholders and MSME actors specifically, demonstrating a clear gap in the literature.

Therefore, more targeted efforts are needed to understand how climate hazards affect the FSN of these agri-food system actors, especially among women, Indigenous Peoples, and other marginalized groups. This review will help fill that gap by centering these communities, providing an evidence base for equity-focused interventions and ensuring that the needs and voices of those most affected by climate change are reflected in global and national responses.

Research Questions

The review will examine the impacts of climate change on diets and nutrition-related outcomes within the last 25 years, with a particular focus on agri-food system workers and micro-, small- and medium- sized enterprises, especially women, Indigenous Peoples, and other marginalized communities in LMICs facing intersecting social exclusion.

Our three main Research Questions are:

- **RQ1:** What is the impact of climate variability and extreme weather on the physical and economic access of nutritious food for marginalized agri-food system workers and MSMEs?
- **RQ2:** What is the impact of climate variability and extreme weather on the diet quality and diversity of marginalized agri-food system workers and MSMEs?
- **RQ3:** What is the impact of climate variability and extreme weather on the nutritional status (e.g., anthropometry and micronutrient deficiencies) of marginalized agri-food system workers and MSMEs?

These research questions follow the PEO framework (Population, Exposure, Outcome):

Population

Local agri-food system workers and MSMEs (15-65 years), including those in the input sector, farmers, livestock keepers, laborers, fishers, aquaculture workers, processors, distributors, vendors in low- and middle- income countries (as defined by the World Bank). We focus on marginalized groups (e.g., women, youth, BIPOC, those facing intersecting exclusions). Studies must involve participants primarily engaged in food systems; spillover consumer effects will be noted.

Exposure

Studies that measure increased exposure to climate change, climate variability and or extreme weather including increases/decreases in temperature and precipitation such as droughts, floods, heat waves, wildfires, landslides, storms.

Outcomes

Studies that measure and report on diet quantity (e.g., physical and economic access, including food security), diet quality (e.g., direct measures of consumption and dietary diversity) or nutritional status (e.g., anthropometry and biomarkers of micronutrient status).

Key definitions

Micro-, Small- and Medium- sized Enterprises (MSMEs)

As defined by OECD (2023), MSMEs are categorized by the following:

- **Micro:** <10 workers, including e.g. small farms, petty trade, informal processing.
- **Small:** 10–49 workers, including e.g. local millers, traders, service providers.
- **Medium:** 50–249 workers, including e.g. regional processors, distributors, cooperatives.

Methodological Approach

Review Framework

Our evidence map systematic review (and meta-analysis, if applicable) will follow **Joanna Briggs Institute (JBI)** guidelines for Systematic Review (observational cross-sectional studies).

Search Strategy

A combination of electronic database searches and grey literature searching will be used. We will search the following academic health databases, as they cover most of the main food systems, agriculture, economics, policy, social protection and nutrition journals that publish in this area:

- MEDLINE (PubMed), 1946-present
- Web of Science Core Collection (Clarivate Analytics), including SCI-Expanded, SSCI, AHCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-Expanded, IC, 1900-present
- Scopus (Elsevier), 1788-present

To ensure maximum coverage of unpublished literature, and reduce the potential for publication bias, we will use the United Nations Food Systems Summit Champions Network as guidance to search organizational websites and databases using the keyword search for unpublished grey literature in the area of agriculture, nutrition and social protection.

A combination of key search terms and search strings will be used to refine searches, including:

- **Population**: “smallholder farmers”, “smallscale producers”, “gender”, “women”, “youth”, “marginalized”, “micro-, small- and medium-sized enterprises”, “Indigenous Peoples”, “BIPOC”, “hidden middle”, “market vendors”, “street vendors”
- **Exposure**: “climate change,” “extreme weather events”, “flood”, “drought”, “heat”, “tropical storm”, “hurricane”, “cyclone”, “typhoon”
- **Outcome**: “diets”, “nutrition,” “malnutrition,” “food security”

Studies published in any language, from January 1, 2000 to December 31, 2025, will be included.

Screening and Inclusion Criteria

Screening of titles, abstracts, and full texts will be guided by the PEO framework.

