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The U.S. Government's Global Hunger & Food Security Initiative

Review of Evidence of Interventions to Improve Nutrition Outcomes During Climate Shocks and Stressors

Evidence Review Report

USAID
FROM THE AMERICAN PEOPLE

DECEMBER 2023

About USAID Advancing Nutrition

USAID Advancing Nutrition is the Agency's flagship multi-sectoral nutrition project, led by JSI Research & Training Institute, Inc. (JSI), and a diverse group of experienced partners. Launched in September 2018, USAID Advancing Nutrition implements nutrition interventions across sectors and disciplines for USAID and its partners. The project's multi-sectoral approach draws together global nutrition experience to design, implement, and evaluate programs that address the root causes of malnutrition. Committed to using a systems approach, USAID Advancing Nutrition strives to sustain positive outcomes by building local capacity, supporting behavior change, and strengthening the enabling environment to save lives, improve health, build resilience, increase economic productivity, and advance development.

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Acronyms

CCAFS	Climate Change, Agriculture, and Food Security
CGIAR	Consultative Group on International Agricultural Research
DHS	Demographic and Health Surveys
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gas
IFAD	International Fund for Agricultural Development
KII	key informant interview
LMIC	low- and middle-income country
OFSP	orange-fleshed sweet potato
RCT	randomized control trial
SSA	sub-Saharan Africa
USAID	United States Agency for International Development

Foreword

In April 2022, USAID published its *Climate Strategy 2022–2030*, The strategy commits USAID to supporting actions across sectors to reduce greenhouse gas emissions and help partner countries adapt to climate impacts and build resilience to climate change. In support of USAID's efforts to integrate climate considerations across its program portfolios, USAID Advancing Nutrition, USAID's global flagship nutrition project, reviewed the strategy and proposed that we assist our colleagues in the Bureau for Resilience and Food Security, Bureau for Global Health, and Bureau for Humanitarian Assistance to better understand the linkages between climate change, nutrition, and resilience.

Nutrition is not featured as a priority topic in USAID's climate strategy. However, existing frameworks and reports suggest that climate change and climate variability have major impacts on food, care, and health systems via various pathways at different levels, and affect the resilience of the populations these systems serve (e.g., Haddad et al. 2015; Salm et al. 2020). Knowing that climate change directly and indirectly influences households' ability to achieve nutrition and food security, particularly those households most vulnerable to natural hazards and malnutrition, the USAID Advancing Nutrition team set out to conduct a review to deepen our understanding of how climate change impacts nutrition outcomes through each of the three systems as well as through the interplay between them. Our plan for building this understanding consisted of activities carried out in three phases: (1) a review of evidence; (2) a rapid pulse check with USAID Missions and implementing partners; and (3) a consultation with USAID staff from the three operating units. Four overarching questions were formulated to guide the activity (box 1).

The four questions that guided this evidence review and the KIIs were developed in collaboration with our colleagues in the three Bureaus and are broad, by design:

1. How is climate change affecting the resilience of the populations served, and can that be observed through specific nutrition anthropometric or dietary outcomes (e.g., wasting)?

2. How does climate change impact food, care and health systems, and nutrition outcomes, including micronutrient deficiency, diet diversity, and undernutrition?

    a. What is the evidence that climate change is impacting nutrition-sensitive and specific programming in food, care, and health systems?

    b. What is the magnitude of climate change impact on nutrition outcomes? (i.e., are some outcomes affected more than others by climate change)?

    c. How do impacts vary across local and regional contexts?

3. What types of climate adaptation/mitigation approaches and interventions are influencing nutrition outcomes (e.g., micronutrient deficiency, diet diversity, and undernutrition)?

    a. Are there adjustments that can be made to nutrition programming to address the challenges presented by climate change?

    b. What is the magnitude of impact of certain approaches and interventions? Are some more effective to achieve nutrition outcomes than others?

4. What aspects of program design and implementation are needed to strengthen climate adaptation and mitigation approaches and interventions to improve nutrition outcomes?

The report that follows highlights our methods and findings from the evidence review which included four nutrition outcomes: micronutrient deficiency, diet diversity, and undernutrition. The findings from this evidence review (Phase 1) were originally intended to help inform the development of questions to be used during key informant interviews (KIIs) with USAID Mission staff and implementing partners (Phase 2) across four countries: Bangladesh, Kenya, Madagascar, and Niger. However, to accommodate time constraints, Phase 1 and Phase 2 were conducted simultaneously rather than sequentially. Therefore, it was not possible for Phase 1 findings to directly inform Phase 2.

This review found a lack of high-quality evidence for nutrition interventions implemented in low- and middle-income countries (LMICs) specifically in response to climate change. This is especially true for interventions within the health and care systems. Not only is information on implemented interventions lacking; implemented interventions that *are* reported in the literature lack a specificity in their design and in the targeting of resources to improve, maintain, or protect nutrition from climate change effects.

Finally, this evidence review points strongly to the need to—

- continue to explore the current thinking and practices used by (USAID-supported) development and humanitarian actors in adapting to or mitigating the effects of climate change on nutrition outcomes within activities across food and health systems
- develop a rigorous research agenda that fills the gaps in evidence and contributes to USAID's ability to effectively promote resilience and maintain and improve nutrition even as our climate continues to change
- ensure intervention designs to protect nutrition in the context of climate change consider equity, justice, and inclusion dimensions
- greatly enhance communication among multi-sectoral nutrition stakeholders working in both development and fragile contexts to share—in real time—what works to protect nutrition in a quickly changing climate, noting that underlying contributors to resilience, such as access to social protection, improved physical infrastructure (roads, electricity, and water systems), and strengthened social capital, may emerge as being even more critical to nutrition than ever

Executive Summary

Climate change can influence nutrition outcomes through many pathways and mechanisms in the food, care, and health systems (Bush et al. 2022, Met Office and WFP 2012, Myers et al. 2017, Salm et al. 2021, Tirado et al. 2013). Despite a large body of literature mapping the potential pathways of climate change impacts across those systems (e.g., Myers et al. 2017, Farooq et al. 2022, Tirado et al. 2013), gaps remain in specific evidence of how much climate change affects nutrition outcomes (Phalkey et al. 2015, Bush et al. 2022) and in quantifying by how much current strategies and interventions can offset that impact (Berrang-Ford et al. 2021, Bush et al. 2022, Levy et al. 2016). These gaps in evidence are due to both the long and complex pathways in which climate effects directly and indirectly influence nutritional status, as well as the lack of interventions and evaluations implemented to specifically reduce the negative consequences of climate change on defined nutritional indicators.

This report summarizes the available evidence of how implemented interventions (and, to a lesser extent, modeling approaches) aimed at enabling affected communities to mitigate or adapt to climate change also improve or maintain nutrition outcomes (i.e., food security, undernutrition, micronutrient deficiency, and dietary diversity). Climate adaptation is understood as "the process of adjusting to the actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" while climate mitigation is understood as activities or processes that contribute to reducing greenhouse gas emissions (USAID 2022).

The findings from this evidence review (Phase 1) were originally intended to help inform the development of questions to be used during key informant interviews (KIIs) with USAID Mission staff and implementing partners (Phase 2) across four countries: Bangladesh, Kenya, Madagascar, and Niger. However, to accommodate time constraints, Phase 1 and Phase 2 were conducted simultaneously rather than sequentially. Therefore, it was not possible for Phase 1 findings to directly inform Phase 2. Ultimately, findings from this review and the KIIs will be presented to USAID in a consolidated final report.

This activity was guided by four questions:

1. How is climate change affecting the resilience of the populations served, and can that be observed through specific nutritional, anthropometric, or dietary outcomes (e.g., wasting)?
2. How does climate change impact food, care, and health systems and nutrition outcomes, including micronutrient deficiency, diet diversity, and undernutrition?
    a. What is the evidence that climate change is impacting nutrition-sensitive and specific programming in food, care, and health systems?
    b. What is the magnitude of climate change impact on nutrition outcomes (i.e., are some outcomes affected more than others by climate change)?
    c. How do impacts vary across local and regional contexts?
3. What types of climate adaptation/mitigation approaches and interventions are influencing nutrition outcomes (e.g., micronutrient deficiency, diet diversity, and undernutrition)?
    a. Are there adjustments that can be made to nutrition programming to address the challenges presented by climate change?
    b. What is the magnitude of impact of certain approaches and interventions (i.e. Are some approaches more effective to achieve positive nutrition outcomes than others?
4. What aspects of program design and implementation are needed to strengthen climate adaptation and mitigation approaches and interventions to improve nutrition outcomes?

This evidence report focuses primarily on guiding questions three and four related to interventions and program design, given the large body of literature on how climate change will impact nutrition outcomes (e.g., Bush et al. 2022, Met Office and WFP 2012, Mock and Jennings 2022, Myers et al. 2017, Salm et al. 2021, Tirado et al. 2013). The introduction section provides a brief summary of existing literature and additional context related to questions one and two, including how the effects of climate change have influenced nutrition and resilience of vulnerable populations (annex 4). Section 3 describes how varying interventions influenced nutrition outcomes.

The evidence was obtained through a systematic literature search of scientific articles, complemented by a gray literature search of targeted websites from governmental and nongovernmental organizations. The evidence review specifically focused on implemented and modeled interventions in low- and middle-income countries (LMIC). The review screened 6,122 abstracts and identified 49 peer-reviewed articles and 2,998 documents from the gray literature. Thirty-eight of these are summarized in the report. Most evidence covers geographical regions in sub-Saharan Africa (SSA). Experiences in Asia, Latin and South America, and island states and territories were less documented in the literature.

The results include five key findings:

1. High-quality, robust, and specific evidence is lacking for implemented nutrition interventions in LMICs specifically in response to climate change. This is especially true for interventions within the health and care systems, as well as for mitigation (vs. adaptation) interventions.
2. Implemented interventions most frequently focus on drought and rainfall-related climate changes. In many cases, the literature does not identify the specific climate-related targets or impact an intervention may have been designed to address.
3. Implemented interventions most frequently focus on food security (defined in variable ways) and undernutrition, while diet diversity, micronutrient deficiency, and obesity are understudied.
4. The existing evidence base of implemented interventions suggests those that provide financial support, build infrastructure, or use multi-sectoral designs targeting food, health, and care systems are promising. Other interventions may have been implemented but not currently captured. Additional information from KIIs will help provide USAID additional context.
5. Climate change co-benefits (i.e., strategies that can both mitigate and adapt to climate change) are largely untested in implemented interventions captured in the literature, but present an important opportunity for future climate responses and their evaluations. For example, interventions for adaptation frequently overlook mitigation potential (e.g., agroforestry's sequestration potential, or aquaculture's potential for shifting diets away from red meat).

Based on existing evidence and the authors' perspective, the following is a set of guiding principles for programs that intend to incorporate climate-related interventions **and** improve nutrition outcomes:

- **Be specific in targeting climate shocks and map (multiple) pathways across time horizons.** Design interventions that target specific extreme weather events and climate change scenarios in a region. Identify the multiple pathways of impact these extreme events and more long-term changes in climate are expected to have on specific nutritional outcome indicators to inform appropriate interventions. Develop or modify programs that correspond to urgent, short-term, or long-term time horizons.

- **Use robust evaluation designs.** Most existing evidence is based on a small number of interventions, research designs that lack rigor, and inconsistent measurements of nutritional impacts. When not ethical or feasible to conduct randomized control trials (RCTs) to evaluate interventions, mixed methods approaches could be employed to assess the effectiveness of these interventions in program contexts.

- **Measure, report, and revisit.** Build stronger monitoring and evaluation approaches over the lifetime of a project to track the variation of climate change effects and the impact of interventions on nutrition outcomes. Use either established tools or develop custom indicators to inform design and facilitate course correction during implementation, as needed.
- **Design to achieve co-benefits.** Many interventions have both adaptation and mitigation potential, which are often not recognized. Identifying the co-benefits in a package of interventions can contribute to more integrated, holistic, and cost-effective climate change responses for improved nutrition outcomes.
- **Incorporate equity and justice.** Apply a guiding framework (e.g., Salm et al. 2021) that ensures intervention designs to protect nutrition in the context of climate change consider equity, justice, and inclusion dimensions. This is crucial for designing interventions that reach those with greatest need and reduce disparities.
- **Generate evidence across multiple geographies, as appropriate.** Most evidence documented here came from single-country studies. Implementing the same interventions across multiple sites and locations, if appropriate, and with consideration of local context, can enable a better understanding of approaches that might work across diverse geographies and contexts.
- **Incorporate social and cultural factors.** Much of the existing literature has focused on "hard" adaptation measures, such as infrastructure, but "soft" measures, including community engagement, social capital, and indigenous knowledge and practices, are also important factors for consideration in the design and implementation of program changes.

1. Introduction

It is both recognized and increasingly evident that the climate is deeply influencing and being influenced by (i.e., through greenhouse gas [GHG] emissions) how our food, health, and care systems function globally. While climate and weather have always affected outcomes in these three systems, the changing climate presents new and unprecedented challenges that populations must adapt to for continued resilience, especially in low- and middle-income countries (LMICs) (Myers et al. 2017). The climate change-related effects come amid other shocks and stressors, including violent conflict, poverty, disease, global demographic changes, and shifting consumer food preferences. These also influence nutrition outcomes, particularly among the most vulnerable: young children, women of reproductive age, and marginalized population subgroups (WFP, WHO, UNICEF 2022).

Nutrition programming is therefore increasingly considering both the ways that programs need to change to **adapt to** climate change and how such programs and interventions may **mitigate** climate change. Climate adaptation is understood as "the process of adjusting to the actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities," while climate mitigation is understood as activities or processes that reduce GHG emissions (USAID 2022).

Despite a large body of literature mapping the potential pathways of climate change impacts across the food, health, and care systems (e.g., Myers et al. 2017, Farooq et al. 2022, Tirado et al. 2013), gaps remain in understanding how much changes in nutrition outcomes can be attributed to climate change (Phalkey et al. 2015, Bush et al. 2022) and the responses, solutions, and interventions that actually work to address these challenges (Berrang-Ford et al. 2021, Bush et al. 2022, Levy et al. 2016). Climate change can impact nutrition outcomes via many pathways and mechanisms in the food, care, and health systems (Bush et al. 2022, Met Office and WFP 2012, Mock and Jennings 2022, Myers et al. 2017, Salm et al. 2021, Tirado et al. 2013). These mechanisms include slower and longer-term changes (e.g., temperature and rainfall changes, physiological changes of plants under higher CO_2 concentrations) as well as increased frequency and intensity of extreme events (e.g., cyclones, floods, droughts) (Erickson et al. 2019, Asmall et al. 2021), which have already affected and will continue to affect nutrition outcomes over different time horizons (Levy et al. 2016; Lieber et al. 2021). However, the current gaps in evidence both about the causal pathways between climate change and nutrition outcomes and the effectiveness of responses and interventions hinder the ability of governments, nonprofits, and business sectors to plan for and respond appropriately. In short, **while wide recognition exists of both current and future nutrition impacts through climate change, evidence-based strategies that can be employed with confidence are lacking** (Berrang-Ford et al. 2021, Bush et al. 2022).

This report includes findings from a review of peer-reviewed publications and gray literature from relevant development and implementing organizations. It summarizes the evidence of existing implemented interventions (and, to a lesser extent, modeling approaches in annex 4) that seek to improve nutrition outcomes while adapting to—or mitigating—the effects of climate change. This report is **not** intended to be a review of how climate change impacts food, care, and health systems and in turn nutrition outcomes (see e.g., Bush et al. 2022, Forster et al. 2021, Myers et al. 2017, and Salm et al. 2021 for extensive existing reviews). The findings from this evidence review (Phase 1) were originally intended to help inform the development of questions to be used during key informant interviews (KIIs) with USAID Mission staff and implementing partners (Phase 2) across four countries: Bangladesh, Kenya, Madagascar, and Niger. However, to accommodate time constraints, Phase 1 and Phase 2 were conducted simultaneously rather than sequentially. Therefore, it was not possible for Phase 1 findings to directly inform Phase 2. Ultimately, findings from both this review and the KIIs will be consolidated into one final report.

