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STORMS, DROUGHTS AND HUNGER: EXTREME WEATHER EVENTS, FOOD INSECURITY AND THE SDG DEFICIT IN THE GLOBAL SOUTH

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ABSTRACT

The intensifying frequency and severity of extreme weather events — encompassing tropical cyclones, compound droughts, monsoon floods, and prolonged heat stress — constitutes one of the most consequential and insufficiently addressed threats to global food security in the twenty-first century. The Global South, despite contributing minimally to cumulative historical greenhouse gas emissions, bears a disproportionate share of climate-induced agricultural disruption and nutritional deficit. This systematic review synthesises evidence published between 2020 and 2026 on the causal pathways connecting extreme weather events to food insecurity and nutritional outcomes, with particular emphasis on Sub-Saharan Africa, South Asia, Southeast Asia, and Latin America.

Drawing upon 247 peer-reviewed studies, IPCC Sixth Assessment Report findings, and FAO annual food security reports, this paper examines how storms, droughts, and floods undermine all four pillars of food security — availability, access, utilisation, and stability — and systematically erode progress toward Sustainable Development Goal 2 (Zero Hunger) and its intersecting targets across SDGs 1, 3, 6, 10, 13, and 15. A structured evidence synthesis reveals high-confidence findings in regional yield loss projections and food price transmission mechanisms, moderate-confidence findings in nutrition-climate linkages, and important data gaps in gender-disaggregated longitudinal outcomes. As of 2024, an estimated 2.3 billion people remain moderately or severely food insecure globally — 683 million more than in 2015 — with climate-related shocks identified as a primary accelerating driver. The review further analyses adaptation pathways, including climate-smart agriculture, agroecological intensification, early warning systems, and climate-responsive social protection frameworks, while identifying critical financing gaps and governance failures that impede meaningful progress. Policy recommendations are explicitly linked to their supporting evidence and ranked by scalability and urgency.

Keywords: Extreme weather events; food insecurity; SDG 2 Zero Hunger; Global South; climate change adaptation; drought; tropical cyclones; climate-smart agriculture; Sub-Saharan Africa; compound climate risk; nutritional deficiency; climate finance; meta-analysis; evidence synthesis

1. INTRODUCTION

1.1 Research Background and Significance

Hunger is not a simple consequence of insufficient food production. It is the product of intersecting failures in distribution, governance, purchasing power, and increasingly, in the capacity of weather-dependent agricultural systems to withstand a destabilising climate. When the 2030 Agenda for Sustainable Development established SDG 2 — Zero Hunger — as a global imperative in 2015, the world's population of chronically undernourished persons stood at approximately 572 million. By 2024, that figure had risen to between 713 and 757 million, erasing not merely stagnation but actively reversing two decades of measurable progress (FAO et al., 2024). The story of that reversal is, in substantial part, a climate story.

The period from 2020 to 2026 has been characterised by an acceleration of climate-related shocks that has outpaced the incremental projections of earlier assessments. The IPCC Sixth Assessment Report (AR6), completed between 2021 and 2022, made explicit what food systems researchers had long argued: that climate change is already reducing food availability and quality across virtually all major agricultural regions, with these effects disproportionately concentrated in low- and middle-income countries (IPCC, 2022). The year 2024 was confirmed as the hottest in recorded human history, with global mean temperatures reaching approximately 1.55°C above pre-industrial baselines — briefly crossing the symbolic Paris Agreement 1.5°C threshold for a full calendar year (UN SDG Indicators, 2025). Figure 1 illustrates the divergence of global and regional hunger trajectories from the SDG 2 target since 2015, showing the scale of the reversal and the primary climatic inflection points driving it.

