

What is the nature of the evidence base on 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 low- and middle-income countries? A Systematic Map

August 2026

Type of Review: Systematic Map



Contents

Authors and Affiliations	2
Abstract	3
Background	4
Theory of Change	4
Stakeholder Engagement	5
Objective and Review Questions	5
Methodology	6
Definition of Question Components	6
Bibliographic Databases	10
Web-based Search Engines	13
Organizational Websites	13
Comprehensiveness of the Search	13
Search Update	13
Screening Strategy	13
Eligibility Criteria	14
Consistency Checking	14
Reporting Screening Outcomes	15
Study Validity Assessment	15
Data Coding Strategy	15
Results	17
Description of the review process	17
Description of the evidence base	18
Discussion	23
Population Gaps	23
Evidence Gaps	23
Methodological Gaps	24
Limitations of the map	24
Declarations	25
References	26

Authors and Affiliations

Yu Chia Natasha Hu¹, Costanza Conti², Maya Moore³, and Bianca Carducci⁴

Affiliations:

1. Dalla Lana School of Public Health, University of Toronto
2. University of Reading, UK
3. Columbia Climate School, Columbia University
4. Global Convergence Research Collaborative, Toronto

Corresponding Author: bianca.carducci@alumni.utoronto.ca

Citation: Hu, Y.C.N., Conti, C., Moore, M., & Carducci, B. (2026). What is the nature of the evidence base on 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 low- and middle-income countries? A Systematic Map. CGspace: <https://hdl.handle.net/10568/185193>.

Keywords: Climate change; Food systems; Agri-food system workers; Micro-, small-, medium-sized enterprises Food security; Diets; Low- and middle-income countries

Cover photo: ILRI Copyright: © 2026. ILRI. This publication is licensed for use under a Creative Commons Attribution 4.0 International License (CC BY 4.0). To view this license, visit <https://creativecommons.org/licenses/by/4.0>

Disclaimers: This publication has been prepared as an output of the CGIAR Climate Action Program. Any views and opinions expressed in this publication are those of the author(s) and are not necessarily representative of or endorsed by the CGIAR System Organization.

Acknowledgements: We are grateful to Neal Haddaway and Aditi Mukherji for their methodological guidance in the development of this scoping review. We are also grateful to the stakeholders who provided feedback during the protocol development and preliminary results: Namukolo Covic, Claudia Ringler, Elizabeth Bryan, Rachel Bezner Kerr, Shouro Dasgupta, Saiful Islam, Hazel Malapit, Meredith Niles, Carol Zavaleta-Cortijo, Praveen Kumar, Vijesh Krishna and Siyabusa Mkuhlani. This work was conducted by Climate Action as part of the CGIAR Climate Program. CGIAR research is supported by contributions to the CGIAR Trust Fund. CGIAR is a global research partnership for a food-secure future dedicated to transforming food, land, and water systems in a climate crisis.

Abstract

Background

Agri-food system workers and micro-, small-, and medium-sized enterprises (MSMEs) are among the most food-insecure and climate-vulnerable populations globally, yet the evidence base on how climate variability and extreme weather affect their food security, diets and nutritional status remains fragmented. No prior review has synthesized this literature with an explicit focus on marginalized actors, including women, youth, and Indigenous communities, in low- and middle-income countries (LMICs).

Objectives

This systematic map characterizes the nature and extent of evidence on climate variability and extreme weather impacts on the food security, diets and nutritional status of agri-food system workers and MSMEs in LMICs, with secondary questions examining differential impacts by gender, age, indigeneity, climate hazard type, and food system activity.

Methods

A comprehensive search of Ovid MEDLINE, Web of Science, and Scopus (January 2000–January 2026) was conducted without language restrictions and supplemented by grey literature searches of 18 major agricultural and development organization websites. Studies were eligible if they included agri-food system workers or MSME actors in LMICs, measured exposure to climate variability or extreme weather, and reported food security, dietary or nutritional outcomes. Screening was conducted manually in duplicate at the title/abstract stage and data was coded and synthesized descriptively.

Results

A total of 15213 references were identified, and after removing 3373 duplicate studies, 11840 studies were screened at the title and abstract stage, 429 studies were included at the full-text review stage, and 275 studies across 60 countries were ultimately included. The evidence base is predominantly concentrated in South Asia and East Africa, with the majority of studies ($n = 167$) conducted in rural settings. Smallholder farmers are the most frequently studied population ($n = 245$), while fishers, pastoralists, Indigenous communities, women, and youth are underrepresented. Drought ($n = 132$), floods ($n = 88$), and general climate variability are the most examined exposures. Food security emerged as the most frequently studied outcome domain, with 217 studies (79%) reporting at least one food security indicator, while diet quality and water quality outcomes were reported in 108 studies (39%) and 82 studies (30%), respectively.

Conclusions

While this map documents a growing evidence base, critical gaps persist across populations (midstream and downstream food system actors, marginalized groups such as women and youth), geographies (Central and Latin America, Southeast Asia, the Middle East), outcomes (diet quality, micronutrient status), and methods (longitudinal designs, objectively measured exposures). These gaps should guide priority investment in future research and inform equity-focused climate adaptation strategies for marginalized populations across agri-food system activities.

Background

Agri-food system workers and actors such as micro-, small- and medium-sized enterprises (MSMEs) produce, process, transport and sell a significant share of the world's food, yet they remain among the most food insecure and vulnerable to climate change (Reardon, 2015; Bezner Kerr et al., 2022). In low- and middle-income countries (LMICs), climate stressors such as extreme heat, erratic rainfall, droughts, floods, and ecosystem shifts are already undermining crop, livestock, and fishery yields, threatening livelihoods, nutrition, and health (Mbow et al., 2019; Mufungizi et al., 2023; 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 (Mufungizi et al., 2023). These disruptions jeopardize livelihoods, food security, nutrition, and health, especially among marginalized groups (IPCC, 2022). Women, Indigenous Peoples, and other vulnerable communities disproportionately bear the burden due to entrenched inequalities in access to land, capital, information, and decision-making power (Adil et al., 2025). Agri-food system workers and actors within MSMEs face climate impacts across the food system from production to consumption, but evidence is limited on the 'hidden middle', such as activities post farm-gate (e.g. processing, packaging, distribution, wholesale and retail markets).

While evidence linking climate change to a range of nutrition outcomes is growing, existing reviews are often narrow in scope, geographically limited, or focused on broad vulnerable populations rather than marginalized food system workers and MSMEs specifically. No review to date synthesizes climate-related food and nutrition security impacts on marginalized agri-food system workers and MSMEs with an explicit focus on gender and Indigenous communities. Understanding how climate change affects the food security, diets and nutrition 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.

This systematic map aims to fill this knowledge gap by centering these communities – marginalized agri-food system workers and MSMEs – 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 response.

Theory of Change

Climate, diets and nutrition are closely interconnected. Seasonality and climate variability – which include year-on-year variations in climate, over seasons to decades, as well as extreme weather events and longer-term climate trends have already been linked to disruptions in health, food, water and social protection systems, leading to heightened food insecurity, poor quality diets, malnutrition, infectious disease burden, morbidity and mortality (FAO, 2007). To ground our research questions, search strategy and results, we leverage a framework by UNICEF, USAID, WHO, and USAID Advancing Nutrition (Figure 1), which illustrates the multi-system and multi-factorial pathways in which shocks, including extreme weather events, affect food security, diets and nutritional status. While this theory of change is not specific to agri-food system workers and MSMEs, this systematic map aims to support the model by identifying nuances and differential effects specific to these populations.

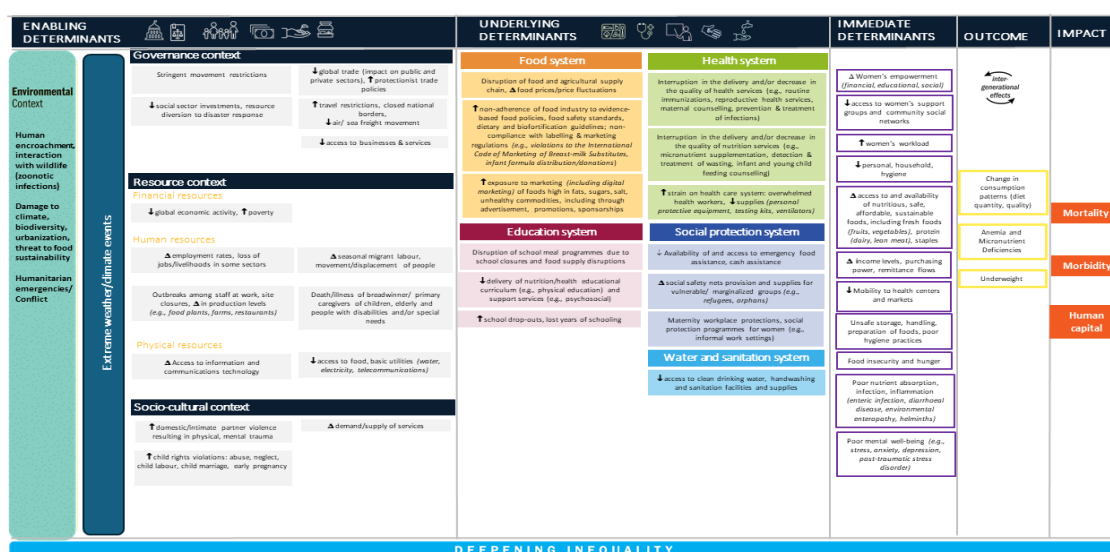


Figure 1. Theory of Change

Adapted from: UNICEF, USAID, WHO, USAID Advancing Nutrition (2022)

Stakeholder Engagement

Research questions were developed within the framework of a call from ILRI, which was then refined through a series of expert consultations. All consulted experts had research experience in specific fields of the relationship between climate and nutrition, including agriculture, livelihoods, and gender. Primary stakeholder groups (SG) include: (i) research organizations such as ILRI, other CGIAR centers, universities and national agricultural research institutions (SG1) and (ii) non-governmental organizations and development practitioners implementing field-level climate adaptation and resilience interventions with smallholders, women-owned businesses and Indigenous communities (SG2).

Stakeholder engagement occurred at two stages: inception and interim.