This evidence review comprises the first phase of an activity informed by four guiding questions:

1. How is climate change affecting the resilience of the populations served, and can that be observed through specific nutritional, anthropometric, or dietary outcomes (e.g., wasting)?
2. How does climate change impact food, care, and health systems and nutrition outcomes, including micronutrient deficiency, diet diversity, and undernutrition?
    a. What is the evidence that climate change is impacting nutrition-sensitive and specific programming in food, care, and health systems?
    b. What is the magnitude of climate change impact on nutrition outcomes (i.e., are some outcomes affected more than others by climate change)?
    c. How do impacts vary across local and regional contexts?
3. What types of climate adaptation/mitigation approaches and interventions are influencing nutrition outcomes (e.g., micronutrient deficiency, diet diversity, and undernutrition)?
    a. Are there adjustments that can be made to nutrition programming to address the challenges presented by climate change?
    b. What is the magnitude of impact of certain approaches and interventions (i.e. Are some approaches more effective to achieve positive nutrition outcomes than others?
4. What aspects of program design and implementation are needed to strengthen climate adaptation and mitigation approaches and interventions to improve nutrition outcomes?

The report first introduces the methods for the evidence review, then describes interventions implemented in response to climate change and their influence (including, where possible, magnitude of impact) on nutrition outcomes. Then, the report discusses potential nutrition programming, program design, and implementation changes, and gaps in the evidence for how to improve nutrition outcomes in a changing climate. A set of annexes includes additional details about the search strategy and evidence surrounding modeling and proposed interventions identified in the literature, including how climate change will affect vulnerable populations and resilience.

2. Methods

2.1 Framework and Approach

We were informed by existing resilience frameworks (e.g., Bush et al. 2022, Mock and Jennings 2022, Myers et al. 2017, Salm et al. 2021) considering food, care, and health systems as the context in which nutrition outcomes are affected by climate change.

Resilience is understood as the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses that enable reduced chronic vulnerability and inclusive growth (Adger 2006; USAID 2022; IPCC 2022).

It is composed of different capacities that can reflect individual and structural components, such as vulnerability, social disparities, and geographical contexts; absorptive capacity, which refers to minimizing exposure to shocks and the capacity to persist and continue; and adaptive capacity, which refers to the ability to access resources to implement strategies to adapt and respond to shocks.

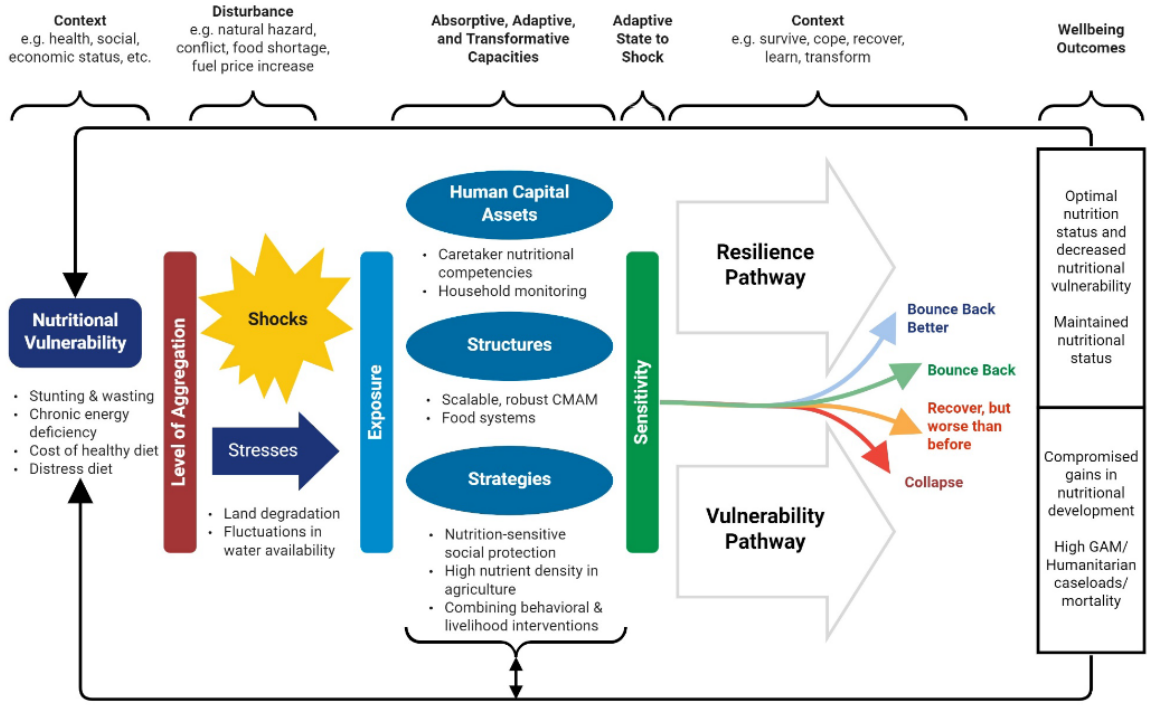
The resilience framework of Mock and Jennings (figure 1) posits that feedback loops exist between the effects of climate change and resilience, whereby communities with adequate resources to build

absorptive, adaptive, and transformative capacity can reduce the negative impacts of climate shocks and stresses on nutrition, whereas those without these resilience capacities suffer decline or even collapse. This review also draws on the conceptual framework on maternal and child nutrition (UNICEF 1990 updated 2023) of the immediate, underlying, and enabling determinants of nutrition, recognizing the role of both food and health systems.

Our search strategy used five categories of terms similar to those used in the framework (climate change; climate change shocks and stressors; interventions related to assets, structures, and strategies; resilience; and nutrition/well-being outcomes) and a combination of terms within each of the five categories to conduct the comprehensive review. The search terms, across the five categories reflective of the framework, were developed with input from USAID Advancing Nutrition (annex 1). **The three primary nutrition outcomes of interest identified for this search were micronutrient deficiency, undernutrition, and diet diversity.** However, multiple papers also included "food security" or "nutrition security" as outcomes and therefore these are included as additional outcomes of focus. As USAID does not officially consider or define food or nutrition security as a nutrition outcome, we explicitly reference the measurement/definition used by the publication's authors for "food/nutrition security" for clarity.

For the peer-reviewed literature, our review employed criteria from the PRISMA checklist[1] (an international standard for systematic literature reviews) for a comprehensive search strategy and process. The search was conducted in January 2023 using Web of Science, the most comprehensive and interdisciplinary search database available that has a clear ability to provide filters and limits.

Figure 1. Framework Guiding Evidence Review



Source: Mock and Jennings 2022

[1] https://www.prisma-statement.org/

2.2 Peer-Reviewed Evidence

A total of 6,129 articles were imported into Covidence, a software program to facilitate systematic evidence reviews. Seven were duplicate articles; 6,122 abstracts were screened by two reviewers independently in the Covidence system. Inclusion for consideration of full review included articles that met all of the following conditions: (1) peer-reviewed article, excluding commentaries and review articles; (2) inclusion of an implemented, modeled, or proposed intervention in response to climate change; (3) a focus on nutrition outcomes, explicitly food security, malnutrition, diet diversity, and/or micronutrient deficiency; (4) implementation in LMICs (using the World Bank list); (5) published within the last 10 years (2012–2023). In the case that reviewers disagreed about whether an article should be included for full review, all abstracts were discussed jointly and consensus reached for inclusion or exclusion in the full-article review.

A total of 83 full-text studies were included for full review, which was conducted by one reviewer. Full-text review, employing the same inclusion criteria, yielded 49 studies for inclusion overall. Figure 1 in annex 1 details the entire search process. Annex 2 provides a full list of all peer-reviewed articles considered. Each of the 49 studies included for review was read and analyzed for components including citation information, country and region of focus, methodology, target population and size, climate change impact addressed, nutrition outcome, intervention type and description, results, scalability/transferability, and resilience implications. This information was compiled in a separate evidence spreadsheet.

2.3 Grey Literature Evidence

A review of gray literature was carried out to complement the systematic review of peer-reviewed literature (Mahood et al. 2014; Munn et al. 2018). Gray literature, from governmental and nongovernmental organizations, was searched to assess nutrition-sensitive and specific interventions related to climate change adaptation and mitigation. Documents reviewed included technical reports, case studies, governmental and nongovernmental white papers, fact sheets, and research reports.

Seventeen targeted websites (governmental and nongovernmental) and two referenced materials (i.e., reports) were decided upon in consultation with USAID Advancing Nutrition (annex 3). Searching and screening of documents was carried out between February 21, 2023, and March 30, 2023. Each site was searched according to the established search terms. However, the search term combinations used were modified to fit the limited and diverse search engines of the targeted websites. Several searches were conducted on each website, though four websites could not be assessed (see the "Limitations" section). Annex 3 includes the search protocols for each, informed by the PRISMA approach, as well as the number of documents screened and approved for inclusion (Mahood et al. 2014; Page et al. 2021). Figure 2 in annex 3 summarizes the gray literature review that accompanied the systematic literature review of the peer-reviewed evidence. The combinations used allowed assessment of relevant documents regarding the research questions, as well as the evidence spreadsheet categories. Each document's descriptions, which in some cases were only abstracts, were screened according to the inclusion criteria. A total of 2,998 documents were screened; of these, 297 full texts were reviewed. Thirty-eight documents met the inclusion criteria. Each of the 38 documents was read and analyzed for components including citation information, type of source (e.g. report, case study), country and region of focus, methodology, target population and size, climate change impact addressed, nutrition outcome, intervention type and description, results, scalability/transferability, and resilience implications. This information was compiled in a separate evidence spreadsheet

3. Findings

Key Findings

High-quality, robust evidence is currently lacking for implemented nutrition interventions in LMICs specifically responding to climate change, especially in the health and care sectors and for mitigation.

Implemented interventions most frequently focus on drought and rainfall-related climate changes, and in some cases identify no specific climate related impact.

Implemented interventions most frequently focus on food/nutrition security (defined in variable ways), and undernutrition, while micronutrient deficiency and obesity are especially understudied.

The existing evidence base of implemented interventions points towards financial, infrastructure, and comprehensive multi-sectoral food, care, and health system interventions as promising strategies.

Climate change co-benefits are not fully recognized in implemented interventions, an important opportunity for integrated climate response.

3.1 Summary of Results

High-quality, robust evidence is lacking for implemented nutrition interventions in LMICs specifically responding to climate change, leaving few proven effective interventions to be recommended across USAID nutrition programs. The existing evidence in LMICs is largely from single countries, predominantly in the sub-Saharan Africa (SSA) region and Asia, and rarely comparative across different geographies. Similar to other systematic reviews (e.g., Salm et al. 2021), undernutrition and food/nutrition security[2] are the most common nutrition outcomes studied, with little focus on micronutrient deficiency and diet diversity.

Drought and rainfall-related climate change impacts are the most frequently explored, while temperature, storms, and variability are less examined. This may reflect the geographical areas of focus in the literature. In some cases, especially in the peer-reviewed literature, intervention responses are vaguely framed as about climate change but lack the specificity of exact effects of climate change in a place or context, which influences the pathways to nutrition outcomes. Failure to develop interventions for specific climate impacts may lead to ineffective responses. For example, a drought impacts nutrition pathways via reduced food availability, while a flood impacts nutrition pathways via reduced food availability and increase in waterborne disease exposure.

The available evidence suggests that many existing development approaches (e.g., water, sanitation, and hygiene interventions, cash transfers) targeting the most vulnerable populations (e.g., poor households, women, and girls) will help respond to the effects of climate change and can impact nutrition outcomes. However, this is not always a safe assumption and needs to be assessed per intervention and context. For example, use of flush toilets compared with pit latrines in a dry area or during an extended drought are associated with worse nutrition outcomes in a modeling study (Drysdale et al. 2021). In male-headed households, young boys have worse nutrition outcomes under different climate change impacts, including lower diet diversity, stunting, and wasting in some modeling studies (Ambikapathi et al. 2021, Dimitrova et al. 2021, Niles et al. 2021). Nutrition programming in response to climate change should therefore consider specific changes in climate and extreme weather events in a region and assess the mechanisms through which climate shocks and stressors will impact food, care, and health systems and

[2] Food security and nutrition security was defined in many ways. When indicated in the results, we have footnoted the explicit definition or measurement of food security and/or nutrition security to provide greater detail.

nutrition outcomes. Programming should also consider a time horizon for impact, including urgent, short-term, and longer-term needs and proposed changes (Tirado et al. 2022).

In assessing the interventions and nutrition programming changes necessary for improving nutrition outcomes under climate change shocks and stressors, additional attention is needed for health and care sectors, as well as joint mitigation/adaptation strategies (that maximize co-benefits) and "soft adaptation" strategies (i.e., beyond technological, agricultural, or infrastructure development and of organizational and social nature). Based on the existing literature and the authors' integrated perspective, nutrition interventions and programming designers could consider the following:

- **Be specific in targeting climate shocks and map (multiple) pathways across time horizons.** Design interventions that target specific extreme weather events and climate change scenarios in a region. Identify the multiple pathways of impact these extreme events and more long-term changes in climate are expected to have on specific nutritional outcome indicators to inform appropriate interventions. Develop or modify programs that correspond to urgent, short-term, or long-term time horizons.
- **Use robust evaluation designs.** Most existing evidence is based on a small number of interventions, research designs that lack rigor, and inconsistent measurements of nutritional impacts. When not ethical or feasible to conduct randomized control trials (RCTs) to evaluate interventions, mixed methods approaches could be employed in process evaluations and implementation research to assess effectiveness in program contexts.
- **Measure, report, and revisit.** Build stronger monitoring and evaluation approaches over a project's lifetime to track the variation of climate change effects and the impact of interventions on nutrition outcomes. Use either established tools (e.g., Dietary Diversity Score; Household Food Insecurity Access Scale) or develop custom indicators to assess interventions in the food, health, and care systems to inform and facilitate course correction during implementation, as needed.
- **Design to achieve co-benefits.** Many interventions have both adaptation and mitigation potential, which are often not recognized. Identifying the co-benefits in a package of interventions can contribute to more integrated, holistic, and cost-effective climate change responses for improved nutrition outcomes.
- **Incorporate equity and justice.** Apply a guiding framework (e.g., Salm et al. 2021) that ensures intervention designs to protect nutrition in the context of climate change. Consider equity, justice, and inclusion dimensions, including how place of residence, race and ethnicity, gender, occupation, religion, education, socioeconomic status, social capital, age, and other factors may influence how benefits/harms accrue. This is crucial for designing interventions that reach those with greatest need and reduce disparities.
- **Generate evidence across multiple geographies, as appropriate.** Most evidence documented here came from single-country studies. Implementing the same interventions across multiple sites and locations, if appropriate, and with consideration of local context, can enable a better understanding of approaches that might work across diverse geographies and contexts.
- **Incorporate social and cultural factors.** Much of the existing literature has focused on "hard" adaptation measures, such as infrastructure. But "soft" measures, including community engagement, social capital, and indigenous knowledge and practices, are also important factors for consideration.