Inclusion/exclusion criteria is outlined in the table below:

Inclusion Criteria	Exclusion Criteria
• Agri-food system workers and MSMEs in LMICs (urban + rural) (15-65 years) • Focus on vulnerable populations (women, youth, Indigenous, marginalised) • Climate variability or extreme weather events as exposure	• No focus on vulnerable groups • Only focus on <15 years of age • Outside LMICs • Not linking climate variables to diets or nutrition-related outcomes • No primary outcomes • Intervention studies or qualitative study designs

- Primary outcomes: diet quantity, diet quality and nutritional status
- Secondary outcomes: income loss, mental health
- Any language
- Publication dates: 2000–2025
- Quantitative studies

After removal of duplicate studies, we will perform a multistage screening process to select studies that meet the eligibility criteria. Each title and abstract will be screened in duplicate. In the second step, two review authors will assess all full texts in duplicate. Covidence software will be used to support duplicate removal and to manage both title/abstract and full text screening and reviewer collaboration.

Data Extraction and Synthesis

Data from included studies will be systematically extracted and coded using predefined forms to capture key information (e.g., author, year, location, methods, findings). Extracted data will be checked for consistency and completeness by multiple reviewers to ensure quality.

Data Extraction

Data from the included studies will be independently coded and extracted by one review author using the predefined data extraction forms to capture key information. Data extraction forms will be reviewed by a second author. A third review author will be consulted in the event of any disagreements, and consensus will be sought. We will attempt to contact authors of the original reports to obtain further details if required.

Data Synthesis

We will present the synthesis of quantitative and qualitative evidence from the included studies through narrative and statistical analysis of comparable outcomes using meta-analysis. Depending on the outcome, we will calculate the pooled prevalence. Where multiple measures are reported for an outcome in a single study, we will utilize the most commonly reported measure across all included studies. We will pool all studies within a given region, assessing the same outcome, in the same population group by conducting a random-effects meta-analysis. To mitigate heterogeneity within included studies, a random effects meta-analysis will be used for all pooled outcomes. Statistical heterogeneity will be assessed by calculating the I^2 statistic, Chi^2 test, and reporting Tau^2. Furthermore, sources of heterogeneity will be explored through subgroup analyses of gender, country income level, and regions. Overall effect estimates will be considered statistically significant if the associated P-value was less than 0.05. Where a meta-analysis is deemed inappropriate due to substantial heterogeneity, we will summarize the findings of the included studies narratively.

Critical Appraisal

The **Risk Of Bias In Non-randomized Studies - of Exposure** (ROBINS-E) tool provides a structured approach to assessing the risk of bias in observational studies (Higgins et al., 2024). The ROBINS-E risk-of-bias assessment addresses seven domains of bias (e.g., bias due to confounding, bias arising from measurement of the exposure, bias in the selection of participants, bias due to post-exposure interventions, bias due to missing data, bias arising from measurement of the outcome and bias in selection of reported results). Each domain is addressed using a series of signalling questions that aim to gather relevant information about the study and analysis being assessed. Most signalling questions have response options ‘Yes’, ‘Probably yes’, ‘Probably no’, ‘No’ and ‘No information’, with ‘Yes’ and ‘Probably yes’

having the same implications for risk of bias and similarly for ‘No’ and ‘Probably no’. Some questions have additional response options (a ‘weak’ and a ‘strong’ version of ‘Yes’ or ‘No’) to help discriminate between higher and lower risk of bias. Two review authors will complete the risk of bias independently. Their judgements for each domain will be matched and an overall judgement will be made (i.e., low risk, medium risk or high risk). Where disagreements occur, a third author will be consulted.

Reporting

To ensure transparency and reproducibility, we will use the **PRISMA-ScR** checklist to guide reporting (Tricco et al., 2018). While alternative frameworks like ROSES have emerged, PRISMA-ScR is widely used across disciplines and better suited to the scope and interdisciplinary nature of this review.

Volume of Literature

Based on preliminary scoping searches, we estimate the expected number of records to be **3000-5000 titles/abstracts**. After full text screening, the anticipated volume is **30-50 studies**.

Team Structure and Responsibilities

Our team integrates deep expertise across nutrition, food systems, and climate adaptation.

Bianca Carducci, MSc, PhD – Independent Consultant (PI)

Nutrition scientist with 12 years of experience linking public and planetary health to food and nutrition security in a changing climate. Leads the Food Systems Countdown Initiative adaptation exercise across 15 countries in collaboration with GAIN. Bianca will be responsible for drafting protocol(s), submitting for publication, and overseeing search, as well as facilitating communications between ILRI and review team.