- At **inception**, we circulated a short background note and the draft protocol to a purposive sample of 11 stakeholders across SG1 and SG2, prioritizing LMIC-based experts. They were invited to complete an online survey (Google Forms) that asked for structured feedback on the systematic map questions, populations of interest, eligibility criteria and relevance of the review.
- In parallel, we convened a half-day hybrid stakeholder workshop on December 12, 2025. This workshop brought 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 were recorded and synthesized 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) were consulted once preliminary mapping and synthesis results were available. We shared a summary of emerging patterns and gaps and invited comments via email and a focused online consultation (e.g., a 60–90-minute virtual meeting). The consultation took place on April 30, 2026. The aim was 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 systematic review.

Objective and Review Questions

The primary research question of this systematic map is:

What is the nature and extent of the evidence base on climate variability and extreme weather on the diets and nutritional status of marginalized agri-food system workers and MSMEs in LMICs, including differential impacts on youth, women and/or Indigenous populations, and across different types of climate hazards?

The primary and secondary questions can be broken down into the following elements:

Population(s): Actors employed across food systems (from inputs, agricultural production, processing, packaging, distribution, markets) including those who work within and own MSMEs (according to OECD definition), across LMICs, in both urban and rural settings. In particular, this systematic map aims to understand the differential impacts on youth, women and Indigenous agri-food system workers and MSMEs.

Exposure(s): Climate variability and/or extreme weather events attributed to climate change such as floods, droughts, heatwaves, cold waves, wildfires, landslides and mudslides, and storms (hail, cyclones, typhoons, hurricanes, monsoons).

Outcome(s): Changes in diets, including quantity (e.g., food security) and quality (e.g., dietary diversity, intake of macro- and micro-nutrients), as well as nutritional status, including anthropometry and biomarkers of micronutrient status.

Methodology

Deviations from the protocol

The published protocol is available in Carducci et al. (2025). There are three deviations to note. First, we expanded our eligibility criteria to include studies which did not specify employment status in agri-food systems, but specified the study was located in rural populations. This is because agriculture is often the dominant activity in many rural LMIC settings. Second, given resource constraints, we omitted extraction of specific data fields, such as extracting secondary outcomes. Finally, our screening of titles and abstracts was conducted in duplicate (compared to only a subset of studies as listed in the protocol).

Definition of Question Components

Types of Study Designs

We considered the following empirical quantitative or qualitative primary study designs:

1. **Case reports:** Detailed documentation of a single individual or household, describing their specific situation, characteristics, exposures, and outcomes. These are useful for identifying unusual patterns or generating hypotheses about potential relationships.
2. **Surveillance:** Systematic, ongoing collection and analysis of health or nutrition data from individuals or households to monitor trends, detect changes, and identify emerging issues over time.
3. **Cross sectional:** Studies that collect data from individuals or households at a single point in time to describe the prevalence of conditions, behaviors, or characteristics and examine associations between exposures and outcomes at that moment.
4. **Cluster studies:** Investigation of an unusually high occurrence of cases among individuals or households grouped together in time, place, or both, to identify potential common exposures or risk factors.
5. **Case-control:** Studies that identify individuals or households with a specific outcome (cases) and compare them to similar individuals or households without that outcome (controls), examining past exposures or characteristics to identify potential risk or protective factors.
6. **Cohort:** Studies that follow individuals or households over time, comparing those with different exposures or characteristics at baseline to determine who develops specific outcomes. These track participants prospectively or use historical data retrospectively.

We excluded animal studies, conference abstracts, and opinion/letters.

Types of Settings and Participants

Local food system workers, including those within or who own MSMEs, across LMICs, in both urban and rural settings, were included in this review (e.g., smallholder farmers and horticulturists, livestock rearers/ranchers, laborers, fishers and aquaculture workers, processors, distributors, vendors). As defined by OECD (2023), MSMEs are categorized by the following:

- **Micro:** <10 workers, including small farms, petty trade, informal processing or vendors.
- **Small:** 10-49 workers, including local millers, traders and cooperatives.
- **Medium:** 50-249 workers, including regional processors, distributors.

In particular, we aimed to conduct subgroup mapping by examining the effects on vulnerable and marginalized food system actors including women, youth, and Indigenous populations, as well as food system actors navigating multiple intersecting forms of social exclusion. We recognize that food system actors are also consumers. Eligible studies included participants employed within the food system, and any spillover effects as consumers were captured. We did not include studies that examined participants employed outside of food systems. We included participants aged 15-19 (youth) and 20+ years (adults) from LMICs using the 2025 World Bank classification.

Types of Climate Exposures

Climate is measured routinely around the world by the meteorological community using internationally agreed standards, with a significant amount of data shared freely in real-time. Historical and current climate data and information products can be used to inform a wide range of planning processes as well as in early warning systems. Importantly, information about the future weather and/or climate varies in specificity (lead-time, spatial and temporal

averaging), the regions and seasons where it is most accurate and its status in terms of operational delivery. Information currently available globally for routine operational decision-making can be divided into three timeframes: weather, season, and climate change. These timescales are related to spatial scale: at one extreme, short-term weather predictions are reliable at the local level, while, at the other, climate change trends (especially temperature) are most reliable at the subcontinental level. For this map, we considered climate variability and extreme weather events that are related to climate change according to IPCC (Ranasinghe et al., 2021 and Ruane et al., 2022), including, floods, droughts, heatwaves, cold waves, wildfires, landslides and mudslides, and storms (cyclones, typhoons, monsoons, hurricanes) (See Figure 1). The following IPCC definitions were used:

Climate Variability: Refers to the natural variations and fluctuations in the earth's climate system over various time scales. It encompasses changes in temperature, precipitation, wind patterns, and other climate elements that can occur over short-term or long-term periods. Climate variability can be influenced by various factors, including natural processes such as volcanic eruptions, solar radiation, and ocean currents, as well as human activities like the emission of greenhouse gases.

Extreme Event (Weather or Climate): An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season).

CID Type	CID Category	Brief Description	Physical description of Phenomena
Heat and Cold	Mean air temperature	Mean surface air temperature and its diurnal and seasonal cycles.	Chapters 2, 3, 4 and Atlas
	Extreme heat	Episodic high surface air temperature events potentially exacerbated by humidity.	Chapter 11
	Cold spell	Episodic cold surface air temperature events potentially exacerbated by wind.	Chapter 11
	Frost	Freeze and thaw events near the land surface and their seasonality.	Chapter 12
Wet and Dry	Mean precipitation	Mean precipitation and its diurnal and seasonal cycles.	Chapters 2, 8 and Atlas
	River flood	Episodic high water levels in streams and rivers driven by basin runoff and the expected seasonal cycle of flooding.	Chapters 8 and 11
	Heavy precipitation and pluvial flood	High rates of precipitation and resulting episodic, localized flooding of streams and flat lands.	Chapter 11
	Landslide	Ground and atmospheric conditions that lead to geological mass movements, including landslide, mudslide and rock falls.	Chapter 12
	Aridity	Mean conditions of precipitation and evapotranspiration compared to potential atmospheric and surface water demand, resulting in low mean surface water, low soil moisture and/or low relative humidity.	Chapters 8, 11 and Atlas
	Hydrological drought	Episodic combination of runoff deficit and evaporative demand that affects surface water or groundwater availability.	Chapters 8 and 11
	Agricultural and ecological drought	Episodic combination of soil moisture supply deficit and atmospheric demand requirements that challenges the vegetation's ability to meet its water needs for transpiration and growth. Note: 'agricultural' vs. 'ecological' term depends on affected biome.	Chapters 8 and 11
	Fire weather	Weather conditions conducive to triggering and sustaining wildfires, usually based on a set of indicators and combinations of indicators including temperature, soil moisture, humidity and wind. Fire weather does not include the presence or absence of fuel load. Note: distinct from wildfire occurrence and area burned.	Chapters 11 and 12
Wind	Mean wind speed	Mean wind speeds and transport patterns and their diurnal and seasonal cycles.	Chapters 2 and 12
	Severe wind storm	Episodic severe storms including extratropical cyclone wind storms, thunderstorms, wind gusts, derechos and tornadoes.	Chapters 11 and 12

	Tropical cyclone	Strong, rotating storm originating over tropical oceans accompanied by high winds, rainfall and storm surges.	Chapter 11
	Sand and dust storm	Storms causing the transport of soil and fine dust particles.	Chapters 8 and 12
Snow and Ice	Snow, glacier and ice sheet	Snowpack seasonality and characteristics of glaciers and ice sheets including calving events and meltwater.	Chapters 2, 9 and Atlas
	Permafrost	Permanently frozen deep soil layers, their ice characteristics, and the characteristics of seasonally frozen soils above.	Chapters 2 and 9
	Lake, river and sea ice	The seasonality and characteristics of ice formations on the ocean and freshwater bodies of water.	Chapters 2 and 9
	Heavy snowfall and ice storm	High snowfall and ice storm events including freezing rain and rain-on-snow conditions.	Chapters 11 and 12
	Hail	Storms producing solid hailstones.	Chapters 11 and 12
	Snow avalanche	Cryospheric mass movements and the conditions of collapsing snowpack.	Chapter 12
Coastal	Relative sea level	The local mean sea surface height relative to the local solid surface.	Chapter 9
	Coastal flood	Flooding driven by episodic high coastal water levels that result from a combination of relative sea level rise, tides, storm surge and wave setup.	Chapters 9 and 12
	Coastal erosion	Long term or episodic change in shoreline position caused by relative sea level rise, nearshore currents, waves and storm surge.	Chapter 12
Open Ocean	Mean ocean temperature	Mean temperature profile of ocean through the seasons, including heat content at different depths and associated stratification.	Chapters 2 and 9
	Marine heatwave	Episodic extreme ocean temperatures.	Chapters 9 and 12
	Ocean acidity	Profile of ocean water pH levels and accompanying concentrations of carbonate and bicarbonate ions.	Chapter 5
	Ocean salinity	Profile of ocean salinity and associated seasonal stratification. Note: distinct from salinization of freshwater resources.	Chapters 2 and 5
	Dissolved oxygen	Profile of ocean water dissolved oxygen and episodic low oxygen events.	Chapter 5
Other	Air pollution weather	Atmospheric conditions that increase the likelihood of high particulate matter or ozone concentrations or chemical processes generating air pollutants. Note: distinct from aerosol emissions or air pollution concentrations themselves.	Chapter 6
	Atmospheric CO ₂ at surface	Concentration of atmospheric carbon dioxide (CO ₂) at the surface. Note: distinct from overall radiative effect of CO ₂ as a greenhouse gas.	Chapter 5
	Radiation at surface	Balance of net shortwave, longwave and ultraviolet radiation at the Earth's surface and their diurnal and seasonal patterns.	Chapter 7

Figure 2. IPCC Climate Impact Drivers and related CID categories with a short description.