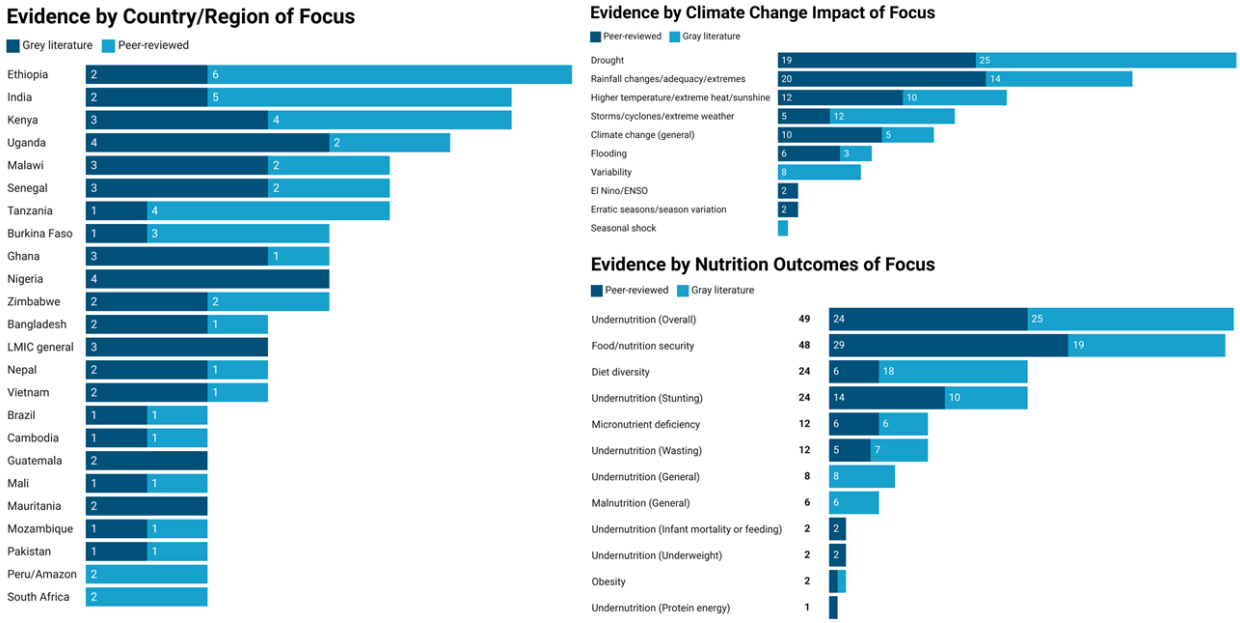
3.2 Overview of the Evidence

Most evidence evaluated covered SSA countries and regions, especially Ethiopia, Kenya, Uganda, Malawi, Senegal, Tanzania, Burkina Faso, Ghana, Nigeria, and Zimbabwe (figure 3), like other recent reviews on climate change and nutrition (Salm et al. 2021). More limited evidence was found for India, Bangladesh, Nepal, and Vietnam. Evidence from Latin and South America was minimal, as was evidence from low- and middle-income island states and territories. Over half (28) of the countries and regions identified in this review had only one article, report, or document.

More reports were found that examined drought and precipitation changes, with fewer examining temperature impacts. Storms and general "climate change" were also common (figure 3). However, specific climate impacts were more common in modeled studies in the peer-reviewed literature using historical climate change-related events for assessing relationships.

The most common nutrition outcomes examined were a broad category of undernutrition (like Salm et al. 2021), and food and nutrition security (figure 3). Diet diversity and micronutrient deficiency were explored less in the literature, and evidence examining obesity was minimal.

Figure 3. Compilation of Evidence Results



3.2.1 Intervention Type

Among all intervention types (implemented, modeled, proposed), implemented interventions were the most common in the gray literature, while modeled interventions were most of the peer-reviewed evidence (Table 1). However, among the 24 implemented interventions identified in the gray literature, the majority (58 percent, n=14) were ongoing and highlighted an intervention that had begun, but often had only incremental or no outcomes to report yet. For the main body of this report, evidence reviewed is for implemented interventions, while annexes 3 and 4 include additional details on modeled and proposed interventions in the literature.

Table 1: Evidence by Intervention Type

Intervention Type	Peer Reviewed	Grey Literature
Implemented	27.5%	63.1%
Modeled	51.0%	7.9%
Proposed	21.5%	21.1%
Proposed and Implemented	0.0%	7.9%

3.3 Climate Adaptation Interventions Influencing Nutrition and Their Magnitude of Impact

This section reviews the evidence of implemented interventions identified in the peer-reviewed and gray literature related to climate change adaptation approaches for four nutrition outcomes (food security, micronutrient deficiency, diet diversity, and undernutrition).

Summary and Overview

The limited availability of implemented interventions to maintain or improve nutrition outcomes in a climate change context, as well as the lack of specificity of those implemented hinders the understanding of interventions and their relative magnitude of impact. Descriptions of interventions are often general and involve multiple strategies and limited quantitative evidence of impact (e.g., "reduced hunger"), leading to vague understanding of the magnitude of impact, and making the mechanism of impact unclear (i.e., multiple interventions were implemented at once).

Much of the evidence base documents proposed strategies or forthcoming/ongoing interventions and programs, suggesting there has been a scaling up of interventions within the last five years, and that evidence will continue to grow as additional interventions are reported.

The existing evidence base of implemented interventions points towards finance, infrastructure, and comprehensive multi-sectoral food, care, and health system interventions as promising strategies. There were no interventions identified that were implemented or modelled focused on food loss and waste and/or food safety in the literature. It should be acknowledged that many other strategies may have been implemented but are not currently captured in the grey or peer-reviewed literature. Additional information from KIIs will help provide USAID additional context.

3.3.1 Food Security and Nutrition

A number of the reviewed interventions focused on improving agriculture or production strategies as the means for improving food security or nutrition outcomes. Many of these agricultural interventions (e.g., climate-resilient agricultural practices, agricultural income improving activities) were noted in the gray literature but with rather imprecise reference to improving food security and nutrition outcomes,

without specifically defined indicators or measured magnitudes of impact (e.g., Chakrabarti 2019). Often, fact sheets or brief reports referred to improved food security through "increased production efficiency" (e.g., in Mozambique, IFAD 2016), though without specific magnitudes of impact, reflecting a prevailing assumption that agricultural yield or other agricultural improvements will result in improved food security or nutrition outcomes.

Notable exceptions of studies and programs that have quantifiable effect on nutrition-related outcomes include the following:

- One intervention identified orange-fleshed sweet potato (OFSP) as a drought-resistant and nutritious crop with promise for protecting household resiliency in the face of climate stress in four East African countries—Tanzania, Kenya, Mozambique, and Ethiopia—and it demonstrated reduced "high" food insecurity[3] (from 34 percent of households at baseline to 16 percent of households at endline in Tanzania) after a three-year implementation focused on OFSP vine cultivation and market expansion (Girard et al. 2021).
- Another program focused on capacity building, extension services, endowments, and technology assets for climate change adaptation among smallholder farmers in West Africa resulted in a reduction in food insecurity for 60 percent of participants (measured via the Household Food Insecurity Access Scale) during the multiyear program (Kizito et al. 2019).
- An agroforestry intervention implemented in Ghana was perceived to have enriched soil nutrients, improved food crop production via new crops (42 percent of farmers), generated additional income through non-timber tree product sales (55 percent of farmers), and improved food security[4] via new food sources (fruit on trees, 58 percent of farmers) (Apuri et al. 2018).

Drought-tolerant or wild foods (often called "hunger crops" or "famine foods") were identified as critical interventions in geographical regions ranging from SSA to Mainland China and Papua New Guinea, though with limited evidence on their potential impact and frequently discussed as coping mechanisms. Cassava (Gwatirisa et al. 2017), sorghum, leafy vegetables (Masao et al. 2023, Ghosh et al. 2021), wild fruits, pearl millet, cowpea (Ghosh et al. 2021), and other wild foods (Gwatirisa et al. 2017, Zhang et al. 2016, Ghosh et al. 2021) are often consumed by households during drought and wet seasons, up to twice a day in the poorest households (Masao et al. 2023), providing important nutrients during the lean season when other foods are less available.

Fishing and aquaculture were also identified in several interventions, though with nuanced and limited evidence demonstrating improved food security. Evidence from Cambodia assessing the potential of small-scale fish aquaculture to help communities adapt to climate change found that although most respondents reported they would continue raising fish after subsidies ended, no significant differences existed in respondents' food security status (defined as "ability to afford to feed my family") between those participating in the program and those not (Richardson et al. 2018). A qualitative study from Nicaragua of the Rama people examined how climate change, especially changes in wind, influenced fisherpeople with different equipment types. Those with motorboats, panta, or gill nets benefited from the increased wind, while those using traditional methods like hand nets or sails with canoes were disadvantaged, revealing that equipment can mediate how climate change affects food security of a given group of people (Papworth et al. 2022).

A few other interventions explored the influence of **social networks** and access to **information** on food security outcomes in the face of climate change effects, though with limited measures of magnitude or evidence of impact. While female empowerment networks and other social networks were identified

[3] Girard et al. do not indicate how food insecurity was measured in this study.
[4] Food insecurity was defined as an "impact of variable local climate," and agroforestry was defined as contributing to reducing food insecurity through food crop production, increased access of income, and source of food for households.

in different studies (e.g., Dey et al. 2018, Gwatirisa et al. 2017) as being important for sharing knowledge and information about food security and wild crops during climate change events, climate information access alone was not associated with improved food security[5] or adoption of climate-smart agriculture practices in Kenya and Senegal (McKune et al. 2018).

Financial assistance, including unconditional cash transfers, as protection against climate change effects was explored in several studies. Cash +, a Food and Agriculture Organization of the United Nations (FAO) intervention that provides unconditional cash transfers, productive inputs or assets including small ruminants, and training and technical extension services following a shock (including climate-induced shocks), was associated in Burkina Faso with an increase in household food security[6] from 35 percent of households before the intervention to 75 percent of households after (FAO 2018). Similar results were observed in Mali (food security improved by 23 percent) and Mauritania (FAO 2018). More rigorous evidence was found in Ethiopia, where households participating in an unconditional subsidy program and disaster preparedness assistance package experienced 50 percent less food insecurity than nonparticipant households (USAID 2022). Food and cash transfers were also part of a suite of interventions implemented in Zimbabwe through a World Vision International project (which included nutrition behavioral change messaging, drought-resistant crops, post-harvest infrastructure, and policy and social safety net programs), which were associated with more than 50 percent reduced odds of going to bed without eating (World Vision 2017).

3.3.2 Micronutrient Deficiency

The most comprehensive peer-reviewed study including micronutrient deficiency as an outcome was the previously mentioned paper examining the impact of different interventions promoting OFSP and nutrition education in four countries in the context of "climate change" generally, not specific stressors or shocks from climate change (Girard et al. 2021). The interventions involved multi-sectoral approaches, including increased distribution of OFSP vines and cultivation, extension services, market support and expansion, and community nutrition education. Several improvements were documented, including significantly improved beta-carotene intake by mothers and children, lowered anemia in pregnant women and reduced maternal wasting in Kenya, and 63 percent higher vitamin A rich food intake by intervention children in Ethiopia. (Girard et al. 2021).

3.3.3 Diet Diversity

The four-country study on OFSP also demonstrated improvements in diet diversity across several locations (Girard et al. 2021). In Tanzania, a 24-hour dietary recall showed an increase in households meeting minimum dietary diversity from 0.4 percent to 46 percent of intervention households, and in Mozambique, children in intervention households had a higher mean dietary diversity score (4.78) compared with nonintervention households (4.19). In Ethiopia, the proportions of both women and children achieving minimum diet diversity were 19 percent higher in intervention households at the endline compared with controls (Girard et al. 2021).

Participants in the Cash + FAO program of unconditional cash transfers in Mali were 70.5 percent more food secure (measured by the Food Insecurity Experience Scale) than control households (Dao 2021). The food and cash transfers included in the previously mentioned suite of interventions implemented in Zimbabwe were associated with a more than doubling of household dietary diversity scores, especially in female-headed households (World Vision 2017).

[5] The indicator for food security was adapted from the Household Food Insecurity Access Scale, using five-question dyads about use of coping mechanisms over the last four weeks. Responses include a yes/no question to start each dyad, then a follow up for yes responses including frequency of use where 1= rarely, 2= sometimes, 3= often). A food security index was created with the sum of responses across each question, ranging from 0 (least food insecure) to 15 (most food insecure).

[6] The document did not include the measurement for "food security."

3.3.4 Undernutrition, Stunting, and Wasting

Breastfeeding as a strategy to combat undernutrition was examined in the context of higher temperatures in Burkina Faso (Part et al. 2022). Overall, time spent on breastfeeding decreased by 2.3 minutes/day and childcare increased by 0.6 minutes/day, per 1 degree Celsius increase in same day mean temperature. The odds of exclusively breastfeeding young infants (0–3 months) decreased as temperature increased. This intervention highlights the complex interplay between temperature, maternal time, childcare, and nutrition outcomes.

Infrastructure investments were the focus of several interventions; however, often these investments were combined with other interventions, making the causality of impact difficult to ascertain. In Gambia, a strategy to reduce climate change impacts on rural communities included water-related infrastructure construction, road improvements to increase agricultural market access, and rehabilitation of 20,000 ha of vulnerable land. An evaluation by the International Fund for Agricultural Development (IFAD) Independent Office of Evaluation found increases in agricultural production, food access, and market development, which, in turn, were associated with a 30 percent reduction in child malnutrition in the target zone (Chakrabarti 2019).

Financial interventions, including the FAO Cash + program, showed demonstrable benefits for acute malnutrition among children aged 6–59 months in Mauritania. Acute malnutrition decreased from 6 percent to 2 percent among participants (FAO 2018).

3.4 Climate Mitigation Interventions Influencing Nutrition and Their Magnitude of Impact

This section reviews the evidence of implemented interventions identified in the peer-reviewed and gray literature related to climate change mitigation approaches for four nutrition outcomes (food security, micronutrient deficiency, diet diversity, and undernutrition).

Summary and Overview

The grey literature reviewed contains more examples of climate mitigation approaches for improving nutrition outcomes, compared with peer-reviewed literature. However, mitigation approaches are still less numerous than adaptation approaches in LMICs. Like the literature on adaptation, examples in health and care sectors were fewers than in the food sector. .

The impact of climate mitigation approaches and interventions is difficult to establish, given that little-to-no-information was provided on indicators representing the expected and measured outcomes (i.e., only a description of intervention). To date, an effort has not been made to evaluate the impact mitigation activities may hav eon undernutrition, nor to design research to identify and assess causal pathways.

Many mitigation approaches focused on mitigating risk from climate-related impacts (e.g., reinforcing infrastructure) rather than decreasing carbon emissions (i.e. reforestation);. However, opportunity exists for climate change co-benefits to be further realized in both implemented mitigation and adaptation practices.

3.4.1 Food Security and Nutrition

Examples of implemented mitigation interventions for food security were often listed as one of many activities in a multiyear intervention and did not necessarily directly link to nutrition outcomes. Some well-known climate mitigation practices (i.e., renewable energy, land conservation, "climate-smart agriculture," and "climate-resilient practices") for reducing GHG emissions appeared, although it was not clear that these activities were included to mitigate climate change effects.

Very few interventions explicitly focused on improving food and/or nutrition security as a climate mitigation effort. Several documents included land rehabilitation and reforestation practices as part of interventions to improve nutrition outcomes; however, the exact impacts on nutrition were rarely discussed (e.g., Chakrabarti 2019). In Chad, Niger, Cabo Verde, and Mauritania, lower food insecurity[7] was found (without data) among participants of projects applying climate-resilient agricultural practices, environmental education, and watershed restoration practices; in Mauritania, improved forage production, soil conservation, and land rehabilitation were also linked to lowering food insecurity (Chakrabarti 2019). These case studies reported that participants had improved food security and diverse diets (Chakrabarti 2019).

Less common approaches included interventions where participants were directly involved in mitigating risk to climate change and mitigating GHG emissions. An intervention in Colombia reported improved household food security, when the program, through an assessment of climate risk areas, determined to adopt climate-smart agricultural practices that enhanced soil health and decreased biodiversity loss and desertification (IFAD 2016).