Costanza Conti, MSc, PhD – M.S. Swaminathan Research Foundation (Co-I)

Food systems researcher with 8+ years of experience specializing in sustainability transformation. Policy Research Lead at MSSRF with experience at FAO, CGIAR, CSIRO, and Eat-Lancet Commission. Focuses on inclusive food systems for smallholders in LMICs. Costanza will oversee stakeholder engagement, as well as lead screening of title/abstract and full-text, extraction, and critical appraisal.

Maya Moore, MSc, PhD Columbia University Climate School (Co-I)

Mixed methods social scientist focusing on gendered dimensions of climate adaptation, farmer decision-making, food security, and biodiversity conservation across sub-Saharan Africa and Latin America. Maya will support stakeholder engagement, screening of title/abstract and full-text, extraction, and critical appraisal.

Yu Chia Natasha Hu, MPH - Dalla Lana School of Public Health, University of Toronto (Co-A)

Public health epidemiologist with 4+ years of research experience in global food systems, climate-nutrition intersections, diet-health relationships, and equity-driven policy research. Selected among global peers for the WHO/Cochrane/Cornell 2025 Summer Institute for

Systematic Reviews in Nutrition for Global Policy Making, she blends rigorous evidence-synthesis skills with policy and systems thinking. Natasha will contribute to the search strategy, screening of title/abstract and full-text, extraction, and critical appraisal.

All team members will be engaged in quantitative and qualitative synthesis and visuals, as well as drafting the systematic review/meta-analysis and PowerPoint Presentation.