Source: Ranasinghe et al., 2021 and Ruane et al., 2022

Types of Outcomes

Primary outcomes encompassed quantitative metrics of food security and diet (e.g., diet quantity (accessibility, affordability) and diet quality (e.g., dietary intake, dietary diversity)) and nutritional status (e.g., anthropometry and biomarkers of micronutrient status) in youth and adults, measured individually or at the household level. We also included quantitative, qualitative, and mixed-methods studies which describe these outcomes qualitatively. Our primary outcomes were used as eligibility criteria for including studies (i.e., if a study does not report any of the primary outcomes, it was excluded).

Table 1. Primary Outcomes

Domain	Sub-Domain	Indicators
Primary Outcomes		
Diets	<i>Physical Access</i>	Mean change or prevalence/incidence of food and water accessibility using the following metrics and tools or other appropriate metrics: • Access to markets • Food Insecurity Experience Scale (FIES) • Household Food Insecurity Access Scale (HFIAS) • Household Water Insecurity Experiences (HWISE) • Household Hunger Score (HHS) • Food Consumption Score (FCS)
Diets	<i>Economic Access</i>	Mean change or prevalence/incidence of food affordability or other appropriate metrics: • Household expenditure on food • Individuals and household relying on social protection measures (food aid, cash vouchers)
Diets	<i>Quality</i>	Mean change or prevalence of direct measures of consumption or other appropriate metrics: • Frequency of consumption • Energy intake • Macronutrient and micronutrient intake • Food group intake Mean change or prevalence/incidence of dietary diversity using the following tools or other appropriate metrics: • Women's Dietary Diversity Score (MDD-W) • Household Dietary Diversity Score (HDDS)
Nutrition	<i>Anthropometry</i>	Mean change or prevalence/incidence of underweight: • Body mass index (BMI) (defined as less than 18.5 kg/m² in adults)
Nutrition	<i>Micronutrient Deficiencies</i>	Mean change or prevalence/incidence of anemia status: • Hemoglobin concentration • Anemia • Iron deficiency anemia (serum ferritin, serum transferrin receptor)
Nutrition	<i>Micronutrient Deficiencies</i>	Mean change or prevalence/incidence of micronutrient status: • Iron • Zinc

		• Folate • Vitamin A • Vitamin B₁₂ • Vitamin D
--	--	--

Search Strategy

A comprehensive search of the literature was conducted from January 1, 2000 to January 12, 2026 (day search was conducted), without language restrictions or search filters (See Table 2 and Appendix I). The selection of the start year was based on the Intergovernmental Panel on Climate Change's third assessment report, published in 2001, which confirmed human influence and activities to exacerbate climate change.

Bibliographic Databases

We searched the following academic databases, as they cover most of the main food systems, climate, agriculture, and nutrition journals that publish in this area:

- Ovid MEDLINE, 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

Table 2. Scopus Search String (Conducted on January 12, 2026)

#	Search Query	Results
1	TITLE-ABS-KEY((environment* OR season*) W/2 (change* OR varia* OR disrupt* OR hazard* OR impact* OR vulnerab* OR footprint* OR extreme OR exposure OR expose*))	1201799
2	TITLE-ABS-KEY((climate OR climatic) W/2 (change* OR changing OR varia* OR disrupt* OR hazard* OR impact* OR vulnerab* OR function* OR extreme OR catastroph* OR emergenc* OR shift* OR dynamic* OR sensitiv* OR sustainab*))	740275
3	TITLE-ABS-KEY((hydrometeorolo* OR atmosphere* OR hydrologic* OR ocean* OR weather) W/2 (change* OR varia* OR disrupt* OR hazard* OR extreme OR exposure OR expose* OR phenomenon*))	121276
4	TITLE-ABS-KEY((global OR planet* OR world OR climat* OR earth OR worldwide OR world-wide OR "ambient air" OR ocean*) W/2 (heating OR warming OR temperature*))	225020
5	TITLE-ABS-KEY((temperature OR cold OR heat OR hot OR "ambient air" OR "relative humidity" OR thermal) W/2 (increas* OR extreme OR elevate* OR irregular OR intense OR reduc* OR pattern* OR global))	1011999
6	TITLE-ABS-KEY((sea-level OR "sea level") W/2 (increas* OR rise OR rising OR change OR changing))	52748
7	TITLE-ABS-KEY((rain* OR precipitation) W/2 (increas* OR extreme OR elevat* OR irregular OR intense OR reduc* OR pattern*))	105384
8	TITLE-ABS-KEY((tide OR tidal OR sea OR ocean*) W/2 surge*)	3095
9	TITLE-ABS-KEY((ocean* OR sea OR marine) W/2 (ph OR acidification OR heating OR warming OR change* OR varia* OR extreme OR expand OR expansion))	100070
10	TITLE-ABS-KEY((fire OR burnt OR inferno OR conflagration) W/2 (change* OR variab* OR extreme OR expand OR expansion OR intense OR elevate* OR increas* OR catastroph* OR emergenc* OR shift* OR dynamic* OR frequen*))	32992
11	TITLE-ABS-KEY(("co2" OR carbon OR methane OR ozone OR "nitrous oxide") W/2 (elevat* OR emission* OR rise OR increas* OR decreas* OR reduc* OR neutral OR offset*))	489935
12	TITLE-ABS-KEY((global OR planet* OR world OR earth OR worldwide OR world-wide) W/2 ("co2" OR carbon OR methane OR ozone OR "nitrous oxide"))	44643
13	TITLE-ABS-KEY(emission* W/2 (elevat* OR rise OR increas* OR decreas* OR reduc* OR offset*))	271522
14	TITLE-ABS-KEY("extreme weather" OR "natural hazard" OR "natural hazards" OR "natural disaster" OR "natural disasters" OR ENSO OR "el nino-southern oscillation" OR "el nino" OR "la nina" OR heatwave* OR "heat-wave" OR "heat-waves" OR "heat wave" OR "heat waves" OR coldwave* OR "cold-wave" OR "cold-waves" OR "cold wave" OR "cold waves" OR flood* OR "water stress" OR drought* OR cyclone* OR hurricane* OR typhoon* OR storm* OR monsoon* OR windstorm* OR landslide* OR "land-slide" OR "land slide" OR "landslides" OR mudslide* OR wildfire* OR wild-fire* OR "wild fire" OR	1229536

	"wild fires" OR "greenhouse effect" OR "green-house effect" OR "greenhouse gas" OR "greenhouse gas" OR "green-house gas")	
15	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14	4319752
16	TITLE-ABS-KEY((agricultur* OR agrarian OR farming OR subsistence OR poor OR rural) W/2 (household* OR communit* OR population))	207207
17	TITLE-ABS-KEY((food OR agri*) W/2 (producer* OR processor* OR distributor* OR worker* OR trader* OR vendor* OR laborer* OR labourer*))	53856
18	TITLE-ABS-KEY((micro OR small OR medium) W/2 (enterprise* OR business* OR vendor*))	571529
19	TITLE-ABS-KEY((factory OR marginali*ed OR temporary OR migrant OR wage OR casual OR seasonal OR contract OR informal OR street OR farm) W/2 (worker* OR vendor* OR laborer* OR labourer*))	41714
20	TITLE-ABS-KEY(("indigenous community" OR "indigenous communities" OR "native people" OR tribal OR "low income" OR low*income OR "low class" OR "informal food" OR campesino* OR peasant* OR women OR woman OR adolescent* OR youth O R "young adult" OR "young adults" OR "child labor" OR "child labour" OR farmer* OR smallholder* OR "small-holder" OR "small-holders" OR "small holder" OR "small holders" OR "dependent on agriculture" OR "depend on agriculture" OR MSME* OR SME* OR fish* OR aquacultur* OR rancher* OR pastoral* O R "indigenous people" OR "indigenous peoples")	7455896
21	16 or 17 or 18 or 19 or 20	6514022
22	TITLE-ABS-KEY((diet* OR food OR micronutrient* OR macronutrient* OR energy) W/2 (divers* OR quality OR intake OR consumption OR evaluat* OR assess*))	1021020
23	TITLE-ABS-KEY(nutrition W/2 (evaluat* OR assess* OR indices OR index OR evaluation* OR surveillance OR survey* OR status OR state*))	83425
24	TITLE-ABS-KEY((insufficient OR poor) W/2 (intake OR consumption))	8153
25	TITLE-ABS-KEY((nutrition* OR micronutrient* OR "trace element" OR vitamin OR iodine OR protein OR niacin OR zinc OR vitamin OR thiamine OR iron) W/2 (deficienc* OR deficit* OR deprivation))	237251
26	TITLE-ABS-KEY(under W/2 (feeding OR nourish* OR nutrition OR weight))	24182
27	TITLE-ABS-KEY(("body mass index" OR "BMI" OR anthropometr* OR hunger OR hungry OR "household hunger score" OR famine OR "water insecurity" OR "water insecure" OR "water security" OR "water secure" OR "water scarcity" OR "water access" OR "access to water" OR "water adequacy" OR "food insecurity" OR "food insecure" OR "food security" OR "food secure" OR "food consumption score" OR "food affordability" OR "food availability" OR "foods available" OR "food expenditure" OR "expenditure on food" OR "food access" OR "market access" OR "access to market" OR "time to market" OR "food aid" OR "food assistance" OR "cash transfer" OR "food voucher" OR "cash voucher" OR "take-home ration" OR "in-kind transfer" OR goiter* OR goitre* OR "amino acid starvation" OR "protein malnutrition" OR "protein starvation" OR "severe acute malnutrition" OR "SAM" OR "moderate acute malnutrition" OR "MAM" OR malnourish* OR malnutrition OR marasmus OR "pellagra*")	1056639
28	22 or 23 or 24 or 25 or 26 or 27	2227956
29	TITLE-ABS-KEY(afghan* OR africa* OR albania* OR algeria* OR angola* OR antigua* OR barbuda* OR argentin* OR armenia* OR aruba* OR azerbaijan* OR asia* OR bahrain* OR bangladesh* OR bengal* OR bangal* OR barbados* OR barbadian* OR bajan OR bajans OR belarus* OR belorus* OR byelarus* OR byelorus* OR belize* OR benin* OR dahomey OR bhutan* OR bolivia* OR bosnia* OR herzegovin* OR botswan* OR batswan* OR bechuanaland* OR brazil* OR brasil* OR bulgaria* OR burkina* OR burkinese* OR "upper volta" OR burundi* OR urundi* OR "cabo verde" OR "cape verde" OR cambodia* OR kampuchea* OR khmer* OR cameroon* OR cameroun* OR "ubangi shari" OR chad* OR chile* OR china* OR chinese OR colombia* OR comoro* OR comore* OR comorian* OR mayotte* OR congo* OR zaire* OR "costa rica" OR "costa rican" OR "cote d'ivoir" OR "cote d'ivoir" OR "cote divoir" OR "cote d ivoir" OR "ivory coast" OR ivorian* OR croatia* OR cuba OR cuban OR cubans OR "cuba's" OR cyprus* OR cypriot* OR czech* OR djibouti* OR "french somaliland" OR dominica* OR ecuador* OR egypt* OR "united arab republic" OR "el salvador" OR salvadoran* OR guinea* OR equatoguinea* OR eritrea* OR estonia* OR eswatini* OR swaziland* OR swazi* OR swati* OR ethiopia* OR fiji* OR gabon* OR gabonese* OR gabonaise* OR gambia* OR georgia* OR ghana* OR gibraltar* OR greece* OR greek* OR grecian* OR grenada* OR grenadian* OR guam* OR guatemala* OR guyana* OR guiana* OR guyanese* OR haiti* OR hispaniola* OR hondura* OR hungary* OR hungarian* OR india* OR indonesia* OR iran* OR iraq* OR "isle of man" OR jamaica* OR jordan* OR kazakh* OR kenya* OR karabati* OR korea* OR kosovo* OR kosova* OR kyrgyz* OR kirgiz* OR kirghiz* OR	1416570