3.4.2 Micronutrient Deficiency

Mitigation approaches were rarely linked to interventions addressing micronutrient deficiency in the gray literature, and such references were usually indirect. In Chad, an intervention that included land rehabilitation activities and improved access to agroclimatic information also focused on improving knowledge in good child feeding practices and micronutrient deficiency (Chakrabarti 2019). An intervention promoting the production of OFSP reduced use of chemical inputs (and thus GHG emissions) while improving participants' knowledge of the importance of vitamins A, B, and C (Abidin et al. 2013).

3.4.3 Diet Diversity

Most references to climate mitigation interventions used the term to mean mitigating risk rather than reducing carbon emissions. One example, in Mauritania, found participants had more diversified diets after an intervention that included forage production and sustainable land management practices, with potential mitigation benefits (Chakrabarti 2019).

3.4.4 Undernutrition, Stunting, and Wasting

In Bolivia, climate change mitigation-related activities, such as carbon sequestration through rehabilitated forest areas, sustainable management of ecosystems through competitive funding, and inclusion of traditional ecological knowledge, were associated with 30 percent reduction of undernutrition (i.e., stunting and wasting) (Chakrabarti 2019). An intervention program focused on reducing undernutrition in Djibouti included 100 square km of mangrove restoration. Activities also included actions for natural resources management and protection of marine ecosystems to enhance fish stocks (Chakrabarti 2017).

3.5 Adjusting Nutrition Programming to Address Climate Change Challenges

The evidence presented in this report was sometimes accompanied by reflections about how findings can inform adjustments of nutrition programming to address climate change challenges. Such reflections were more common in the peer-reviewed literature, which usually includes extensive discussion sections, but less common in brief gray literature evidence. Here the authors also provide their perspectives, in combination with the documented evidence, about potential strategies for adjusting nutrition programming to respond to climate change.

[7] The document did not include the measurement for "food security."

Nutrition programming in response to climate change must be specific to a potential climate change impact. While there appears to be an increasing number of implemented interventions to address climate change, they are still rare, and often vague. Effective nutrition programming in response to climate change could employ the following strategies, based on the evidence reviewed and the integrated perspective of the authors:

- **Be Specific.** Identify specific climate change impacts to be addressed through the program, based on a historical review of climate-related threats and shocks, and the specific nutrition outcomes of interest to (measurably) protect or improve. Moreover, consider the geographic and biophysical context, which will influence the degree of exposure and sensitivity to different shocks and stressors, as well as the current capacities of the community and vulnerable groups.

- **Map the Pathways of Impact.** Use existing conceptual frameworks (e.g., Bush et al. 2022, Myers et al. 2017, Salm et al. 2021) to map the potential climate impact onto the mechanisms that will influence the nutrition outcomes of focus, which was shown to be effective in OFSP interventions in SSA (Girard et al. 2021). Understanding the pathways of impact, which could be facilitated through modeling, will support more specific programmatic planning, design, and responses. Explicitly consider the care and health services sector pathways, which are understudied (Salm et al. 2021).

- **Consider Multiple Pathways.** While a diversity of interventions have been identified, many focus on the food system pathway of influence, while other pathways may be less evident and require different interventions. This finding is consistent with Salm et al. (2021), who identified in their equity analysis that the primary pathway of impact typically identified is from direct effects on agriculture to food insecurity to reduced dietary intake and undernutrition. However, other pathways are also critical. For example, Xu et al. (2019) identifies that heat increases will not only influence food security via reduced food availability, but also impair digestion and absorption functions in people, affecting fluid and electrolyte disturbances. Nutrition programming to respond to food availability versus human physiological impacts from climate change require different interventions.

- **Identify the Time Horizon.** Tirado et al. (2022) highlight the need to identify programs as urgent, short-term, or long-term in their approach to appropriately allocate funding and set expectations. However, the authors also suggest using these time horizons to assess the potential negative or unforeseen impact of programmatic changes on other food, care, and health areas. For example, food aid packages in Vanuatu following cyclones included mainly highly processed foods (e.g., white rice, biscuits, sugar, flour, noodles), which influenced the long-term dietary patterns of residents, including, in some cases, abandoning the cultivation of certain crops (yams) and tending to vegetable gardens (Savage et al. 2021).

- **Recognize Co-Benefits.** These findings identify more existing evidence for adaptation (vs. mitigation) interventions to maintain or improve nutrition outcomes in the face of climate change. Furthermore, many "mitigation" strategies implemented described mitigating risk, rather than reducing or sequestering GHG emissions. However, in many cases, adaptation strategies (e.g.. agroforestry, aquaculture that could promote dietary shifts) may have mitigation potential, but these were not recognized in the literature. Similarly, mitigation strategies such as land reclamation or reforestation may also have adaptation benefits (e.g., improved WASH and nutrition outcomes), that were not discussed. Identifying and explicitly recognizing both potential adaptation and mitigation co-benefits of interventions will enable greater understanding of the holistic climate change approaches implemented.

- **Incorporate Social and Cultural Factors.** Much of the existing literature has focused on "hard" adaptation measures, such as infrastructure and technology, but "soft" measures,

including community engagement and awareness, are also important. As climate change mitigation and adaptation strategies are increasingly necessary for nutrition programming, recognizing and incorporating social and cultural factors in the design and implementation of program changes merits attention.

Overall, this review highlights the dearth of evidence for mitigation approaches to addressing nutrition outcomes, especially in LMICs. Further programming could more explicitly couple adaptation and mitigation through approaches that include ecosystem services recognition (e.g., the multiple services provided by ecosystems for human well-being) (EPA 2022). Examining a potential intervention or program through an ecosystem services approach would identify the multiple benefits or potential impacts of a strategy for both ecological and human health, including climate change co-benefits, amongst others. More recently, such approaches are leading to "nature-based solutions," whereby ecological or conservation strategies offer synergistic or beneficial human well-being outcomes (World Bank 2022). These approaches are more common in the health and climate sector, and have the greatest cost-effective mitigation potential in forests, wetlands, and grasslands (Reise et al. 2022), so large forested countries stand to benefit the most from their implementation (Roe et al. 2021). While they have been less considered in food and nutrition systems, agroforestry offers a relevant potential approach that would not displace agricultural land and adversely affect food security (Kuyah et al. 2019, Seddon 2022).

Other evidence in this review highlighted the need for nutrition programming to expand further into the health and care systems, moving beyond agricultural or technological approaches to adaptation. This includes the need for increasing training and education for health care workers, as well as additional investments in health care facilities to be able to respond to acute and long-term climate change-induced nutrition needs. For example, one study from Zimbabwe documented the need to increase the quantity of basic supplies (e.g., mineral vitamin mix, resomal, micronutrient powder, and supplementary food stocks) available at health care facilities in LMICs to enhance the capacity of facilities to respond to climate change-induced drought nutrition impacts (Sithole et al. 2021).

Finally, several articles highlighted the need to increase programming for "soft measures" of climate adaptation, since most of the interventions have resulted in "hard measures" such as rebuilding infrastructure (Pacillo et al. 2022). In particular, Pacillo et al. (2022), a study focused in Vietnam, identifies community awareness raising as critical to build climate readiness and preparedness at the household and community level. They advocate for both financial and non-financial resources to support these activities, especially for those most vulnerable to climate impacts. Savage et al. (2021) also identify a need to focus on social and cultural issues (Savage et al. 2021), including how climate change impacts and responses shift cultural traditions, including the erosion of local food-related practices and traditional knowledge. In this study, focused in Vanuatu, many stopped gardening following a cyclone and drought because of coping responses that led to greater reliance on imported, store-bought foods, as well as diminished food agency of local people who relied on food aid, both of which has driven a dietary transition. As such, Savage et al. (2021) suggest that the crucial question for planning for climate change adaptation in food and nutrition security is, "how can communities and individuals be empowered to exercise agency in their food and health choices in the face of a changing climate and the nutrition transition?" They advocate that climate change adaptation should be about adjusting both to climate and social change, and that structural vulnerabilities and social and cultural impacts as a result of adaptation must be addressed.

3.6 Program Design and Implementation of Climate Change Interventions to Improve Nutrition Outcomes

Most, if not all, the literature reviewed documented expected or actual effects of climate change on health and nutrition. However, evidence is inadequate to inform robust, measurable program design and implementation. This is especially true of implemented interventions in the health and care sectors, as

most of the existing evidence is from food system interventions. USAID could play a major role in closing this information gap and building the evidence base on effective interventions. In addition, among the resources reviewed, successful implementation of effective interventions (e.g., OFSP) highlights the importance of multi-sectoral collaborative approaches and of ensuring that local partners and governments are compensated for their time and contributions (Girard et al. 2021):

1. **Study design tradeoffs and mixed methods.** Existing evidence is derived mostly from less rigorous designs, making determining which strategy or combination of strategies can influence nutrition outcomes while adapting to or mitigating the effects of climate change difficult. RCTs, the gold standard for evidence generation and estimating the magnitude of impact, have limitations (Carey et al. 2015) especially in LMICs, including cost and the longer time frame required for design, preparation, and exposure (Evans et al. 2023, Osrin et al. 2009). While the qualitative studies reviewed provided rich contextual insights (e.g., Apuri et al. 2018, Ghosh et al. 2021, Papworth et al. 2022), such data are not always representative or transferable.
2. **Measure and revisit.** Across studies, different measurements were used to assess the same nutrition outcome, especially in food and nutrition (in)security, indicating a lack of consensus on specific metrics, and/or whether those used most widely are relevant for climate change. Including operations research as well as regular assessments, for example, through tools such as strengths, weaknesses, opportunities, threats (SWOT) analyses (TAMU 2023), can inform higher quality and more effective implementation (Girard et al. 2021).
3. **Expand the evidence base.** Most of the evidence base in this report is from interventions modeled, proposed, or implemented in a single country or region. USAID's geographic and programmatic reach presents an opportunity for cross-country research to assess different strategies' effectiveness while adapting approaches to unique cultural climatic and environmental conditions.
4. **Incorporate equity and justice.** Include a guiding framework (e.g., Salm et al. 2021) that encompasses equity, justice, and inclusion, and identifies local policies and social norms that may exacerbate disparities by gender, economic background, age, and other dimensions. Such frameworks should be applied to local contexts for identifying the groups most vulnerable to adverse nutrition outcomes from climate change. Consistent with USAID's recent commitment to localization, local partners and participants in the decision-making process will be essential to interventions' success (Girard et al. 2021). Interventions could also benefit from resources that provide clarity in concepts, definitions, strategies, and other elements to better comprehend gender and equity disparities and ways of addressing them, such as the Gender and Inclusion Toolbox: Participatory Research in Climate Change and Agriculture (Jost et al. 2014; Cramer et al. 2017).

4. Discussion and Additional Considerations

This evidence review confirms what other studies have recently concluded related to climate change and health research: evidence is scant on how interventions designed for communities coping with climate disruptions can protect against negative impacts on human nutritional status and through which pathways (Berrang-Ford et al. 2021). This gap could be addressed by USAID and other implementing partners and agencies by establishing evaluation designs to untangle which activities protect nutrition.

4.1 Additional Research Needs

Like other recent reviews of climate change adaptations (Berrang-Ford et al. 2021), most of the evidence comes from certain geographical areas (i.e., SSA). Additional research with more rigorous design and more timely documentation and dissemination of results is needed globally. More research is

also needed to reduce the negative impacts of drought and flooding and protect nutrition in the face of increasing temperature and heat, extreme events, and weather variability, all three of which have been least studied. In the evidence base, adaptation interventions were significantly more common in the literature on LMICs than mitigation interventions. Interventions that included mitigation largely focused on mitigating climate impacts (i.e. risk reduction) and not mitigating greenhouse gas emissions. However, mitigation approaches tended to focus on sustainable natural resources management and conservation, which also allow adaptation benefits. Furthermore, more research is needed especially to identify effective health system interventions that protect nutrition in the face of climate change. Finally, prioritizing racial, gender, ethnic, and economic equity in the research agenda is important.

4.2 Limitations

While this evidence review followed a systematic process for both the peer-reviewed and gray literature, there are study limitations. First, the evidence available is inherently biased, as what is published depends on the location of researchers, resources, and the stories told in particular communication venues (Levy et al. 2016). What is presented here most certainly does not represent the full body of evidence on interventions implemented. A relevant example of this is the existing evidence reviewed on OFSP, which has been extensively written about but is not a silver bullet for addressing nutrition outcomes during climate change. Furthermore, some search engines and websites for consideration in the gray literature search were not fully functioning, which means this review may not include all possible interventions implemented and documented. Moreover, challenges occurred in accessing some websites (e.g., pages not running properly). Thus, this review may be missing other relevant documents that fit the inclusion criteria.

5. Conclusion

Climate change shocks and stressors affecting food, care, and health systems can impact nutrition outcomes, particularly in LMIC contexts where climate change vulnerability is increasing. Nutrition interventions that include climate adaptation and mitigation approaches can aid in addressing such impacts by reducing vulnerability and improving resilience. This report reviewed existing evidence to assess interventions in response climate change effects and their relative magnitude of impact for improving or maintaining nutrition outcomes. Overall, the review found a limited number of robust implemented interventions, with limited evidence. These observed shortcomings provide ample opportunity for programmatic design and implementation planning to increase the rigor of interventions and the availability of their evidence. The integration of these findings with the next phase of this activity, incorporating information from the KIIs conducted with USAID Mission staff and implementing partners in four countries, will provide a more comprehensive roadmap for USAID to consider in addressing climate change effects in food, care, and health systems.

References

Adger, W. N. 2006. "Vulnerability." *Global Environmental Change*. 16(3): 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006.

Ambikapathi, R., M. N. Kosek, G. O. Lee, M. P. Olortegui, B. Zaitchik, P. P. Yori, A. Bauck, and L. E. Caulfield. 2021. "La Niña Weather Impacts Dietary Patterns and Dietary Diversity among Children in the Peruvian Amazon." *Public Health Nutrition*. 24(11): 3477–3487.

Apuri, I., K. Peprah, and G. T. W. Achana. 2018. "Climate Change Adaptation through Agroforestry: The Case of Kassena Nankana West District, Ghana." *Environmental Development*. 28: 32–41.

Asmall, T., A. Abrams, M. Röösli, G. Cisse, K. Carden, and M. A. Dalvie. 2021. "The Adverse Health Effects Associated with Drought in Africa." *Science of The Total Environment*. 793: 148500.

Berrang-Ford, L., A. J. Sietsma, M. Callaghan, J. C. Minx, P. F. Scheelbeek, N. R. Haddaway, and A. D. Dangour. 2021. "Systematic Mapping of Global Research on Climate and Health: A Machine Learning Review." *The Lancet Planetary Health*. 5(8): e514–e525.

Berrang-Ford, L., A. R. Siders, A. Lesnikowski, A. P. Fischer, M. W. Callaghan, N. R. Haddaway, T. Z. Abu. 2021. "A Systematic Global Stocktake of Evidence on Human Adaptation to Climate Change." *Nature Climate Change*. 11(11): 989–1000.

Bouzid, M., L. Hooper, and P. R. Hunter. 2013. "The Effectiveness of Public Health Interventions to Reduce the Health Impact of Climate Change: A Systematic Review of Systematic Reviews." *PLoS One*. 8(4): e62041.

Bush, A., S. Wrottesley, E. Mates, and B. Fenn. 2022. *Nutrition and Climate Change - Current State of Play: Scoping Review*. Emergency Nutrition Network (ENN). Oxfordshire, United Kingdom. https://www.ennonline.net/nutritionandclimatechange

Carey, T. A., and W. B. Stiles. 2016. "Some Problems with Randomized Controlled Trials and Some Viable Alternatives." *Clinical Psychology & Psychotherapy*. 23: 87–95. https://doi.org/10.1002/cpp.1942.

Chakrabarti, S. 2019. "The West and Central Africa Advantage: Fighting Fragility for Smallholder Resilience." IFAD Advantage Series. Rome: IFAD (International Fund for Agricultural Development).