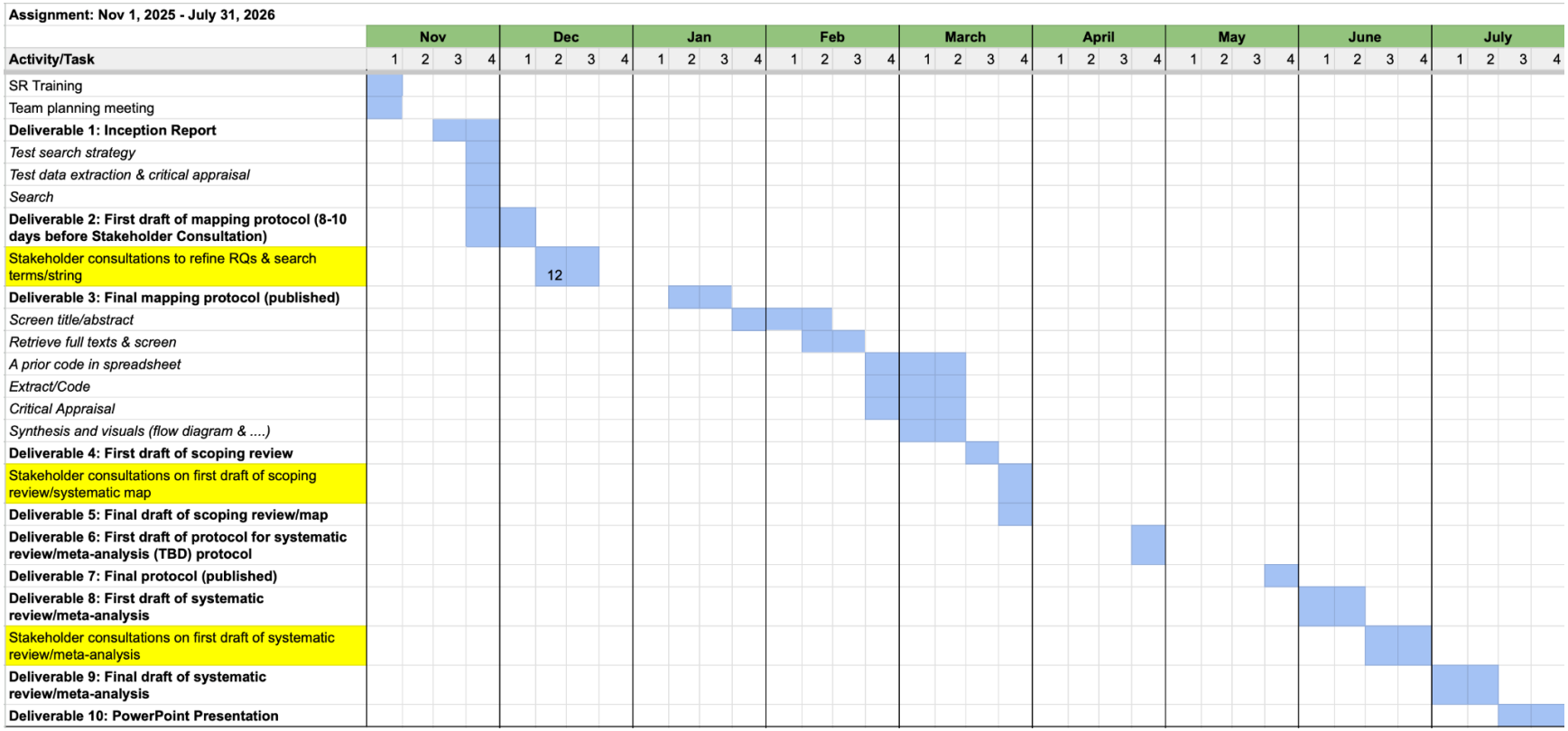
Stakeholder Engagement Plan

Stakeholder engagement is integrated into the review design to improve relevance, rigour, and usability. We will involve targeted groups of stakeholders, with a deliberate emphasis on LMIC representation. These stakeholders will be engaged to shape, review, and provide key inputs at different stages of the systematic review. Primary stakeholder groups (SG) include: (i) research organisations such as ILRI, other CGIAR centres, universities and national agricultural research systems (SG1) and (ii) non-governmental organisations and development practitioners implementing field-level climate adaptation and resilience interventions with smallholders, women farmers and Indigenous communities (SG2).

Stakeholder engagement will occur at three stages: inception, interim and final validation.

- At **inception**, we will circulate a short background note and the draft protocol to a purposive sample of around **15–20 stakeholders** across SG1 and SG2, prioritising LMIC-based experts (Appendix A). They will be invited to complete an online survey (Google Forms) that asks for structured feedback on the systematic review questions, populations of interest, eligibility criteria and relevance of the review. In parallel, we will convene a half-day hybrid stakeholder workshop on 12 December 2025. This workshop will bring together ILRI staff, CGIAR partners, LMIC researchers and practitioners to discuss the same issues in more depth, resolve divergent views and identify any critical omissions in the protocol. Notes, poll results and chat comments will be recorded and synthesised in a short note that documents how feedback is incorporated.
- During the **interim stage**, a smaller group of stakeholders (including several from the inception phase) will be consulted once preliminary mapping and synthesis results are available. We will share a short summary of emerging patterns and gaps and invite comments via email and a focused online consultation (e.g. 60–90-minute virtual meeting). The aim is to decide whether the developing evidence map and planned subgroup analyses are useful and to identify priority lenses (e.g. gender, type of MSME, region) for the final analyses.
- For **final validation**, we will organise a final workshop/webinar with LMIC experts, practitioners and policy actors (SG1, SG2). These sessions will focus on: (i) testing the validity and usefulness of the findings for real policy and programme decisions; (ii) identifying context-specific implications for agri-food MSMEs and marginalized workers; and (iii) agreeing on 3–5 clear messages for different audiences (research, policy, implementation). The workshops will be documented, and participant feedback will be used to refine the discussion, conclusions and recommendations in the final review and any associated materials.

Work Plan and Timeline



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Appendix A: List of Stakeholders

1. Rachel Bezner Kerr, Cornell University
2. Namukolo Covic, ILRI
3. Shouro Dasgupta, Fondazione CMCC
4. Jess Fanzo, Johns Hopkins University
5. Praveen Kumar, Boston College
6. Hazel Malapit, IFPRI DC
7. Meredith Niles, University of Vermont
8. Carol Zavaleta, Universidad Cayetano Heredia, Peru
9. Claudia Ringler, IFPRI
10. Elizabeth Bryan, IFPRI
11. Vijesh Krishna, CIMMYT
12. Md Saiful Islam, CIMMYT

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To learn more about the Climate Action Program, please visit this webpage.

To learn more about this and other Science Programs and Accelerators in the CGIAR Research Portfolio 2025–2030, please visit www.cgiar.org/cgiar-research-porfolio-2025-2030/

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