	laos OR lao OR laotian* OR latvia* OR lebanon* OR lebanese* OR lesotho* OR lesothan* OR lesothonian* OR basutoland* OR mosotho* OR basotho* OR liberia* OR libya* OR jamahiriya* OR lithuania* OR macedonia* OR madagascar* OR malagasy* OR malawi* OR nyasaland* OR malaysia* OR malay* "federation or maldives" OR maldivian* OR "indian ocean" OR mali OR malian* OR "mali's" OR malta OR maltese* OR "malta's" OR micronesia* OR marshallese* OR kiribati* OR "marshall island" OR nauru OR nauran OR nauruans OR "naurian's" OR mariana OR marianas OR palau OR paluan* OR tuvalu* OR mauritania* OR mauritan* OR mauritius* OR mexico* OR mexican* OR moldova* OR moldovia* OR mongol* OR montenegr* OR morocco* OR moroccan* OR ifni OR mozambique* OR mozambican* OR myanmar* OR burma* OR burmese OR namibia* OR nepal* OR "new caledonia" OR "netherlands antilles" OR "lesser antilles" OR nicaragua* OR niger* OR oman* OR omani OR omanis OR "oman's" OR pakistan* OR palestin* OR gaza* OR "west bank" OR panama* OR paraguay* OR peru OR peruvian* OR "peru's" OR philippine* OR philipine* OR philippine* OR philippine* OR filipino* OR filipina* OR poland* OR polish OR pole OR poles OR portugal* OR portuguese OR "puerto rico" OR romania* OR russia* OR ussr* OR soviet* OR russia* OR rwanda* OR rwandese OR ruanda* OR ruandese OR samoa* OR "navigator island" OR "pacific islands" OR polynesia* OR "sao tome and principe" OR "sao tomean" OR santomean* OR "saudi arabia" OR saudi OR saudis OR senegal* OR serbia* OR seychell* OR "sierra leone" OR slovak* OR sloven* OR melanesia* OR "solomon island" OR "norfolk island" OR somali* OR "sri lanka" OR ceylon* OR "saint kitts and nevis" OR "st kitts and nevis" OR kittian* OR nevisian* OR "saint lucia" OR "st lucia" OR "saint vincent" OR "st vincent" OR vincentian* OR grenadine* OR sudan* OR surinam* OR syria* OR tajik* OR tadjik* OR tadjik* OR tanzania* OR tanganyika* OR thai* OR "timor leste" OR "east timor" OR timorese* OR togo* OR togoles* OR "togo's" OR tonga* OR trinidad* OR tobago* OR tunisia* OR turkiy* OR turkey* OR turk OR turks OR turkish OR turkmen* OR uganda* OR ukraine* OR uruguay* OR uzbek* OR vanuatu* OR "new hebrides" OR venezuela* OR vietnam* OR "viet nam" OR yemen* OR yugoslav* OR zambia* OR zimbabwe* OR rhodesia* OR arab* OR "middle east" OR "global south" OR sahara* OR subsahara* OR magreb* OR maghrib* OR "west indies" OR caribbean* OR "central america" OR "latin america" OR "south america" OR "central asia" OR "north asia" OR "northern asia" OR "southeastern asia" OR "south eastern asia" OR "southeast asia" OR "south east asia" OR "west asia" OR "western asia" OR "east europe" OR "eastern europe" OR "developing country" OR "developing nation" OR "developing population" OR "developing world" OR "less developed country" OR "less developed nation" OR "less developed world" OR "lesser developed country" OR "lesser developed nation" OR "lesser developed world" OR "under developed country" OR "under developed nation" OR "under developed world" OR "underdeveloped country" OR "underdeveloped nation" OR "underdeveloped world" OR "middle income country" OR "middle income nation" OR "middle income population" OR "low income country" OR "low income nation" OR "low income population" OR "lower income country" OR "lower income nation" OR "lower income population" OR "underserved country" OR "underserved nation" OR "underserved population" OR "under served population" OR "under served nation" OR "under served population" OR "deprived country" OR "deprived population" OR "high burden country" OR "high burden nation" OR "countdown country" OR "countdown nation" OR "poor country" OR "poor nation" OR "poor population" OR "poor world" OR "poorer country" OR "poorer nation" OR "poorer population" OR "poorer world" OR "developing economy" OR "less developed economy" OR "underdeveloped economy" OR "under developed economy" OR "middle income economy" OR "low income economy" OR "lower income economy" OR "low gdp" OR "low gnp" OR "low gross domestic" OR "low gross national" OR "lower gdp" OR "lower gnp" OR "lower gross domestic" OR "lower gross national" OR Imic OR Imics OR "third world" OR "lami country" OR "transitional country" OR "emerging economy" OR "emerging nation"	
30	TITLE-ABS-KEY(epidemiological OR "cross-sectional" OR "cross sectional" OR cohort* OR longitudinal OR prospective OR retrospective OR "case-control" OR "case control" OR exposure* OR impact* OR effect* OR association* OR risk* OR surveillance OR "mixed method" OR "mixed methods" OR "mixed-methods" OR "mixed-method" OR survey* OR quantitative OR qualitative OR interview* OR "focus group" OR "focus groups" OR ethnograph* OR "case report" OR "case reports" OR "case series" OR cluster* OR "panel-study" OR "field observation" OR phenomenology* OR "grounded theory" OR "participant observation" OR "discussion group" OR questionnaire*)	42878525
31	15 and 21 and 28 and 29 and 30	4817
32	Limit to 2000-current	4645

Web-based Search Engines

We used a modified version of the database search string to search Google Scholar and used the first 200 records retrieved by the search for Title and Abstract screening. Keywords included the following: ("climate change" OR "climate variability" OR "extreme weather" OR "flood" OR "drought" OR "heatwave" OR "cyclone") AND ("Indigenous" OR "smallholder" OR "farmer" OR "fisher" OR "pastoral") AND ("diet" OR "nutrition" OR "food security" OR "dietary diversity").

Organizational Websites

To ensure maximum coverage of unpublished literature, and reduce the potential for publication bias, we used the United Nations Food Systems Summit Champions Network as guidance to search the following organizational websites and databases using the keyword search for grey literature in the area of climate change, agriculture and nutrition including the following:

- Africa's Food Systems Forum, <https://afs-forum.org/>
- African Development Bank, <https://www.afdb.org/en>
- Asia-Pacific Association of Agricultural Research Institutions, <https://www.apaari.org/>
- Asian Development Bank, <https://www.adb.org/>
- Asian Farmers' Association for Sustainable Rural Development, <https://asianfarmers.org/>
- Bioversity International, Consultative Group on International Agricultural Research, <https://alliancebioversityciat.org/>
- Food and Agriculture Organization, <https://www.fao.org/home/en>
- Global Alliance for the Future of Food, <https://futureoffood.org/>
- Global Forum on Agricultural Research, <https://gfair.network/>
- Inter-American Development Bank, <https://www.iadb.org/en>
- International Fund for Agricultural Development, <https://www.ifad.org/en/>
- International Initiative for Impact Evaluation (3ie), <https://www.3ieimpact.org/>
- La Via Campesina, <https://viacampesina.org/en/>
- World Bank, <https://www.worldbank.org/ext/en/home>
- World Farmers' Organization, <https://www.wfo-oma.org/>
- World Fish, <https://www.worldfishcenter.org/>
- World Food Programme, <https://www.wfp.org/>
- World Resources Institute, <https://www.wri.org/>

Comprehensiveness of the Search

Based on previous experience with the subject matter, we identified ten benchmark articles that met all eligibility criteria. All ten articles were returned by at least one database and/or supplementary search.

Search Update

We do not plan on updating the search as the timescale of search-to-publication is sufficiently short that a search update would not warrant the resources.

Screening Strategy

Studies were screened and full-text reviewed using the review platform Covidence. After the removal of duplicate studies, we performed a multistage screening process to select studies that meet the eligibility criteria. At the title and abstract stage, studies were assessed by two reviewers, independently removing those that are not relevant. Any disagreements were resolved by discussion and, where necessary, by consulting a third review author. At the

full-text stage of the screening process, studies were assessed by one reviewer independently and we documented the reasons for exclusion. We excluded studies without primary outcomes. We did not exclude studies on the basis of the reporting of an outcome (i.e., that an effect size is not estimable although the outcome was clearly measured).

Eligibility Criteria

Studies were assessed according to the Population, Exposure, Outcome (PEO) defined in Table 3.

Table 3. Eligibility Criteria

	Inclusion	Exclusion
Population	Local agri-food system workers including those who work within and own MSMEs (15 years or older), 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 World Bank). We focus on marginalized groups (e.g., women, youth, and those facing intersecting exclusions). Studies must involve participants primarily engaged in food systems; spillover consumer effects were noted.	Studies with animal subjects or any specific high-risk population other than general populations. Studies that do not specify employment within the food sector or are conducted in high-income countries.
Exposure	Studies that measure increased exposure to climate variability and or extreme weather including increases/decreases in temperature and precipitation, as well as as droughts, floods, heat waves, wildfires, landslides, and storms.	Extreme weather not attributed to climate (i.e., earthquakes) according to IPCC.
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).	Studies with morbidity/mortality outcomes other than diets and nutritional status.
Study Designs	Studies with quantitative and/or qualitative data on exposure-response relationships, and clear exposure-response metrics using observational study designs published without language restrictions, between January 1, 2000 and January 12, 2026.	Studies published before January 1, 2000 or experimental study designs (including adaptation/mitigation studies).