Cramer L, S. Huyer, A. Lavado , A. M. Loboguerrero, D. Martínez-Barón, M. Nyasimi, T. Thomas, P. Thornton, J. van Etten, and M. van Wijk. 2017. *Methods Proposed to Evaluate the Potential Impact of Climate Change on Food and Nutrition Security in Central America and the Dominican Republic*. CCAFS Working Paper no. 196. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Dey, A., G. Singh, and A. K. Gupta. 2018. "Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants." *World Development*. 103: 336–359.

Dimitrova, A. 2021. "Seasonal Droughts and the Risk of Childhood Undernutrition in Ethiopia." *World Development*. 141: 105417.

Drysdale, R. E., U. Bob, and M. Moshabela. 2021. "Coping through a Drought: The Association between Child Nutritional Status and Household Food Insecurity in the District of Ilembe, South Africa." *Public Health Nutrition*. 24(5):1052–1065. https://doi.org/DOI: 10.1017/S1368980020000105.

Environmental Protection Agency (EPA). 2022. "Ecosystem Services Research." https://www.epa.gov/eco-research/ecosystem-services-research. Assessed July 14, 2023.

Erickson, T. B., J. Brooks, E. J. Nilles, P. N. Pham, and P. Vinck. 2019. "Environmental Health Effects Attributed to Toxic and Infectious Agents following Hurricanes, Cyclones, Flash Floods and Major Hydrometeorological Events." *Journal of Toxicology and Environmental Health*. Part B. 22(5-6): 157–171.

Ethiopia Climate Change Country Profile | Fact Sheet | Africa. 2023. USAID (US Agency for International Development). https://www.usaid.gov/climate/country-profiles/ethiopia.

Evans, David K. 2023. "Towards Improved and More Transparent Ethics in Randomised Controlled Trials in Development Social Science." *Journal of Development Effectiveness*. https://doi.org/10.1080/19439342.2023.2196978.

Food and Agriculture Organization (FAO) of the United Nations. 2018. "Building Stronger Partnerships for Resilience: Opportunities for Greater FAO Engagement in Realizing the Goals of the DFID Humanitarian Policy." https://www.fao.org/documents/card/en/c/CA1001EN. Assessed July 6, 2023.

Farooq, M. S., M. Uzaiir, A. Raza, M. Habib, Y. Xu, M. Yousuf, and M. Ramzan Khan. 202. "Uncovering the Research Gaps to Alleviate the Negative Impacts of Climate Change on Food Security: A Review." *Frontiers in Plant Science*. 2334. 13(2022).

Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, and D. J. Lunt, et al. 2021). "The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity." In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, and N. Caud, et al., 923–1054. New York: Cambridge University Press. https://doi.org/10.1017/9781009157896.009.

Ghosh-Jerath, S., R. Kapoor, U. Ghosh, A. Singh, S. Downs, and J. Fanzo. 2021. "Pathways of Climate Change Impact on Agroforestry, Food Consumption Pattern, and Dietary Diversity among Indigenous Subsistence Farmers of Sauria Paharia Tribal Community of India: A Mixed Methods Study." *Frontiers in Sustainable Food Systems*. 5: 667297.

Girard, A. W., A. Brouwer, E. Faerber, F. K. Grant, and J. W. Low. 2021. "Orange-Fleshed Sweetpotato: Strategies and Lessons Learned for Achieving Food Security and Health at Scale in Sub-Saharan Africa." *Open Agriculture*. 6(1): 511–536.

Gwatirisa, P. R., B. Pamphilon, and K. Mikhailovich. 2017. "Coping with Drought in Rural Papua New Guinea: A Western Highlands Case Study." *Ecology of Food and Nutrition*. 56(5): 393–410.

IFAD (International Fund for Agricultural Development) 2016. *Investing in Rural People in Colombia.* [Fact sheet] https://www.ifad.org/en/web/knowledge/-/publication/enabling-poor-rural-people-to-overcome-poverty-in-colombia.

IPCC (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.

IPCC (Intergovernmental Panel on Climate Change). 2023. "Summary for Policymakers." In *Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

Jost C., N. Ferdous, and T. D. Spicer. 2014. *Gender and Inclusion Toolbox: Participatory Research in Climate Change and Agriculture*. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); CARE International and the World Agroforestry Centre (ICRAF).

Khalid, H., S. Gill, and A. Fox. 2019. "Global Aid for Nutrition-Specific and Nutrition-Sensitive Interventions and Proportion of Stunted Children across Low- and Middle-Income Countries: Does Aid Matter?" *Health Policy and Planning*. 34:2: ii18–ii27. https://academic.oup.com/heapol/article/34/Supplement_2/ii18/5625030.

Kizito, F., C. Mwongera, B. Pondi, C. M. Mwungu, C. Odhiambo, N. Koech, and K. M. Shikuku, et al. 2019. *Results and Impacts of the Integrated Land and Water Management for Adaptation to Climate Variability and Change (ILWAC) Project: Evaluation Report*. Kigali, RW 102 p.

Kuyah, S., C. W. Whitney, M. Jonsson, G. W. Sileshi, I. Öborn, C. W. Muthuri, and E. Luedeling. 2019. "Agroforestry Delivers a Win-Win Solution for Ecosystem Services in Sub-Saharan Africa. A Meta-Analysis." *Agronomy for Sustainable Development*. 39: 1–18.

Levy, K., A. P. Woster, R. S. Goldstein, and E. J. Carlton. 2016. "Untangling the Impacts of Climate Change on Waterborne Diseases: A Systematic Review of Relationships between Diarrheal Diseases and Temperature, Rainfall, Flooding, and Drought." *Environmental Science & Technology*. 50(10): 4905–4922.

Lieber, M., P. Chin-Hong, K. Kelly, M. Dandu, and S. D. Weiser. 2022. "A Systematic Review and Meta-Analysis Assessing the Impact of Droughts, Flooding, and Climate Variability on Malnutrition." *Global Public Health*. 17(1): 68–82.

Mahood, Q., D. Van Eerd, and E. Irvin. 2014. "Searching for Grey Literature for Systematic Reviews: Challenges and Benefits." *Research Synthesis Methods*. 5(3): 221–234. https://doi.org/10.1002/jrsm.1106.

Masao, C. A., J. Igoli, and E. T. Liwenga. 2023. "Relevance of Neglected and Underutilized Plants for Climate Change Adaptation and Conservation Implications in Semi-Arid Regions of Tanzania." *Environmental Management*. 71(1): 114–130.

McKune, S., L. Poulsen, S. Russo, T. Devereux, S. Faas, C. McOmber, and T. Ryley. 2018. "Reaching the End Goal: Do Interventions to Improve Climate Information Services Lead to Greater Food Security?" *Climate Risk Management*. 22: 22–41.

Met Office Hadley Center and WFP (World Food Programme) 2012. *Climate Impacts on Food Security and Nutrition: A Review of Existing Knowledge.* https://documents.wfp.org/stellent/groups/public/documents/communications/wfp258981.pdf

Mock, N., and J. Jennings. 2022. *Nutrition and Resilience: Discussion Brief on Better Integration of Nutrition into Resilience-Strengthening Programs*. Washington, DC: Resilience, Evaluation, Analysis and Learning (REAL) Associate Award.

Munn, Z., M. D. J. Peters, C. Stern, C. Tufanaru, A. McArthur, and E. Aromataris. 2018. "Systematic Review or Scoping Review? Guidance for Authors When Choosing between a Systematic or Scoping Review Approach." *BMC Medical Research Methodology*. 18(1): 143. https://doi.org/10.1186/s12874-018-0611-x.

Myers, S. S., M. R. Smith, S. Guth, C. D. Golden, B. Vaitla, N. D. Mueller, A. D. Dangour, and P. Huybers. 2017. "Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition." *Annual Review of Public Health*. 38(1): 259–277. https://doi.org/10.1146/annurev-publhealth-031816-044356.

Nakstad, B., V. Filippi, A. Lusambili, N. Roos, F. Scorgie, M. F. Chersich, S. Luchters, and S. Kovats, S. 2022. "How Climate Change May Threaten Progress in Neonatal Health in the African Region." *Neonatology*. 119(5): 644–651. https://doi.org/10.1159/000525573.

Niles, M. T., B. F. Emery, S. Wiltshire, M. E. Brown, B. Fisher, and T. H. Ricketts. 2021. "Climate Impacts Associated with Reduced Diet Diversity in Children across Nineteen Countries." *Environmental Research Letters*. 16: 015010. https://doi.org/10.1088/1748-9326/abd0ab.

Osrin, D., K. Azad, A. Fernandez, D. S. Manandhar, C. W. Mwansambo, P. Tripathy, and A. M. Costello. 2009. "Ethical Challenges in Cluster Randomized Controlled Trials: Experiences from Public Health Interventions in Africa and Asia." *Bulletin of the World Health Organization*. 87(10): 772–779.

Pacillo, G., N. V. Bao-Nam, D. D. Burra, H. T. Trinh, T. D. Le, M. T. Truong, and P. Läderach. 2022. "Disruptive Innovations for Well-Functioning Food Systems: The Data-Driven 'Food and Nutrition Security Under Climate Evolution' Framework." *Frontiers in Sustainable Food Systems*. 5: 525.

Page, M. J., J. E. McKenzie, P. M. Bossuyt, I. Boutron, T. C. Hoffmann, C. D. Mulrow, and L. Shamseer, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ*. n71. https://doi.org/10.1136/bmj.n71.

Papworth, A. J., M. Maslin, and S. Randalls. 2022. "How Food-System Resilience Is Undermined by the Weather: The Case of the Rama Indigenous Group, Nicaragua." *Ecology and Society*. 27(4).

Part, C., V. Filippi, J. A. Cresswell, R. Ganaba, S. Hajat, B. Nakstad, and S. Kovats. 2022. "How Do High Ambient Temperatures Affect Infant Feeding Practices? A Prospective Cohort Study of Postpartum Women in Bobo-Dioulasso, Burkina Faso." *BMJ Open*. 12(10): e061297. https://doi.org/10.1136/bmjopen-2022-061297.

Phalkey, R. K., C. Aranda-Jan, S. Marx, B. Höfle, and R. Sauerborn. 2015. "Systematic Review of Current Efforts to Quantify the Impacts of Climate Change on Undernutrition." *Proceedings of the National Academy of Sciences*. 112(33): E4522–E4529.

Reise, J., A. Siemons, H. Böttcher, A. Herold, C. Urrutia, L. Schneider, and M. Davis. 2022. *Nature-Based Solutions and Global Climate Protection*. German Environment Agency.

Richardson, R. B., and M. Suvedi. 2018. "Assessing the Potential for Small-Scale Aquaculture in Cambodia." *Environments*. 5(7): 76.

Roe, S., C. Streck, R. Beach, J. Busch, M. Chapman, V. Daioglou, and D. Lawrence. 2021. "Land-Based Measures to Mitigate Climate Change: Potential and Feasibility by Country." *Global Change Biology*. 27(23): 6025–6058.

Salm, L., N. Nisbett, L. Cramer, S. Gillespie, and P. Thornton. 2021. "How Climate Change Interacts with Inequity to Affect Nutrition." *Wiley Interdisciplinary Reviews: Climate Change*. 12(2): e696.

Savage, A., H. Bambrick, and D. Gallegos. 2021. "Climate Extremes Constrain Agency and Long-Term Health: A Qualitative Case Study in a Pacific Small Island Developing State." *Weather and Climate Extremes*. 31: 100293.

Seddon, N. 2022. "Harnessing the Potential of Nature-Based Solutions for Mitigating and Adapting to Climate Change." *Science*. 376(6600): 1410–1416.

Sithole, Z., T. Nyadzayo, T. Kanyowa, J. Mathieu, T. Kambarami, M. Nemaramba, and A. Gasasira. 2021. "Enhancing Capacity of Zimbabwe's Health System to Respond to Climate Change Induced Drought: A Rapid Nutritional Assessment." *Pan African Medical Journal*. 40(1): 40:113

Stolberg, H. O., G. Norman, and I. Trop. 2004. "Randomized Controlled Trials." *American Journal of Roentgenology*. 183(6): 1539–1544. https://doi.org/10.2214/ajr.183.6.01831539.

TAMU (Texas A&M University). 2023. "What Is the Purpose of an Environmental Scan?" https://tamu.libguides.com/c.php?g=434057&p=8560236.

Tirado, M. C., P. Crahay, L. Mahy, C. Zanev, M. Neira, S. Msangi, R. Brown, C. Scaramella, D.C. Coitinho, and A. Müller. 2013. "Climate Change and Nutrition: Creating a Climate for Nutrition Security." *Food and Nutrition Bulletin*. 34(4): 533–547. https://doi.org/10.1177/156482651303400415.

UNICEF (United Nations Children's Fund). 1990. "Policy Review. Strategy for Improving Nutrition of Children and Women in Developing Countries." https://digitallibrary.un.org/record/227230?ln=en. Assessed June 20, 2023.

USAID (United States Agency for International Development). 2012. "Building Resistance to Recurrent Crisis: USAID Policy and Program Guidance."

USAID (United States Agency for International Development). 2022. "USAID Climate Strategy 2022–2030: Advancing Equitable and Ambitious Actions to Confront the Climate Crisis." https://www.usaid.gov/policy/climate-strategy.

WFP (World Food Programme), WHO (World Health Organization), and UNICEF (United Nations Children's Fund). 2022. "The State of Food Security and Nutrition in the World." https://www.who.int/publications/m/item/the-state-of-food-security-and-nutrition-in-the-world-2022

World Bank. 2022. "Climate Explainer: What You Need to Know about Nature-Based Solutions to Climate Change." https://www.worldbank.org/en/news/feature/2022/05/19/what-you-need-to-know-about-nature-based-solutions-to-climate-change.

World Vision (2017) Comparative Analysis of Shock Response Programs & Their Impacts on Resilience in Zimbabwe. [Evaluations and Research: Technical Guidance] https://www.fsnnetwork.org/resource/comparative-analysis-shock-response-programs-their-impacts-resilience-zimbabwe.

Xu, R., Q. Zhao, M. S. Coelho, P. H. Saldiva, M. J. Abramson, S. Li, and Y. Guo. 2019. "The Association between Heat Exposure and Hospitalization for Undernutrition in Brazil during 2000−2015: A Nationwide Case-Crossover Study." *PLoS Medicine*. 16(10): e1002950.

Zadkovic S., N. Lombardo, and D. C. Cole. 2021. "Breastfeeding and Climate Change: Overlapping Vulnerabilities and Integrating Responses." *Journal of Human Lactation*. 2021;37(2): 323–330. https://doi.org/10.1177/0890334420920223.

Zhang, L., Z. Chai, Y. Zhang, Y. Geng, and Y. Wang. 2016. "Ethnobotanical Study of Traditional Edible Plants Used by the Naxi People during Droughts." *Journal of Ethnobiology and Ethnomedicine*. 12(1): 1–16.