Consistency Checking

To ensure consistency in applying eligibility criteria at the full-text review stage, a random subset (10%) of studies was selected and assessed for agreement. A kappa coefficient above 0.6 was considered good agreement. Discrepancies were discussed and clarifications were made in interpreting the eligibility criteria to maximise the consistency for remaining studies. A third reviewer was consulted if a decision was not reached, and clarification on eligibility criteria was added to aid further decision-making.

Reporting Screening Outcomes

Screening, full-text review and extraction outcomes were visualized using the PRISMA flowchart provided by Covidence. Lists of the total numbers of records, those included and those excluded (with reasons) are available in separate supplementary files.

Study Validity Assessment

Critical appraisal is optional for systematic maps and therefore was not carried out. However, data related to study characteristics and outcomes were extracted, which may be related to study validity.

Data Coding Strategy

Data from the included studies were independently coded and extracted by one review author using the predefined data extraction forms.

Meta-data to be coded

The following variables were extracted from each included article in Excel:

1. **General information:**
 - Study title (free text)
 - Authors (free text)
 - Year of publication (free text)
 - Location type (single-country, multi-country)
 - Country
 - Type of data (quantitative, qualitative, mixed methods)
2. **Study setting and population**
 - Setting (urban, rural, coastal, mountainous, riverine, mixed, other, not specified)
 - Type of population (micro, small, medium, other, not specified)
 - Context (free text) (e.g., youth, women, Indigenous, low SES, migrant worker etc.)
 - Stage of the agri-food value chain (i.e., producers, processors, distributors, retailers, other, not specified)
3. **Exposure**
 - Type of climate/weather event (seasonality, extreme weather event or general climate change)
 - Changes in rainfall/timing (yes/no)
 - Type of extreme weather event specified (floods, droughts, heatwaves, cold waves, wildfires, landslides and mudslides, and storms (cyclones, typhoons, monsoons, hurricanes), other, not specified)
4. **Primary Outcomes**
 - Type of primary outcome (Diets, Nutrition, Food Security, other, undisclosed)
 - Type of primary outcome (free text)
 - Name of outcome tool or measurement (free text)
5. **Other Notes (Free text)**

Consistency Checking

A standardized data extraction form was developed and pilot-tested on a subset of studies (10%) by two independent reviewers. Extraction was matched and assessed for agreement.

Type of Mapping

The extracted metadata is available in the form of a table. The systematic map provides information about the relation between the exposure and outcome, disaggregated by relevant population subgroups where data permits. This includes analyzing relationships across different parts of the value chain (e.g., producers, processors, distributors and retailers) and vulnerable population groups (e.g., youth, women and Indigenous peoples). Furthermore, the investigated associations between the exposure and outcome were mapped to identify knowledge gaps and give directions for the systematic review and meta-analysis and articles that covered the combination of several outcomes were of interest. Moreover, the type of study designs (e.g. cross-sectional, cohort) and study populations (e.g. youth, women, Indigenous people) were inspected. We present our results using figures, tables, and other descriptive illustrations.

Narrative Synthesis Methods

We present the characteristics of included studies through descriptive statistics (e.g. percentages, frequencies) visualized in tables and figures. We first categorized the studies based on type of exposure, then by outcome.

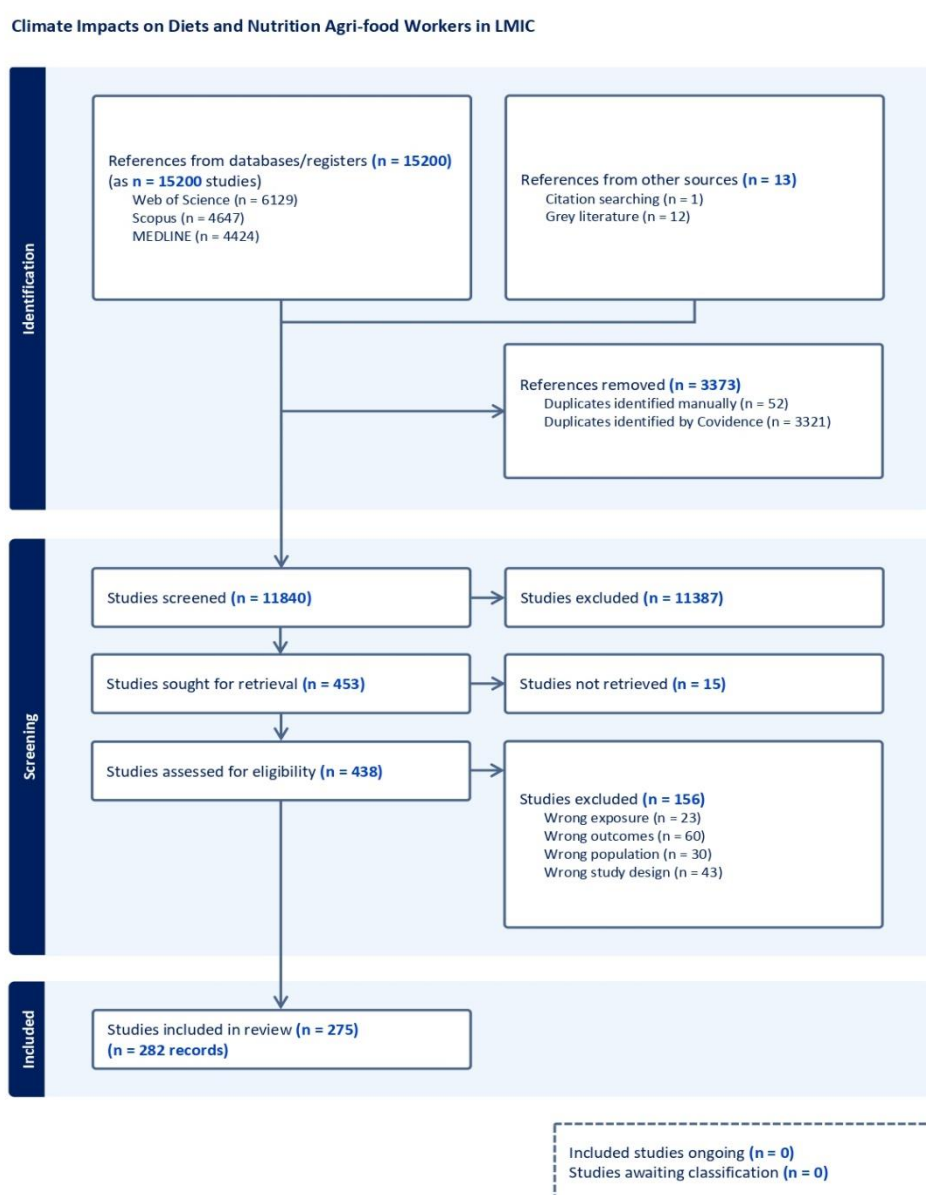
Knowledge Gap Identification Strategy

The systematic map will inform refinements to our scope, research questions, and inclusion criteria for the subsequent systematic review and meta-analysis.

Results

Description of the review process

The search strategy retrieved 15213 records, which comprised of 15200 peer-reviewed articles, 30 grey literature documents, and 1 reference from citation searching. Among the articles retrieved from databases, 11840 articles underwent title and abstract screening, with 11387 excluded and 3373 marked as duplicates. The remaining 438 articles underwent full-text review, 156 were excluded for the following reasons: wrong outcomes (n=60), wrong study design (n=43), wrong population (n=30), wrong exposure (n=23), wrong or could not be retrieved (n=15) (Figure 3). A total of 272 peer-reviewed studies were included in this review. Among grey literature articles, 13 articles underwent screening and 8 articles under full-text review. Eight grey literature articles were included. In total, 275 studies were included in this systematic map.



20th April 2026



Figure 3. PRISMA flow diagram

Description of the evidence base

The systematic map includes 275 studies across 60 countries and five continents (Figure 4). Of these, 47% of studies used a mixed-methods design ($n = 129$), while 32% used a quantitative design ($n = 89$), and 21% ($n = 57$) used a qualitative design only. Most studies were published within the last five years (2020-2025) and were located in Sub-Saharan Africa (SSA) and South Asia, with fewer studies from Central and Latin America, Oceania, Europe and the Middle East. Within SSA, studies were mainly conducted in Ethiopia, Ghana, Kenya, Nigeria, Tanzania, Uganda, Malawi, South Africa and Zimbabwe (69%). In South Asia, coverage was concentrated in Bangladesh, India, Pakistan and Nepal (29%). The majority of studies ($n = 161$) were conducted in rural settings, with a smaller subset situated in distinct geographic contexts, including coastal ($n = 23$), mountainous ($n = 12$), and riverine settings ($n = 8$) (Figure 5). Only one included study was in an urban setting.

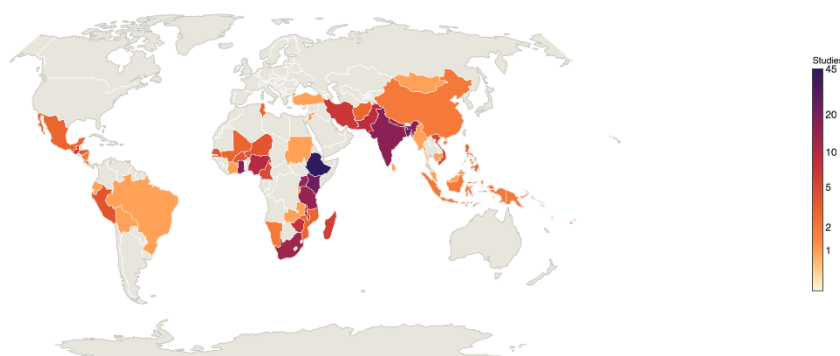


Figure 4. Geographic distribution of included studies by country

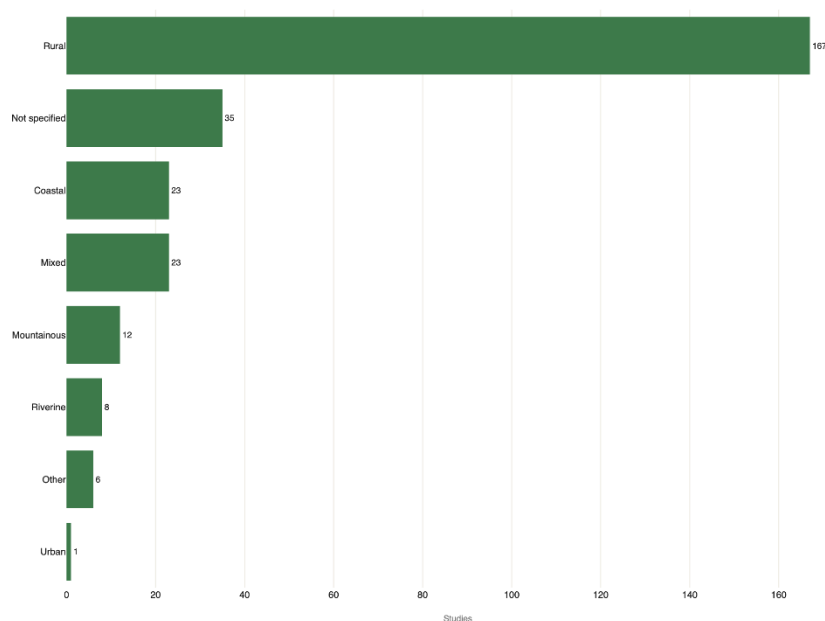


Figure 5. Distribution of studies by agroecological/geographical setting

Across population categories, smallholder farmers were the most frequently represented group ($n = 236$), followed by women ($n = 31$), fishers ($n = 25$), Indigenous or tribal populations ($n = 24$), pastoralists ($n = 23$) and youth ($n = 16$) (Figure 6). Across the exposure categories, extreme weather events ($n = 215$) were included more often than climate variability ($n = 176$), with drought being the most frequently examined weather event ($n = 148$), followed by floods ($n = 91$) and storms ($n = 39$). Heatwaves, erosion, landslides, wildfires, hailstorms and cold waves were represented less frequently (Figures 7 and 8).

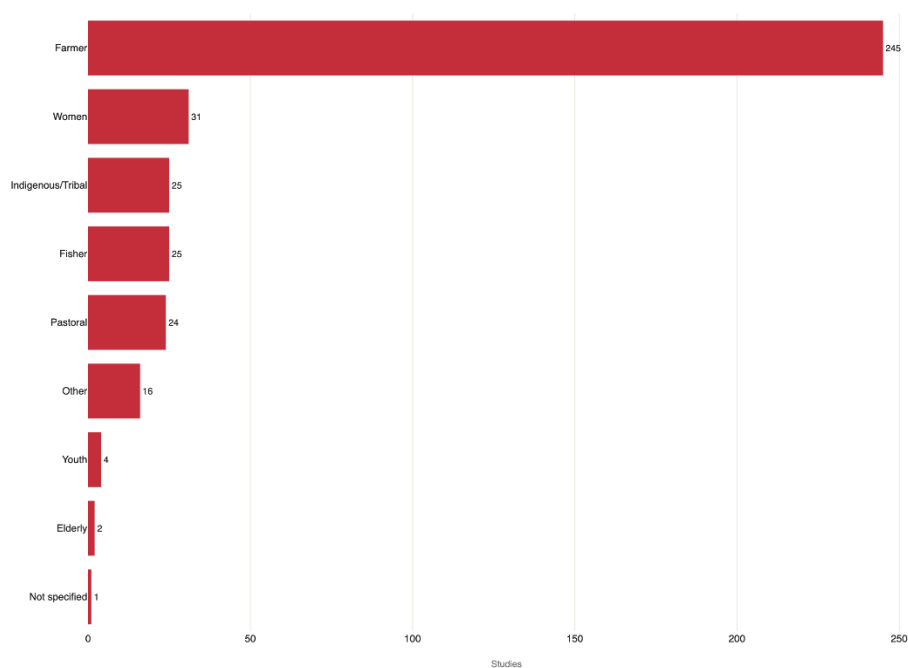


Figure 6. Distribution of studies by agri-food system actor characteristics

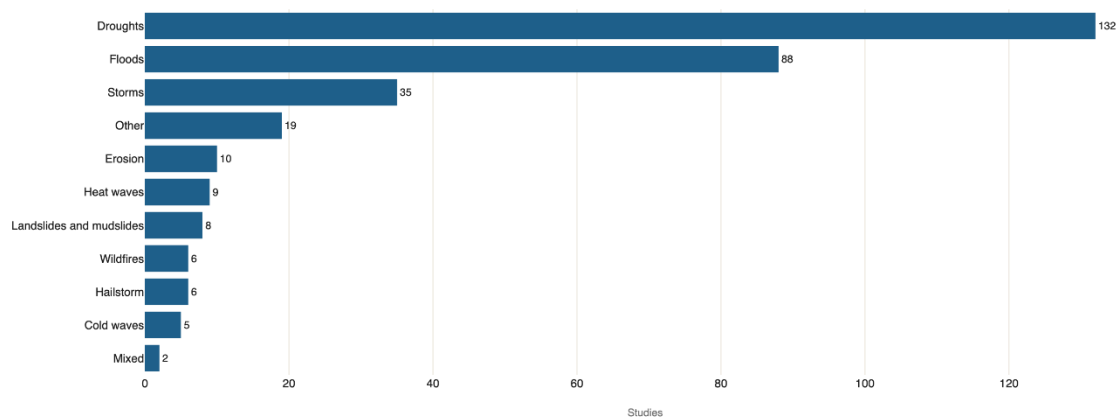


Figure 7. Frequency of extreme weather events examined across included studies

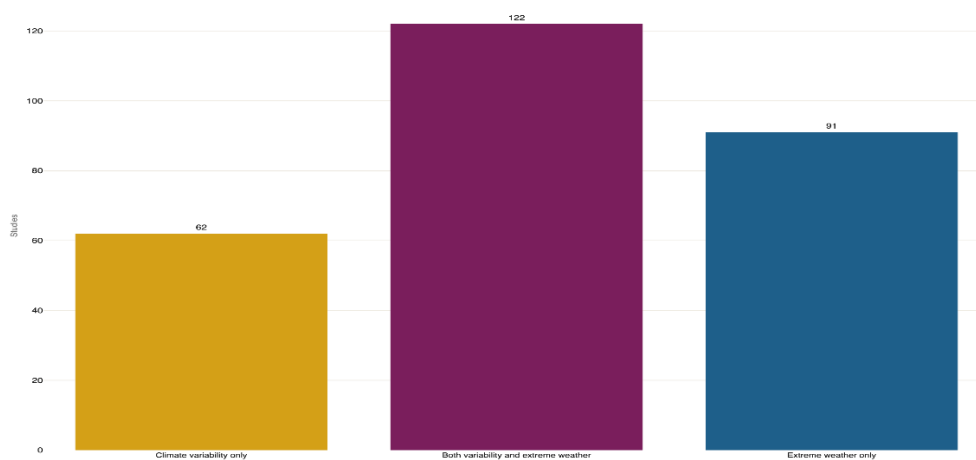


Figure 8. Co-occurrence of climate exposures across 275 included studies

Food security emerged as the most frequently studied outcome domain, with 217 studies (79%) reporting at least one food security indicator. The most common food security measures were general indicators of reduced or changed household consumption and number of meals ($n = 102$), general food insecurity ($n = 56$), reliance on cash or food aid ($n = 48$), and general food availability ($n = 31$). A smaller subset employed validated tools or scores ($n = 62$), most often the Household Food Insecurity Access Scale (HFIAS, $n = 29$), the Food Consumption Score ($n = 11$), the Food Insecurity Experience Scale (FIES, $n = 9$), and the Household Food Security Score ($n = 8$) (Figure 9).

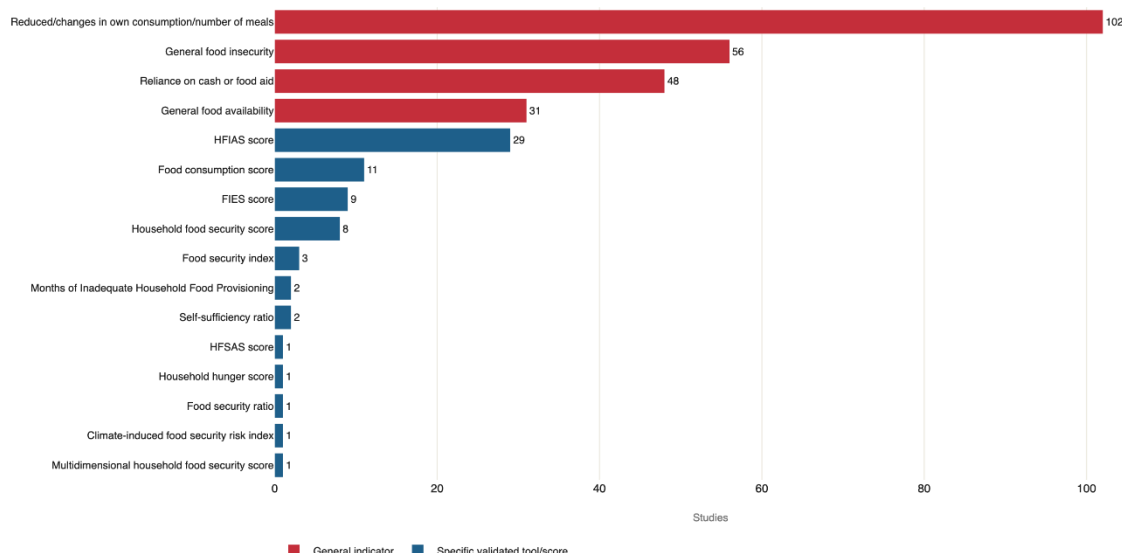


Figure 9. Food security outcomes

Note. Bars are not mutually exclusive; studies reporting multiple indicators within a domain contribute to each relevant bar.

Diet quality outcomes were reported in 108 studies (39%), most commonly as changes in food group consumption ($n = 57$), reduced food choice ($n = 44$), changes in wild food consumption ($n = 26$), and dietary diversity scores ($n = 20$). Fewer studies examined changes in macro- and micronutrient intake or caloric adequacy ($n = 8$), changes in ultra-processed food consumption ($n = 5$), and changes in dietary patterns ($n = 3$) (Figure 10).