Annex 1. Search Terms and Process for Peer-Reviewed Evidence

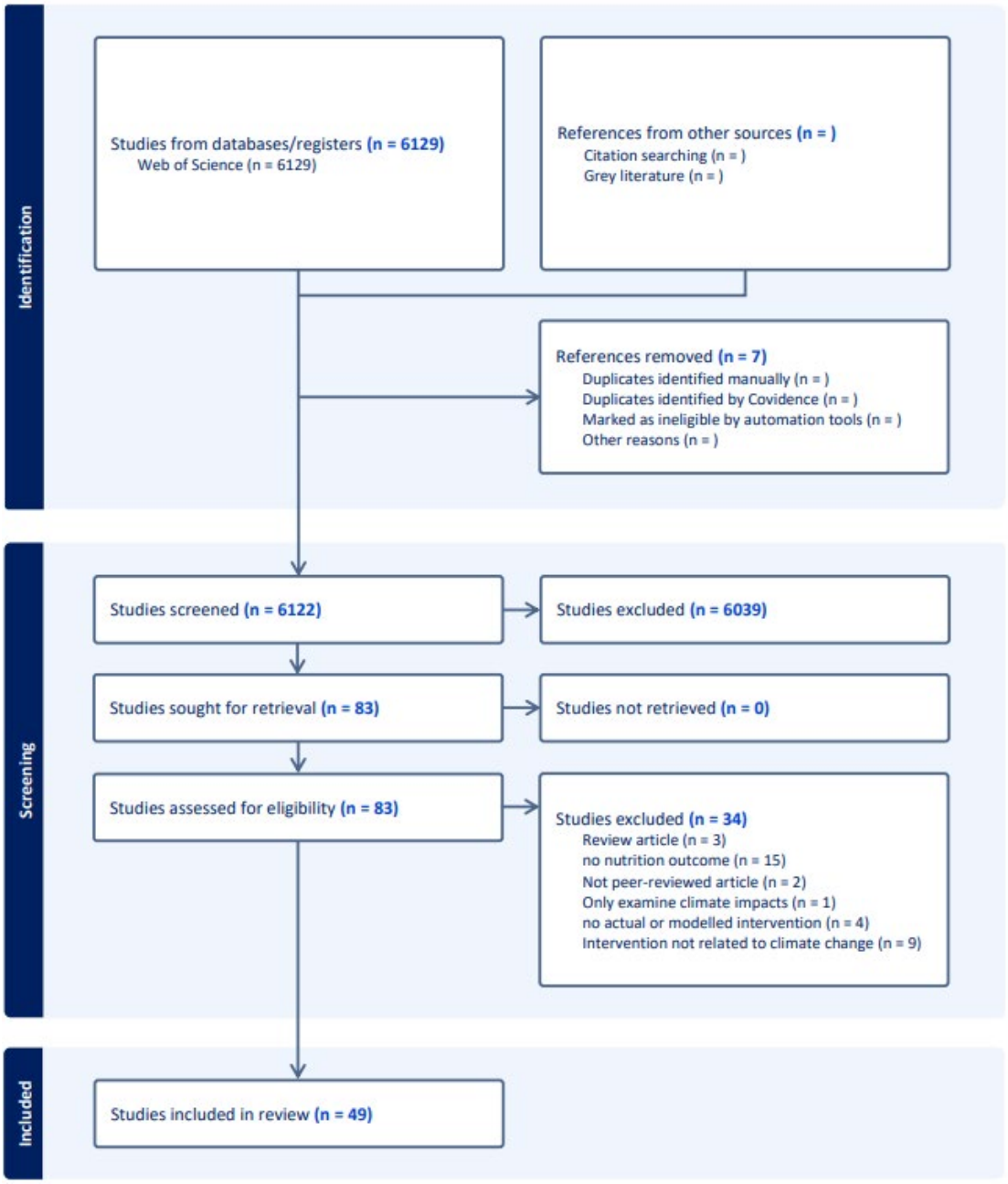
Table A.1 shows the search strategy terms and syntax for the systematic literature review (using Boolean search terms). It is based on the framework (figure 1) and includes searches using one term from each of the five key areas (climate change, climate impacts, resilience, interventions, and nutrition). While not all climate terms or responses to climate factors are necessarily climate change related, we assume the two to be interrelated for these purposes. Furthermore, the boundaries of this review include responses and nutrition outcomes (malnutrition, diet diversity, and undernutrition) done or proposed in response to climate change as indicated by the search terms, rather than a general search of all development interventions that could be done to improve these specific nutrition outcomes.

Table A1: Search Strategy Syntax

Terms	Syntax
Climate Change Terms	"greenhouse gas" OR "climate impact" OR "climate shock" OR "climate vulnerability" OR "climate stress" OR "climate change"
AND	
Climate Shocks and Stressors Terms	drought OR cyclone OR hurricane* OR temperature* OR heat* OR "heat stress" OR "extreme weather event" OR "extreme weather" OR "precipitation" OR "precipitation change" OR "rainfall" OR flood* OR "water availability" OR water OR pathogen
AND	
Intervention Terms	intervention OR program OR "policy intervention*" OR "program intervention*" OR "intervention mechanism*" OR "food system*" OR "care system*" OR "health system*" OR fortif* OR dietary OR "dietary supplementation" OR supplementation OR "maternal health" OR feeding OR breastfeed* OR "food security" OR "nutrition security" OR "water and sanitation" OR WASH OR strateg* OR implement* OR tailor*
AND	
Resilience Terms	resilience* OR capacity OR vulnerab* OR adaptation OR mitigation OR coping OR sustainab* OR equit*
AND	

Nutrition Outcome Terms	nutrition OR "nutrition-specific" OR "nutrition-sensitive" OR micronutrient OR "micronutrient deficiency" OR "diet diversi*" OR undernutrition OR stunt* OR nutrient OR "nutrient content" OR "diet quality" OR "nutrition quality" OR "nutrient density" OR "food quality" OR diarrhea OR wasting

Figure A1. PRISMA Diagram of the Peer-Reviewed Literature Systematic Literature Review



Annex 2. Full List of Citations for Peer-Reviewed Studies

Ahmad, D., and M. Afzal. 2021. "Impact of Climate Change on Pastoralists' Resilience and Sustainable Mitigation in Punjab, Pakistan." *Environment, Development and Sustainability*. 23: 11406–11426.

Ambikapathi, R., M. N. Kosek, G. O. Lee, M. P. Olortegui, B. Zaitchik, P. P. Yori, and L. E. Caulfield. 2021. "La Niña Weather Impacts Dietary Patterns and Dietary Diversity among Children in the Peruvian Amazon." *Public Health Nutrition*. 24(11): 3477–3487.

Apuri, I., K. Peprah, and G. T. W. Achana. 2018. "Climate Change Adaptation through Agroforestry: The Case of Kassena Nankana West District, Ghana." *Environmental Development*. 28: 32–41.

Bahru, B. A., C. Bosch, R. Birner, and M. Zeller. 2019. "Drought and Child Undernutrition in Ethiopia: A Longitudinal Path Analysis." *PLoS One*. 14(6): e0217821.

Bailey, M. K., A. R. McCleery, G. Barnes, and L. S. McKune. 2019. "Climate-Driven Adaptation, Household Capital, and Nutritional Outcomes among Farmers in Eswatini." *International Journal of Environmental Research and Public Health*. 16(21). https://doi.org/10.3390/ijerph16214063.

Banerjee, R., and R. Maharaj. 2020. "Heat, Infant Mortality, and Adaptation: Evidence from India." *Journal of Development Economics*. 143: 102378.

Block, S., B. Haile, L. You, and D. Headey. 2021. "Heat Shocks, Maize Yields, and Child Height in Tanzania." *Food Security*. 14(2022): 1–17.

Bryson, J. M., K. Patterson, L. Berrang-Ford, S. Lwasa, D. B. Namanya, S. Twesigomwe, and S. L. Harper. 2021. "Seasonality, Climate Change, and Food Security during Pregnancy among Indigenous and Non-Indigenous Women in Rural Uganda: Implications for Maternal-Infant Health." *PLoS One*. 16(3): e0247198.

Cheruiyot, S. J., M. Kimanthi, J. S. Shabani, N. F. Nyamu, C. Gathu, F. Agoi, and F. De Meijer. 2022. "Climate Change Poses a Threat to Nutrition and Food Security in Kilifi County, Kenya." *African Journal of Primary Health Care & Family Medicine*. 14(1): 4.

Cooper, M. W., M. E. Brown, S. Hochrainer-Stigler, G. Pflug, I. McCallum, S. Fritz, J. Silva, and A. Zvoleff. 2019. "Mapping the Effects of Drought on Child Stunting." *Proceedings of the National Academy of Sciences*. 116(35): 17219–17224. https://doi.org/10.1073/pnas.1905228116.

Demeke, A. B., A. Keil, and M. Zeller. 2011. "Using Panel Data to Estimate the Effect of Rainfall Shocks on Smallholders Food Security and Vulnerability in Rural Ethiopia." *Climatic Change*. 108(1): 185–206. https://doi.org/10.1007/s10584-010-9994-3.

Dey, A., G. Singh, and A. K. Gupta. 2018. "Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants." *World Development*. 103: 336–359.

Dimitrova, A. 2021. "Seasonal Droughts and the Risk of Childhood Undernutrition in Ethiopia." *World Development*. 141: 105417.

Dobbie, S., K. Schreckenberg, J. Dyke, M. Schaafsma, and S. Balbi. 2018. "Agent-Based Modelling to Assess Community Food Security and Sustainable Livelihoods." *Journal of Artificial Societies and Social Simulation*. 21(1): 1–23.

Drysdale, R. E., U. Bob, and M. Moshabela. 2021. "Coping through a Drought: The Association between Child Nutritional Status and Household Food Insecurity in the District of iLembe, South Africa." *Public Health Nutrition*. 24(5): 1052–1065. https://doi.org/10.1017/S1368980020000105.

Ghosh-Jerath, S., R. Kapoor, U. Ghosh, A. Singh, S. Downs, and J. Fanzo. 2021. "Pathways of Climate Change Impact on Agroforestry, Food Consumption Pattern, and Dietary Diversity among Indigenous Subsistence Farmers of Sauria Paharia Tribal Community of India: A Mixed Methods Study." *Frontiers in Sustainable Food Systems*. 5: 667297.

Girard, A. W., A. Brouwer, E. Faerber, F. K. Grant, and J. W. Low. 2021. "Orange-Fleshed Sweetpotato: Strategies and Lessons Learned for Achieving Food Security and Health at Scale in Sub-Saharan Africa." *Open Agriculture*. 6(1): 511–536.

Gwatirisa, P. R., B. Pamphilon, and K. Mikhailovich. 2017. "Coping with Drought in Rural Papua New Guinea: A Western Highlands Case Study." *Ecology of Food and Nutrition*. 56(5): 393–410.

Hawkins, P., W. Geza, T. Mabhaudhi, C. Sutherland, K. Queenan, A. Dangour, P. Scheelbeek. 2022. "Dietary and Agricultural Adaptations to Drought among Smallholder Farmers in South Africa: A Qualitative Study." *Weather and Climate Extremes*. 35: 100413.

Irenso, A. A., S.Letta, A. S. Chemeda, A. Asfaw, G. Egata, N. Assefa, and R. Laws. 2022. "Maternal Time Use Drives Suboptimal Complementary Feeding Practices in the El Niño-Affected Eastern Ethiopia Community." *International Journal of Environmental Research and Public Health*. 19(7): 3937.

Jankowska, M. M., D. Lopez-Carr, C. Funk, G. J. Husak, and Z. A. Chafe. 2012. "Climate Change and Human Health: Spatial Modeling of Water Availability, Malnutrition, and Livelihoods in Mali, Africa." *Applied Geography*. 33: 4–15.

Khan, J. R., M. B. Hossain, and N. Awan. 2022. "Community-Level Environmental Characteristics Predictive of Childhood Stunting in Bangladesh: A Study Based on the Repeated Cross-Sectional Surveys." *International Journal of Environmental Health Research*. 32(3): 473–486.

Lawlor, K., S. Handa, D. Seidenfeld, and Zambia Cash Transfer Evaluation Team. 2019. "Cash Transfers Enable Households to Cope with Agricultural Production and Price Shocks: Evidence from Zambia." *The Journal of Development Studies*. 55(2): 209–226.

Lazzaroni, S., and N. Wagner. 2016. "Misfortunes Never Come Singly: Structural Change, Multiple Shocks and Child Malnutrition in Rural Senegal." *Economics & Human Biology*. 23: 246–262.

Limuwa, M. M., W. Singini, and T. Storebakken. 2018. "Is Fish Farming an Illusion for Lake Malawi Riparian Communities under Environmental Changes?" *Sustainability*. 10(5): 1453.

Mainardi, S. 2021. "Preference Heterogeneity, Neighbourhood Effects and Basic Services: Logit Kernel Models for Farmers' Climate Adaptation in Ethiopia." *Environment, Development and Sustainability*. 23(5): 6869–6912.

Makuvaro, V., S. Walker, T. P. Masere, and J. Dimes. 2018. "Smallholder Farmer Perceived Effects of Climate Change on Agricultural Productivity and Adaptation Strategies." *Journal of Arid Environments*. 152: 75–82.

Masao, C. A., J. Igoli, and E. T. Liwenga. 2023. "Relevance of Neglected and Underutilized Plants for Climate Change Adaptation and Conservation Implications in Semi-Arid Regions of Tanzania." *Environmental Management*. 71(1): 114–130.

McKune, S., L. Poulsen, S. Russo, T. Devereux, S. Faas, C. McOmber, and T. Ryley. 2018. "Reaching the End Goal: Do Interventions to Improve Climate Information Services Lead to Greater Food Security?" *Climate Risk Management*. 22: 22–41.

Neupane, N., S. Paudel, R. Sapkota, Y. P. Joshi, Y. Rijal, and A. Chalise. 2022. "Enhancing the Resilience of Food Production Systems for Food and Nutritional Security under Climate Change in Nepal." *Frontiers in Sustainable Food Systems*. 6(2022): 342.

Nicholas, K., L. Campbell, E. Paul, G. Skeltis, W. Wang, and C. Gray. 2021. "Climate Anomalies and Childhood Growth in Peru." *Population and Environment*. 43: 39–60.

Niles, M. T., and M. E. Brown. 2017. "A Multi-Country Assessment of Factors Related to Smallholder Food Security in Varying Rainfall Conditions." *Scientific Reports*. 7(1): 16277. https://doi.org/10.1038/s41598-017-16282-9.

Niles, M. T., B. F. Emery, S. Wiltshire, M. E. Brown, B. Fisher, and T. H. Ricketts. 2021. "Climate Impacts Associated with Reduced Diet Diversity in Children across Nineteen Countries." *Environmental Research Letters*. 16: 015010. https://doi.org/10.1088/1748-9326/abd0ab.

Oskorouchi, H. R., and A. Sousa-Poza. 2021. "Floods, Food Security, and Coping Strategies: Evidence from Afghanistan." *Agricultural Economics*. 52(1): 123–140.

Pacillo, G., N.-V. Bao-Nam, D. D. Burra, H. T. Trinh, T. D. Le, M. T. Truong, S. D. Nguyen, D. T. Tran, and P. Läderach. 2022. "Disruptive Innovations for Well-Functioning Food Systems: The Data-Driven 'Food and Nutrition Security Under Climate Evolution' Framework." *Frontiers in Sustainable Food Systems*. 5: 525.

Papworth, A. J., M. Maslin, and S. Randalls. 2022. "How Food-System Resilience Is Undermined by the Weather: The Case of the Rama Indigenous Group, Nicaragua." *Ecology and Society*. 27(4): 1.

Part, C., V. Filippi, J. A. Cresswell, R. Ganaba, S. Hajat, B. Nakstad, N. Roos, K. Kadio, M. Chersich, and A. Lusambili. 2022. "How Do High Ambient Temperatures Affect Infant Feeding Practices? A Prospective Cohort Study of Postpartum Women in Bobo-Dioulasso, Burkina Faso." *BMJ Open*. 12(10): e061297.

Richardson, R. B., and M. Suvedi. 2018. "Assessing the Potential for Small-Scale Aquaculture in Cambodia." *Environments*. 5(7): 76.

Rodriguez-Llanes, J. M., S. Ranjan-Dash, O. Degomme, A. Mukhopadhyay, and D. Guha-Sapir. 2011. "Child Malnutrition and Recurrent Flooding in Rural Eastern India: A Community-Based Survey." *BMJ Open*. 1(2): e000109. https://doi.org/10.1136/bmjopen-2011-000109.

Rodriguez-Llanes, J. M., S. Ranjan-Dash, A. Mukhopadhyay, and D. Guha-Sapir. 2016. "Looking Upstream: Enhancers of Child Nutritional Status in Post-Flood Rural Settings." *PeerJ*. 4: e1741.