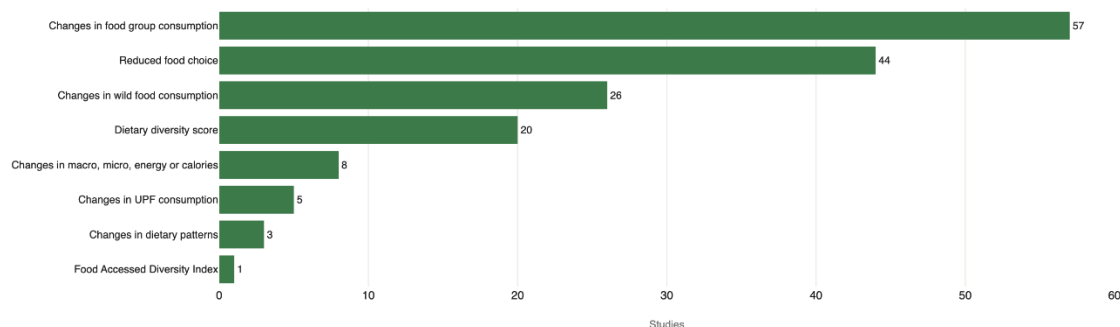


Figure 10. Diet quality outcomes

Note. Bars are not mutually exclusive; studies reporting multiple indicators within a domain contribute to each relevant bar.

Water security outcomes were less frequently studied, appearing in 82 studies (30%), and were characterized predominantly by changes in water access ($n = 75$) and water quality ($n = 32$), with only one study examining bottled water consumption (Figure 11).

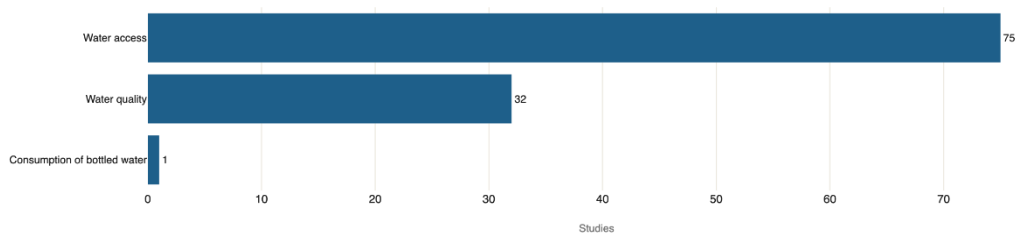


Figure 11. Water outcomes

Note. Bars are not mutually exclusive; studies reporting multiple indicators within a domain contribute to each relevant bar

Other outcomes spanned livelihood, economic, and nutritional dimensions, appearing in 200 studies (73%). The most commonly reported were changes in agricultural production ($n = 157$), changes in income ($n = 90$), changes in food prices ($n = 43$), market access or availability ($n = 38$), and vulnerability or coping indices ($n = 28$). Less frequently studied outcomes included changes in purchasing patterns ($n = 18$), changes in food expenditures ($n = 15$), anthropometric measures ($n = 7$), and general malnutrition or nutritional status ($n = 6$) (Figure 12).

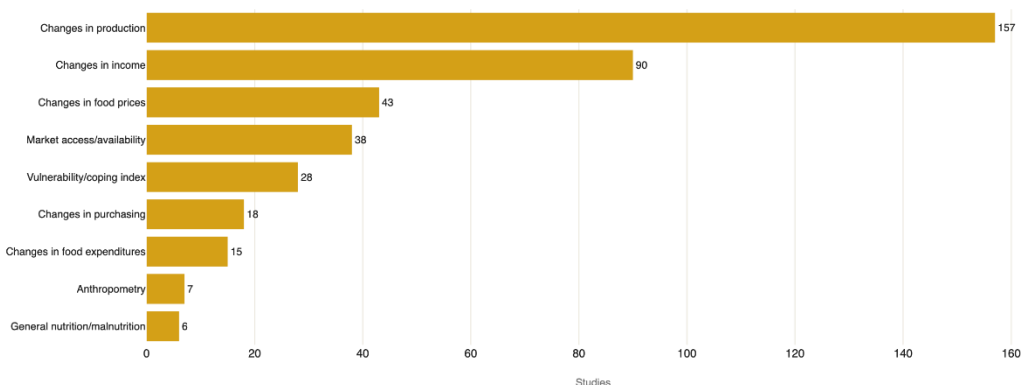


Figure 12. Other outcomes

Note. Bars are not mutually exclusive; studies reporting multiple indicators within a domain contribute to each relevant bar.

Figures 13 and 14 reveal two strong concentrations in the evidence base. First, climate variability and droughts account for the majority of exposure–outcome links, with relatively little evidence on heat waves, landslides, or wildfires despite their growing relevance to food systems. Second, farmer-focused studies dominate the population landscape, leaving substantial gaps for women-focused, Indigenous, fisher, and pastoralist populations across all four outcome domains.

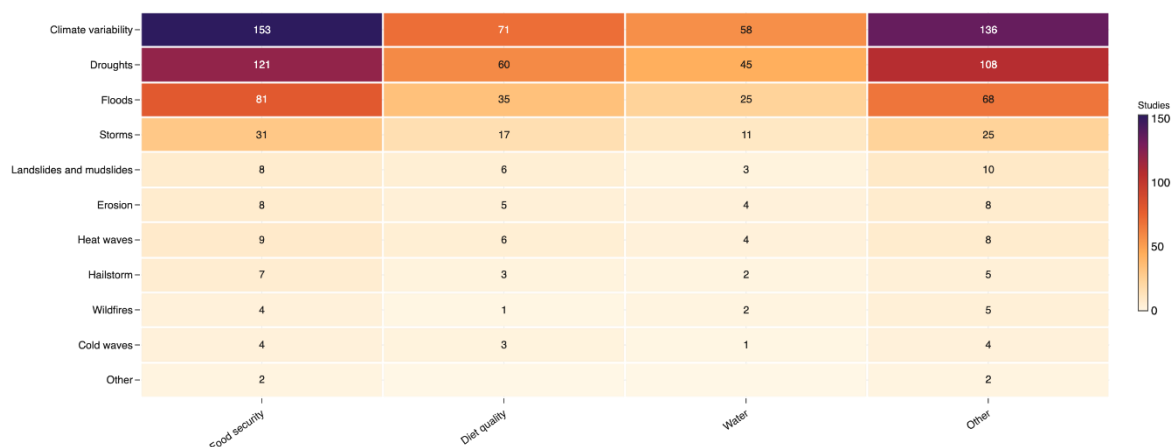


Figure 13. Number of studies by exposure and outcome domain



Figure 14. Number of studies by population and outcome domain

Discussion

This map advances the understanding of the evidence base linking climate variability and extreme weather to food security, diets and nutrition among marginalized agri-food system workers in LMICs, and identifies three key findings.

Population Gaps

First, while this map synthesized a large number of studies, it identified significant population and geographic gaps in the available literature. Of the 275 studies included in this map, 57.6% were concentrated in South Asia and East Africa, regions that, while critically important, do not represent the full range of climate-exposed LMICs. Central and Latin America, Southeast Asia, the Middle East, and small island developing states are substantially underrepresented, despite being among the regions where climate projects signal the most severe and accelerating risks to food systems (IPCC, 2022). This geographic skew suggests the evidence base is systematically weighted toward specific agroecological and socioeconomic contexts, limiting its generalizability and its utility for policymakers in underrepresented regions.

Beyond geography, the evidence remains thin on populations beyond production, including MSMEs, informal vendors, processors, transporters, and retailers. Despite frequent use of 'food system' language, most studies focus narrowly on smallholder farmers at the production stage, overlooking midstream and downstream actors who move the majority of food in LMICs. It has been estimated that these actors move 65% of food consumed in Africa and South Asia (Reardon et al., 2021). This gap is partly structural. Unlike farming households, informal vendors and processors often lack fixed locations or registration records, making them difficult to reach through conventional study designs. Climate change is predicted to have increasing repercussions on these actors, causing concrete and increasing disruptions in storage, processing, transport, markets, and food safety (IPCC, 2022).

Heat and humidity also add further challenges by accelerating spoilage of perishables including fruits, vegetables, fish and stored grains, while storms and climate shocks damage warehouses, contaminate food and water, block roads and disrupt retail activity (Duchenne-Moutien and Neetoo, 2021; FAO, 2017). These disruptions reduce availability of nutrient-dense foods, raise prices, cut incomes for informal vendors, and increase food safety risks (Mbow et al., 2019; Bezner Kerr et al., 2022; Reardon et al., 2021). These disruptions might translate into severe consequences for MSMEs, in terms of employment and reduced incomes, yet remain a 'hidden middle' in both research and policy (Reardon et al., 2021). Despite this exposure, MSMEs in agri-food systems receive an insufficient share of both research attention and climate finance, reinforcing a common blind spot across research and policy (UNDP, 2024). Importantly, limited attention is paid to women, youth, the elderly, and Indigenous populations in the selected studies. Women who are simultaneously producers, processors, and vendors face compounded intersecting risks that the literature has not yet adequately captured, and these vulnerabilities are not systematically documented in policy (Bryan et al., 2023). Most studies focus on smallholders in rural areas, neglecting other potentially-at-risk areas such as mountainous, coastal, riverine, and urban settings.

Evidence Gaps

Most studies in this map relied on self-reported or qualitative characterizations of climate variability, rather than being objectively measured by meteorological data linked directly to study locations. Perceived and measured exposure introduces recall bias and prevents standardization across studies, which severely constrains the comparability of findings and the feasibility of meta-analysis. The literature treats climate hazards largely as discrete shocks, yet compound events (such as drought followed by flood, or heat stress coinciding with seasonal food scarcity) are increasing under climate change and may produce poorer outcomes than those of isolated shocks. Furthermore, the evidence base is dominated by food security outcomes, with limited evidence on diet quality and nutritional status.

Food security and nutrition security are related but distinct concepts that are poorly characterized in this literature. This reflects the nature of the broader literature, which provides limited insight on climate change impacts on diet quality, micronutrient adequacy, anaemia, BMI, or other nutrition indicators. For example, previous systematic reviews have studied the association between production diversity, diets and nutrition in smallholder farmers, placing them as a group that is especially affected by undernutrition and limited dietary diversity, especially in LMICs; however, how climate affects, or worsens, this is unclear (Sibhatu and Qaim, 2018).

Diet quality is expected to worsen under climate change (Owino et al., 2022; Belayneh et al., 2021), yet to our knowledge no systematic review has examined this relationship in agri-food system workers in LMICs. Research should therefore move beyond food security as the primary outcome and measure dietary diversity more rigorously, while policy and funding should shift from short-term food security interventions toward longer-term strategies promoting dietary diversity under climate disruption (Meenakshi & Quisumbing, 2025).