Rufino, M. C., P. K. Thornton, S. K. Ng'ang'a, I. Mutie, P. G. Jones, M. T. van Wijk, and M. Herrero. 2013. "Transitions in Agro-Pastoralist Systems of East Africa: Impacts on Food Security and Poverty." *Agriculture, Ecosystems & Environment*, *179*. https://doi.org/10.1016/j.agee.2013.08.019.

Savage, A., H. Bambrick, and D. Gallegos. 2021. "Climate Extremes Constrain Agency and Long-Term Health: A Qualitative Case Study in a Pacific Small Island Developing State." *Weather and Climate Extremes*. 31: 100293.

Sithole, Z., T. Nyadzayo, T. Kanyowa, J. Mathieu, T. Kambarami, M. Nemaramba, R. Machaka, H. Bekele, H. Njovo, and A. Gasasira. 2021. "Enhancing Capacity of Zimbabwe's Health System to Respond to Climate Change Induced Drought: A Rapid Nutritional Assessment." *Pan African Medical Journal*. 40(1).

Sorgho, R., I. Mank, M. Kagoné, A. Souares, I. Danquah, and R. Sauerborn. 2020. "'We Will Always Ask Ourselves the Question of How to Feed the Family': Subsistence Farmers' Perceptions on Adaptation to Climate Change in Burkina Faso." *International Journal of Environmental Research and Public Health*. 17(19): 7200.

Sulser, T. B., B. Nestorova, M. W. Rosegrant, and T. van Rheenen. 2011. "The Future Role of Agriculture in the Arab Region's Food Security." *Food Security*. 3: 23–48.

Xu, R., Q. Zhao, M. S. Z. S. Coelho, P. H. N. Saldiva, M. J. Abramson, S. Li, and Y. Guo. 2019. "The Association Between Heat Exposure and Hospitalization for Undernutrition in Brazil during 2000−2015: A Nationwide Case-Crossover Study." *PLoS Medicine*. 16(10): e1002950.

Yeboah, E., N. Kuunibe, I. Mank, D. Parisi, E. Bonnet, J. Lohmann, and S. Hamadou, et al. 2022. "Every Drop Matters: Combining Population-Based and Satellite Data to Investigate the Link between Lifetime Rainfall Exposure and Chronic Undernutrition in Children under Five Years in Rural Burkina Faso." *Environmental Research Letters*. 17(5): 54027. https://doi.org/10.1088/1748-9326/ac661c.

Zhang, L., Z. Chai, Y. Zhang, Y. Geng, and Y. Wang. 2016. "Ethnobotanical Study of Traditional Edible Plants Used by the Naxi People during Droughts." *Journal of Ethnobiology and Ethnomedicine*. 12(1): 1–16.

Annex 3. Search Terms for Grey Literature Evidence

Table A2 shows the search protocols used in each targeted website. Websites' search engines were not able to input the search term combinations used for the systematic literature review (Table A1). A scoping strategy was therefore used to search each site, according to the established parameters, informed by this report's conceptual framework.

Table A2. Gray Literature

Website	Upcoming Plans
Biodiversity International	1. Page was accessed. 2. The research tab was opened (https://alliancebioversityciat.org/alliance-accelerated-change-preserve-and-protect-our-environment). 3. "Publications and data" was selected (https://alliancebioversityciat.org/publications-data). a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity") coupled with (1) "intervention" was included. b. The publication types assessed were brief, journal article, report, report/factsheet, internal document, scientific publication (only for cross reference), and working paper. (See section 2.1 and table A.1 for inclusion and exclusion criteria.) c. Publications considered were from 2010 to 2022. d. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. e. Approval to include in evidence spreadsheet followed screening of the full text.
CGIAR Research Program on Climate Change, Agriculture and Food Security?	1. CCAFS' official web page was not working. An alternative was accessed: CGSpace (CGIAR repository). 2. CCAFS' repository was opened (https://cgspace.cgiar.org/handle/10568/3530). 3. Each of the following collections was accessed: a. CCAFS Briefs b. CCAFS Outcome Cases c. CCAFS Project Reports d. CCAFS Social Learning Case Studies e. CCAFS Working Papers. 4. In the search box of each collection, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet

Website	Upcoming Plans
	diversity") was included, coupled with (1) "intervention" and (2) "climate." a. If the collection consisted of fewer than 200 documents, all were screened. b. Publications considered were from 2010 to 2022. c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. Approval to include in the evidence spreadsheet followed screening of the full text.
Feed the Future	1. Page was accessed. 2. The resources tab was opened (https://www.feedthefuture.gov/resources/). 3. The "filter resources by" section of the "browse all resources" area was used to conduct the search. a. The publication types assessed were "strategy/plan," "fact sheet," and "report/study". Each type was screened separately. Given that none overpassed 100 documents, all documents were screened, and no search terms were included—the website also does not give the option to search by terms. b. Publications considered were from 2010 to 2022. c. Selection for reviewing full text proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. For strategy/plan documents, the date criteria were considered when there were two plans for X country. For example, if there were two reports (X year, Y year) for a determined country, only the latest year was screened. In the case of reports/studies, the latest document was assessed. For example, if there was an interim report for X country in 2016, and a full report of that country in 2017, the latter was assessed. d. Approval to include in the evidence spreadsheet followed screening of the full text. 4. The latest progress report (*Feed the Future Progress Report 2016*) available on the website was also screened (https://www.feedthefuture.gov/resource/feed-the-future-progress-report-2016/). The same with the latest Progress Snapshot (2022) available on the website (https://www.feedthefuture.gov/resource/2022-feed-the-future-progress-snapshot/).
FAO UN	1. Page was accessed.

Website	Upcoming Plans
	2. The publications tab was opened (https://www.fao.org/publications/en/). a. The FAO 2022 publications catalog was accessed (https://www.fao.org/documents/card/en/c/cc2323en). The agriculture, climate change, and nutrition sections were screened (titles and descriptions) for publications that aligned with the scope of this work. b. The FAO Investment Centre website was accessed (https://www.fao.org/support-to-investment/en/). (See 3–5 for the selection and review process) i. The publications tab was accessed (https://www.fao.org/support-to-investment/publications/en/). The following terms were searched: nutrition (10), intervention (0), undernutrition (0), climate change (13), stunting (0), wasting (0), nutrition outcome (0), drought (2), heat (7), extreme event (0), extreme weather event (0), cyclone (0), health (8), maternal health (0), maternal (0), child (0), temperature (0), climate variability (1). c. All of the publications ("feature publications") that appeared in the publications area were screened according to the primary objectives of the literature review. Documents on the same topic (i.e., X country overview) were selected based on the latest publication. 3. The publication types assessed were brief, report, and report/factsheet published 2010–2022. 4. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. 5. Approval to include in the evidence spreadsheet followed screening of the full text.
IDEALs FSN Network	1. The Resource Library tab was opened (https://www.fsnnetwork.org/resource). 2. Given that all documents compiled (evaluations and research, case studies, technical guidance [reports], and policy briefs) exceeded 600 items, a search with relevant items was carried out. a. The search engine was limited. The following combinations were therefore used to limit the search to the search strategy's criteria: "nutrition and intervention," "nutrition and climate change," dietary diversity," "stunting," "wasting," "undernutrition," and "malnutrition." 3. The publication types assessed were evaluations and research, case studies, and policy briefs, published 2010–2022.

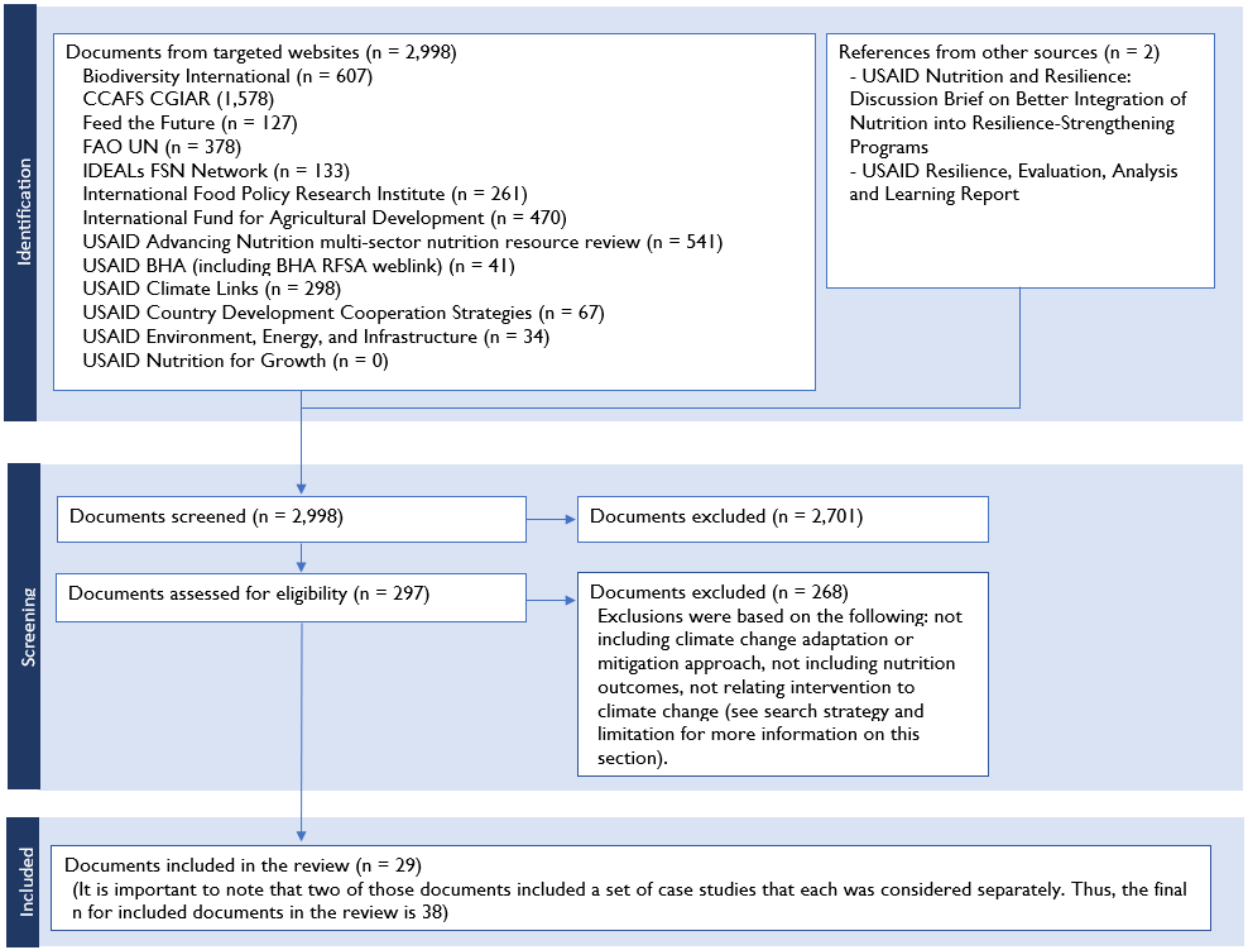
Website	Upcoming Plans
	4. Selection for text review proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts, adaptation, and mitigation. 5. Approval to include in the evidence spreadsheet followed reviewing the full text.
IFPRI	1. Page was accessed. 2. The "Publications and Tools" tab was opened (https://www.ifpri.org/publications/search). a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity") coupled with (1) "intervention" was included. b. The publication types assessed were briefs, discussion papers, and reports (see search strategy for inclusion and exclusion criteria). c. Publications considered were from 2010 to 2022. d. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. e. Approval to include in the evidence spreadsheet followed screening of the full text.
IFAD	1. Page was accessed (https://www.ifad.org/en/). 2. The "Knowledge" tab was accessed (https://www.ifad.org/en/web/knowledge/publications). a. Three section publications were accessed: "in brief," "research (reports)," and "factsheets." b. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity") coupled with (1) "intervention" and "climate change" was included. c. Publications considered were from 2010 to 2022, in English. d. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. e. e. Approval to include in the evidence spreadsheet followed screening of the full text.
USAID Advancing Nutrition	1. Page was accessed (https://www.advancingnutrition.org/). 2. The "Resources" tab was accessed (https://www.advancingnutrition.org/resources).

Website	Upcoming Plans
	a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity") coupled with (1) "intervention" and "climate change," was included. Lone terms were not used because some surpassed 600 entries. b. Publications considered were from 2010 to 2022, in English. See search criteria for types of publications considered. c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. Approval to include in the evidence spreadsheet followed a screening of the full text. 3. The "Multi-Sectoral Nutrition Resource Review" tab was accessed, and then the "Archive" section was accessed (https://www.advancingnutrition.org/resources/resource-review/archive). a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity") coupled with (1) "intervention" and "climate change," was included. b. Publications considered were from 2010 to 2022, in English. "Reports and tools" publications were considered. c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. Approval to include in the evidence spreadsheet followed screening of the full text.
USAID Bureau for Humanitarian Assistance (BHA) (including BHA Resilience Food Security Activity (RFSA))	1. Page was accessed (https://www.usaid.gov/humanitarian-assistance). 2. The "Policies and Reports" tab was accessed (https://www.usaid.gov/humanitarian-assistance/policies-and-reports). a. The BHA FY 2021 Annual Report was accessed (https://www.usaid.gov/humanitarian-assistance/policies-and-reports/bha-annual-report). i. Nutrition-related terms ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity"), as well as "intervention" and climate change terms (see table A.1) were searched within the document.. b. Publications considered were from 2010 to 2022, in English. See section 2.1 for types of publications considered.

Website	Upcoming Plans
	c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. Approval to include in the evidence spreadsheet followed screening of the full text. 3. The "Multi-Sectoral Nutrition Resource Review" tab was accessed, and then the "Archive" section was accessed (https://www.advancingnutrition.org/resources/resource-review/archive). a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity"), coupled with (1) "intervention" and "climate change," was included. b. Publications considered were from 2010 to 2022, in English. "Reports and tools" publications were considered. c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. Approval to include in the evidence spreadsheet followed screening of the full text.
USAID Climate Links	1. Page was accessed (https://www.climatelinks.org/). 2. The "Resources Library" tab for all resources was accessed (https://www.climatelinks.org/resources). a. In the search box, a nutrition-related term ("nutrition," "undernutrition," "stunting," "wasting," or "diet diversity"), coupled with (1) "intervention" and "climate change," was included. b. Publications considered were from 2010 to 2022, in English. See search criteria for types of publications considered. c. Selection for text screening proceeded after screening the title and abstract/description to include terms related to nutrition outcomes, interventions, and climate change's impacts. d. d. Approval to include in the evidence spreadsheet followed screening of the full text.
USAID Country Development Cooperation Strategies	1. Page was accessed (https://www.usaid.gov/results-and-data/planning/country-strategies-cdcs). 2. Each country profile description was screened to determine whether it fit the search strategy and conceptual framework.

Website	Upcoming Plans
USAID Environment, Energy, and Infrastructure	1. Page was accessed (https://www.usaid.gov/environment-energy-infrastructure). 2. The "Climate Change" section under "Sector Overview" was considered for evaluation. Each of the following tabs related to the search strategy and project objectives was accessed: "Climate Strategy," "Adaptation," "Natural Climate Solutions," and "Country Profiles." a. "Climate Strategy" tab: The *USAID Climate Strategy 2022–2030* document was accessed. Contents were searched to find proposed or implemented adaptation or mitigation interventions in relation to nutrition outcomes. b. "Adaptation tab": Three fact sheets available were accessed. Contents were searched to find proposed or implemented adaptation or mitigation interventions in relation to nutrition outcomes. c. "Natural Climate Solutions" tab: Documents pertaining to the 9 programs outlines were accessed on each website. Contents were searched to find proposed or implemented adaptation or mitigation interventions in relation to nutrition outcomes. These were then discarded because they did not focus on nutrition outcomes. d. "Country Profiles" tab: Each profile description was screened for the following terms: "food security," "nutrition security," "malnutrition," "nutrition," "stunting," "wasting," and "undernutrition," in relation to climate change terms (see table A.1). Profile descriptions that contained inclusion terms were selected for revision.