Methodological Gaps

The third finding concerns methodological heterogeneity, which cuts across both exposure measurement and study design, limiting what can be concluded from this body of evidence. The literature is dominated by cross-sectional studies, which capture associations at a single point in time. Cross-sectional studies provide valuable insights into prevalence and associations within populations, but their design limits inferences regarding causality. Due to the nature of the exposure to climate variability and extreme weather events, it is challenging to measure our outcomes of interest prior to the exposure. Further analysis on the pathways from shock to nutritional and food security outcomes may also be mediated by coping strategies, food aid interventions, market disruptions, and household income losses that cross-sectional designs cannot capture.

Studies also frequently measured climate exposure at the regional or district level while outcomes were assessed at the household or individual level. This mismatch may also create ecological fallacy risks that limit the precision of exposure-response estimates. Similarly, methodological and reporting heterogeneity in outcome measurement, across different food security scales, dietary diversity tools, and anthropometric indicators, constrains comparability and limits the studies available to perform meta-analysis.

Finally, mixed-methods study designs that integrate quantitative exposure data with qualitative accounts of coping strategies, social dynamics, and local knowledge were more common than purely quantitative or qualitative study designs, which can help to understand how climate shocks impact food security and dietary outcomes across different social and agroecological contexts (Sparling et al., 2024). Despite this, the dominance of cross-sectional designs reflects the practical realities of conducting research in resource-constrained settings with mobile, informal and seasonally active populations. Acknowledging these constraints is a necessary step to direct long-term research investments that make more rigorous designs feasible in the contexts where evidence is most urgently needed.

Limitations of the map

Despite a comprehensive search strategy, this map may still be subject to retrieval and publication biases. While no language restrictions were applied, search terms were in English, which may have limited retrieval of non-English studies.

Conclusion

Future research should prioritize midstream and downstream actors in informal and MSME-dominated food systems, measuring how climate shocks affect storage, processing, transport, and markets. Studies should also disaggregate findings by additional characteristics such as stage of the food system, household characteristics and demographics, and employment status (formal, seasonal/contract, informal) within the agri-food system, given the compounded vulnerabilities and evidence gaps documented in this map.

In terms of diet quality, urgent attention is needed to better unpack climate-related risks and inherent solutions for achieving healthy and nutritious diets for all, especially in the case of overlooked and vulnerable groups (Rockström et al., 2025). Finally, the geographic concentration of this evidence base in South Asia and East Africa signals an urgent need for investment in primary research in regions that face severe climate trajectories but are largely absent from the literature, such as Central and Latin America, Southeast Asia, the Middle East, and small island developing states.

Declarations

Demonstrating Procedural Independence

No member of the research team has authored articles that may be retrieved by the search strategy detailed above.

Competing Interests

The authors do not have competing interests to declare.

Funding Information

This systematic evidence map was funded by the International Livestock Research Institute.

Author's Contributions

YCNH conducted title and abstract screening, full-text review, extraction and writing of the report. MM developed the research topic, study design, title and abstract screening, full-text review, extraction and writing of the report. CC developed the research topic, study design, title and abstract screening, extraction and writing of the report. BC developed the research topic, study design, drafted the protocol manuscript, conducted full-text review, analysis and supervised all stages of the review.

References

- Adil, L., Eckstein, D., Künzel, V., & Schäfer, L. (2025). *Climate risk index 2025: Who suffers most from extreme weather events?* Germanwatch e.V.
- Belayneh, M., Loha, E., Lindtjörn, B. (2021). Seasonal Variation of Household Food Insecurity and Household Dietary Diversity on Wasting and Stunting among Young Children in a Drought Prone Area in South Ethiopia: A Cohort Study. *Ecology of Food and Nutrition* 60, 44–69. <https://doi.org/10.1080/03670244.2020.1789865>
- Bezner Kerr, R., Hasegawa, T., Lasco, R., Bhatt, I., Deryng, D., Farrell, A., Gurney-Smith, H., Ju, H., Lluch-Cota, S., Meza, F., Nelson, G., Neufeldt, H., & Thornton, P. (2022). Food, fibre, and other ecosystem products. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 713–906). Cambridge University Press. <https://doi.org/10.1017/9781009325844.007>
- Bryan, E., Alvi, M., Huyer, S., & Ringler, C. (2023). Addressing gender inequalities and strengthening women's agency to create more climate-resilient and sustainable food systems. *Global Food Security*, 40, 100731. <https://doi.org/10.1016/j.gfs.2023.100731>
- Carducci, B., Conti, C., Hu, Y. C. N., & Moore, M. (2025). What is the nature of the evidence base on 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 low- and middle-income countries? A protocol for systematic evidence and gap map. CGIAR.
- Duchenne-Moutien, R.A., Neetoo, H. (2021). Climate Change and Emerging Food Safety Issues: A Review. *Journal of Food Protection* 84, 1884–1897. <https://doi.org/10.4315/JFP-21-141>
- FAO (2007). *Climate Variability and Change: Adaptation to Drought in Bangladesh: A Resource Book and Training Guide*. Institutions for Rural Development 9. Asian Disaster Preparedness Center, F Food and Agriculture Organization of the United Nations, Rome.
- FAO (2017). *Water for Sustainable Food and Agriculture*. Food and Agriculture Organization of the United Nations, Rome.
- Harvey, C. A., Saborio-Rodríguez, M., Martínez-Rodríguez, M. R., Viguera, B., Chain-Guadarrama, A., Vignola, R., & Alpizar, F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. *Agriculture & Food Security*, 7, 57. <https://doi.org/10.1186/s40066-018-0209-x>
- Intergovernmental Panel on Climate Change. (2022). Health, wellbeing and the changing structure of communities. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1041–1170). Cambridge University Press. <https://doi.org/10.1017/9781009325844.009>
- Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama, Eds.). Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Khatri, P., Kumar, P., Shakya, K.S., Kirlas, M.C., Tiwari, K.K. (2024). Understanding the intertwined nature of rising multiple risks in modern agriculture and food system. *Environ. Dev. Sustain.* 26, 24107–24150. <https://doi.org/10.1007/s10668-023-03638-7>
- Mbow, C., C. Rosenzweig, L.G. Barioni, T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu. (2019): Food Security. In: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. <https://doi.org/10.1017/9781009157988.007>
- Meenakshi, J.V., Quisumbing, A., 2025. Diet quality and micronutrient intakes in nutritional value chains: A synthesis and suggestions for further research. *Food Policy* 130, 102789. <https://doi.org/10.1016/j.foodpol.2024.102789>
- Mufungizi, A. A., Musakwa, W., & Chanza, N. (2023). Shifting ecosystems, past, current, and emerging trends: A bibliometric analysis and systematic review of literature. *Ecological Indicators*, 156, 111175. <https://doi.org/10.1016/j.ecolind.2023.111175>

- Owino, V., Kumwenda, C., Ekesa, B., Parker, M.E., Ewoldt, L., Roos, N., Lee, W.T., Tome, D. (2022). The impact of climate change on food systems, diet quality, nutrition, and health outcomes: A narrative review. *Front. Clim.* 4. <https://doi.org/10.3389/fclim.2022.941842>
- Ranasinghe, R., Ruane, A. C., Vautard, R., Arnell, N., Coppola, E., Cruz, F. A., et al. (2021). Climate change information for regional impact and for risk assessment. In V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, et al. (Eds.), *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1767–1926). Cambridge University Press. <https://doi.org/10.1017/9781009157896.014>
- Reardon, T. (2015). The hidden middle: the quiet revolution in the midstream of agrifood value chains in developing countries. *Oxford Review of Economic Policy*, 31(1), 45–63. <http://www.jstor.org/stable/43664670>
- Reardon, T., Liverpool-Tasie, L. S. O., & Minten, B. (2021). Quiet revolution by SMEs in the midstream of value chains in developing regions: Wholesale markets, wholesalers, logistics and processing. *Food Security*, 13(6), 1577–1594. <https://doi.org/10.1007/s12571-021-01224-1>
- Rockström, J., et al. (2025). The EAT-Lancet Commission on healthy, sustainable, and just food systems. *The Lancet*, 406, 1625–1700. [https://doi.org/10.1016/S0140-6736\(25\)01201-2](https://doi.org/10.1016/S0140-6736(25)01201-2)
- Ruane, A. C., Vautard, R., Ranasinghe, R., Sillmann, J., Coppola, E., Arnell, N., et al. (2022). The Climatic Impact-Driver Framework for assessment of risk-relevant climate information. *Earth's Future*, 10, e2022EF002803. <https://doi.org/10.1029/2022EF002803>
- Sibhatu, K.T., Qaim, M. (2018). Review: Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. *Food Policy* 77, 1–18. <https://doi.org/10.1016/j.foodpol.2018.04.013>
- Sparling, T.M., Offner, C., Deeney, M., Denton, P., Bash, K., Juel, R., Moore, S., & Kadiyala, S. (2024). Intersections of climate change with food systems, nutrition, and health: An overview and evidence map. *Advances in Nutrition*, 15, Article 100274. <https://doi.org/10.1016/j.advnut.2024.100274>
- United Nations Children's Fund (UNICEF), United States Agency for International Development (USAID), World Health Organization (WHO), United States Agency for International Development Advancing Nutrition (USAID Advancing Nutrition). Multi-sectoral Impacts of the COVID-19 Pandemic on Nutrition Outcomes: An Analytical Framework. New York: United Nations Children's Fund; 2022. Available from: <https://iris.who.int/bitstream/handle/10665/357869/9789240041424-eng.pdf?sequence=1>
- UNDP Innovative Finance for the Private Sector (IRFF). (2024). *The climate finance gap for small-scale agrifood systems*. United Nations Development Programme. <https://irff.undp.org/publications/climate-finance-gap-small-scale-agrifood-systems>



Supplementary files

1. Additional file 1. ROSES checklist
2. Additional file 2. Systematic map excel file
3. Additional file 3. Grey literature search
4. Additional file 4. Database search strategies



CGIAR Climate Action drives the transition to low-emission, climate-resilient, and equitable food, land, and water systems in Africa, Asia, and Latin America. It advances science-driven investments, policies, and tools across five Areas of Work, consolidating CGIAR's climate offer with harmonized data and Portfolio-wide impact.

This work was jointly supported by CGIAR Climate Action and ILRI.

We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund (<https://www.cgiar.org/funders/>).