Figure A2. Gray Literature Search Diagram Based on the PRISMA Protocol



Annex 4. Evidence from Modeled Interventions Identified in the Review

Food Security and Nutrition

Across a suite of modeled studies, multiple factors were associated with food/nutrition security. Climate shocks and stressors can influence both agricultural strategies and dietary strategies among smallholder farmers, according to a qualitative study of 32 male farmers in Burkina Faso (Sorgho et al. 2020). Infrastructure, including access to electricity (Mainardi 2021), was associated with greater ability to respond to climate change, which was associated with lower food insecurity, in a study of 50 farm households across 20 districts in Ethiopia. Expanded irrigation scenarios and investment in agricultural research modeled globally resulted in 7–40 percent higher per capita calorie availability in "developing countries" (the term used in the article) by 2050. This were expected to lead to 60 percent fewer malnourished children by 2050 in a large-scale modeling study across the Arab region using scenarios and the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT model) (Sulser et al. 2011).

Many social and demographic factors were associated with food security and nutrition outcomes modeled under climate change scenarios. Households with older household heads were more likely to be flooded, and flooding exposure decreased calorie consumption by 60kcal, as well as decreased iron, vitamin A, and vitamin C deficiency by 11, 12, and 27 percent, respectively. Flooding was also associated with lower diet quality in a study in Afghanistan using national survey data (population size not identified) (Oskorouchi and Sousa-Poza 2021). Women were modeled to be most vulnerable to food insecurity resulting from climate changes due to institutional barriers to access credit and property rights in a 50 smallholder farmer household survey study in Ethiopia (Mainardi 2021). Larger households, in the context of variable rainfall, were associated with greater food security in a multiyear panel modeling study in Ethiopia across 450 to 1,477 rural households (Demeke et al. 2011), while access to education and extension services were positively associated with food security during drought among pastoralists in Pakistan (Ahmad and Afzal 2021) using data from 768 pastoralist households and mixed method surveys, focus groups, and regression models.

Implementation of agricultural management or animal ownership was associated with greater food security in several modeled studies. Adoption of conservation practices, veterinary access, pasture regeneration, and growing fruit trees was positively associated with food security among pastoralists in Pakistan (Ahmad and Afzal 2021). Livestock ownership was also associated with better food security outcomes in variable rainfall changes (Demeke et al. 2011), while agricultural inputs and fertilizer were associated with reduced food insecurity in households experiencing wetter than average rainfall years, and drier than average year households (for fertilizer only) in a study using survey data of 1,955 households from 14 LMICs coupled with 30 years of historical rainfall data (Niles and Brown 2017).

Multiple studies indicate financial factors associated with reduced food insecurity during climate change events and impacts, including among households with access to credit (Ahmad and Afzal 2021), local savings groups (Demeke et al. 2011), financial services for drier than average households (Niles and Brown 2017), and that participate in unconditional cash transfer programs (Lawlor et al. 2017). For the latter, cash transfer programs increased food expenditures during a climate shock, and reduced the probability of being severely food insecure by 22 to 23 percentage points among those shocked by climatic events, using data from 4,817 households in three rural areas of Zambia, with 2,404 receiving the cash transfer and 2,413 in a control group (Lawlor et al. 2017).

Further and related evidence suggests that women are most vulnerable to climate-induced food insecurity due to institutional barriers to access credit and property rights (Mainardi 2020). Lower-

income households, as well as rural households, and people living in valleys and hills, are vulnerable to climate shocks and stresses. These include flooding, which decreases household calorie consumption, and is associated with lower diet quality and decreased iron, vitamin A, and vitamin C (Oskorouchi and Sousa-Poza 2020). Other studies identify characteristics of households that also increase vulnerability to food insecurity during climate-related shocks and stressors. These include lower food insecurity among agricultural laborers and farmers than nonagricultural workers, which is largely driven by lack of land access, as shown in a cross-sectional study of 3,840 household surveys from a national data set using agent-based models in Malawi (Dobbie et al. 2018).

Diet Diversity

Modeled interventions exploring diet diversity outcomes demonstrated that climate-related shocks and stressors can influence diet diversity. These include through La Niña events, which result in a shift toward starches in the diet, as shown by a longitudinal study of 252 mother-child dyads using 24-hour dietary recall and panel regression models (Ambikapathi et al. 2021). In this study (based in the Peru and Amazon basin), girls had a higher diet diversity than boys, but households with girls also had 16 percent higher consumption of donated foods. Similarly, Niles et al. (2021) found that children five and under in male-headed households were associated with lower diet diversity in a modeling study that used USAID Demographic and Health Surveys Program (DHS) data from over 107,000 children in 19 LMICs, coupled with 30 years of temperature and rainfall data explicit to the household location. In the same study, the following factors were also associated with higher diet diversity among children five and younger: older children, improved toilets, higher education of the household head, and higher than average precipitation in the year before the survey data collection. Reductions in diet diversity were associated with higher livestock density, higher than average long-term temperatures, higher than average temperature anomalies in the year before survey data collection, and greater distance to urban centers and roads (Niles et al. 2021).

Undernutrition

This evidence review identified many peer-reviewed articles modeling the association of numerous factors with undernutrition outcomes. These studies also affirmed associations between climate stresses and shocks and undernutrition outcomes, including stunting and wasting. Cooper et al. (2019) identified greater mean precipitation mitigated drought's effect on stunting in a modeling study coupling DHS with climatic data across more than 50 LMICs, while higher monthly maximum temperatures worsened it. Other studies, including Khan et al. (2022), which used DHS and climate data in their models with 19,896 child observations, confirm these findings, with temperature having an inverse relationship to stunting and rainfall having nonlinear associations with stunting; both too little and too much were associated with higher levels of stunting in Bangladesh. Yeboah et al. (2022), using household survey data from 12,919 children in Burkina Faso coupled with rainfall data and modeling, identified similar patterns where rainfall below 75mm monthly average tended to produce poor nutritional outcomes, but that rainfall's relationship to undernutrition was also nonlinear in Burkina Faso. Higher temperatures were modeled to demonstrate that every 1 degree C increase in daily mean temperature was associated with a 2.5 percent increase in hospitalizations for undernutrition in the preceding 0–7 days (which was greatest for individuals aged 80 years or older, and children 18 and under) in Brazil, where Xu et al. (2019) used data from 1,814 cities and 238,320 hospitalizations in a time-stratified case-crossover design. Climate shocks including floods were associated with greater odds of stunted children in a cross-sectional study with regression models built on retrospective data from 757 flooded and 816 non-flooded households in India. Stunted children were 1.6 times greater odds in flooded households than non-flooded households, and underweight was 1.86 greater odds in flooded village households compared with non-flooded village households (Rodriguez-Llanes 2011).

Pacillo et al. (2022) went further to model that climate variability mediates the factors that predict stunting in Vietnam, using a whole population predictive model with national data sources and open-

source earth observations data. This included that in areas of high climate variability, stunting can be significantly predicted based on economic activities, minority ethnicity, education, health of mothers, and the level of readiness and preparedness to climate impacts of villages and communities. Conversely, in areas of low climate variability, stunting is mostly predictable based on the ability of households to access essential services (such as education, health) and communal resources (water, storage, etc.) (Pacillo et al. 2022). As a result, Pacillo et al. (2022) recommend that in areas of low climate variability, monitoring nutrition insecurities and climate resilience capacities of households and communities should be focused on mountainous areas, where access to essential services and communal resources is lower. In areas with higher climate variability, monitoring climate resilience capacities of households and communities should be carried out on a selection of sociodemographic factors and less on location-specific drivers. Relatedly, Khan et al. (2022) using DHS and climate data, identified environmental characteristics of regions with higher association of stunting during rainfall and temperature anomalies, including distance to protected areas, vegetation index (both nonlinear), and greater distance to water bodies positively associated with stunting. As a result, Khan et al. concluded that "these characteristics should be taken into account during intervention design to minimize the negative effects of environmental change on child health" (Khan et al. 2022).

In addition to the environmental characteristics of regions, many studies modeled the relationship of household or individual characteristics on undernutrition outcomes during climate shocks and stressors. Education, including both lower maternal education (Bahru et al. 2019, 2,000 child observations across four rounds of cohort data in Ethiopia, and Dimitrova 2021, 21,551 child observations from three rounds of DHS data in Ethiopia), and lower paternal education (Rodriguez-Llanes et al. 2016, 684 communities, 299 flooded, 385 non-flooded using two-stage population-based survey of children, anthropometric measurements, and interviews) were associated with higher prevalence of child stunting and wasting. Younger children were found to be more susceptible to stunting in Mali using DHS data from 14,238 children under 5 and climate data (Jankowska et al. 2012) and also in Burkina Faso (Yeboah et al. 2022). There were some conflicting results related to gender in the literature, where Dimitrova (2021) in Ethiopia found that boys and twins were more likely to be stunted and wasted during drought in the main agricultural season, which they indicate lends support to the "male fragility" literature, while Yeboah et al. (2022) in Burkina Faso found no significant differences between average lifetime rainfall exposure and stunting outcomes between boys and girls (both were negative). Similarly, Block et al. (2021), using secondary data from children and mothers and regression modeling, linked agricultural yield losses in Tanzania during extreme heat to pregnant mother's body mass, which was associated with postnatal stunting for boys, but not girls. Delayed motherhood overall was also associated with 3.4 percent lower prevalence per year in child wasting in flood areas in India (Rodriguez-Llanes 2016).

Household locations and financial resources were associated with undernutrition outcomes across a number of modeled studies. Not surprisingly, many studies identify that children from poor households are the most affected by stunting and wasting, including during droughts (Dimitrova 2021, Drysdale et al. 2020 in South Africa, using cross-sectional household surveys during and after drought among 431 children and 387 children in two rounds of data collection) and after floods (Rodriguez-Llanes 2016). However, Yeboah et al. (2022) identified that rainfall and stunting relationships were not linear in Burkina Faso, and that while children from all wealth quintiles were negatively affected by reduced rainfall, the effect was greatest for poorer (but not poorest) households. Relatedly, water and sanitation strategies were associated with different undernutrition outcomes during climate-related shocks and stressors in South Africa, where reduced wasting and reductions in underweight were associated with children using a pit latrine and having access to public standpipes or a shower in the household during a drought (Drysdale et al. 2020).

Modeled interventions showed variability about the effect of rural versus urban household classification and characteristics on undernutrition outcomes during climate shocks and stressors. Topographic ruggedness was associated with worse stunting outcomes during drought (Cooper et al. 2019), and rural

regions overall had worse stunting than urban regions across 53 countries of study. As well, rice and plateau livelihood regions had more prevalence of stunting than pastoral regions in Mali, likely driven by the climate related livelihoods (i.e. those impacted by climate) in these areas that fail to support cereal crops. However, arid regions had significantly lower anemia, likely because of livestock rearing common in those areas and the meat and iron consumption (Jankowska et al. 2021). However, Cooper et al. (2019) and Drysdale et al. (2020) found stronger associations with stunting in higher population densities and with urban children during drought. Nicholas et al. (2021), using DHS data from 6,985 children coupled with climate data and regression modeling, found nuance in this finding. Urban children in the Peruvian Amazon had higher stunting associated with temperature extremes. However, rural indigenous children had higher stunting during prenatal excess rainfall, while urban nonindigenous children had higher stunting with postnatal excess rainfall (Nicholas et al. 2021).

Numerous studies modeled the effect of agricultural strategies on undernutrition outcomes. These strategies included higher nutritional diversity of local agricultural systems, irrigation, greater import of foods, and staple crop production. All were associated with reduced stunting during drought (Cooper et al. 2019). Chicken husbandry had the greatest positive impact across a suite of adaptation strategies in reducing both wasting and stunting during drought in Eswatini, using data from 300 smallholder farmers and regression models (Bailey et al. 2019).

Finally, government interventions and policies were modeled in a few studies. These findings included that a community health care worker program improved infant mortality rates, while a public work program did not in India during high temperatures, using data from over 500,000 infants and in utero children and regression models (Banerjee and Maharaj 2019).

Annex 5. Additional Proposed Interventions Identified in the Review

Adaptation

Food Security and Nutrition

In many articles, interventions were also proposed to adapt and respond to climate change stresses and shocks. In many cases, these proposed interventions were coping strategies to maintain food security and nutrition, rather than improve these outcomes. These are included here for depth for USAID, as they may suggest additional intervention strategies not previously considered. The following were additional proposed interventions identified in the peer-reviewed literature:

- Agricultural
    - Irrigation (Hawkins et al. 2022)
    - Retaining small livestock (chickens specifically) for reserve income and food (Hawkins et al. 2022)
    - Agricultural inputs (Hawkins et al. 2022)
    - Improved storage capacity for water and crops (Hawkins et al. 2022)
    - Fishponds (Limuwa et al. 2018)
    - Crop management including adopting drought-tolerant crops, changing crop cycles, riverbed farming, contingency crop planning, changing planting dates, and planting short-duration varieties (Neupane et al. 2022)
- Dietary
    - Sharing food (Hawkins et al. 2022)
- Education
    - Male participation in cooking and nutrition classes (Cheruiyot et al. 2022)
    - Knowledge transfer for growing and utilizing unfamiliar and untraditional crops (Rufino et al. 2013)
- Employment and livelihoods
    - Within village livelihood options for women to minimize disruptions to maternal care (such as the time spent away from home for gather water and food, which reduces time allocated to child feeding) (Irenso et al. 2022)
    - Out-migration (Neupane et al. 2022)
- Extension and technical assistance
    - Reliable weather information for illiterate farmers, incorporation of traditional knowledge with science-based weather forecasts, and expansion of extension services (Sorgho et al. 2020)
- Government and policy
    - Policies to promote consumption of indigenous crops, including cassava, sorghum, millet, and pigeon pea (Rufino et al. 2013)
    - Policies to support safety nets, markets, and infrastructure (Rufino et al. 2013)
- Land access and ownership for women (Bryson et al. 2021).

Undernutrition and Micronutrient Deficiency

One study in Zimbabwe that conducted an assessment of hospitals' and health care facilities' (n=19) preparedness for climate-related shocks and stresses (drought in particular) proposed improving access to availability of mineral vitamin mix, resomal, and micronutrient powder stocks, as well as supplementary food stocks. This same study also identified proposed interventions to include increasing health worker training for the management of acute malnutrition, as 94 percent of facilities they identified had less than 50 percent of their health workers trained in this issue. A total of 26 percent (5/19) of the facility hospitals and 32 percent (6/19) of the primary health care facilities were not admitting according to integrated management of acute malnutrition protocol. Sixty-three percent (12/19) had none of their staff trained in infant and young child feeding, 58 percent (11/19) had no staff trained in growth monitoring, and 63 percent (12/19) of the facilities had no trained staff in baby-friendly hospital initiative. All were identified as important and critical interventions for responding to climate change stresses and shocks (Sithole et al. 2021).

Mitigation

Proposed interventions using a climate mitigation approach in the gray literature were scarce: just two for improving food security and nutrition. First was a proposed set of interventions by USAID to reduce undernutrition in various countries, including carbon sequestration and GHG emissions reduction through climate-smart agriculture (USAID 2022). Second was a proposed intervention for Uganda, Vietnam, and the Philippines, focused on improving food security and food production. This intervention included activities involving ecosystem services and use of biodiversity to help people adapt to climate change impacts while safeguarding their livelihoods and the resources they depend on (USAID 2017). No proposed interventions used a climate mitigation approach that addressed dietary diversity or micronutrient deficiency. Nonetheless, one example focused on undernutrition (stunting and wasting). A proposed intervention in Malawi to reduce undernutrition and incidence of hunger periods included developing sustainable management practices for vulnerable and erosion-prone lands, which may also have mitigation co-benefits (Chakrabarti 2017).

FEED THE FUTURE
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USAID ADVANCING NUTRITION

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