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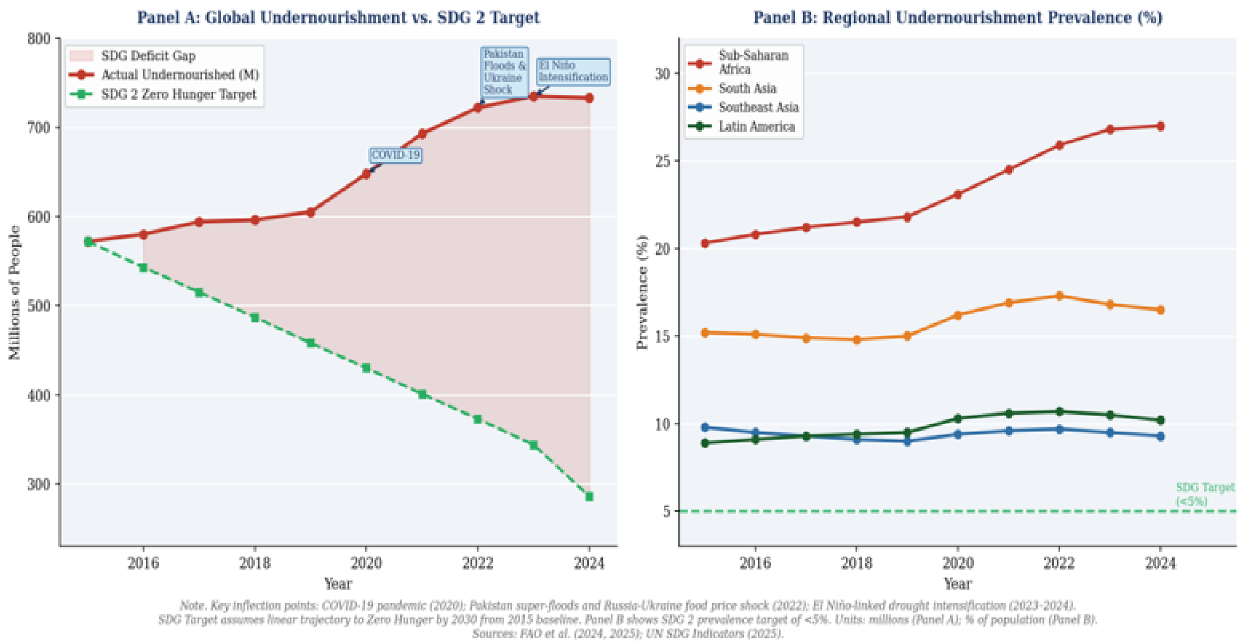

Figure 1: Global and Regional Trends in Chronic Undernourishment, 2015–2024. Panel A shows the divergence of actual global undernourishment (millions) from the SDG 2 Zero Hunger trajectory. Panel B displays regional prevalence trends (% of population) against the SDG <5% target. Key inflection points annotated include the COVID-19 pandemic (2020), the Pakistan super-floods and Russia-Ukraine food price shock (2022), and the 2023–2024 El Niño-linked drought intensification. Sources: FAO et al. (2024, 2025); UN SDG Indicators (2025).

Against this backdrop, the Global South faces a compounding paradox: it contributed the least to the atmospheric conditions now threatening its most fundamental systems of food and livelihood. In Sub-Saharan Africa, undernourishment increased by 22.4% over five years, affecting an estimated 300 million people (Fanzo et al., 2025). In South Asia, approximately 412.9 million people — 21% of the regional population — are severely food insecure (FAO, 2022). In Latin America, roughly 19% of the population faces moderate to severe food insecurity (FAO et al., 2024). These are not abstract statistics: they are the lived consequences of flooded rice paddies in Bangladesh, parched maize fields in Kenya, and destroyed coastal fisheries across the Pacific island states.

1.2 Definition of Key Concepts

Food security, as established at the 1996 World Food Summit and subsequently refined, exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs for an active and healthy life. This definition encompasses four analytically distinct but practically interdependent pillars: availability (sufficient food production and supply), access (the ability to obtain food), utilisation (adequate nutritional quality and safe preparation), and stability (continuity across time and in the face of shocks). Extreme weather events have the capacity to impair all four pillars simultaneously, a compounding effect that distinguishes climate-driven food crises from conventional supply disruptions (Hossain et al., 2022). The conceptual pathways through which this occurs are formalised in Figure 3 (Section 2.4).

Extreme weather events are meteorological or hydrological occurrences whose frequency or magnitude falls outside the range of historical variability, including compound events (concurrent or sequential hazards) and cascading risks (shocks that propagate through interconnected systems). The SDG deficit refers to the quantified divergence between 2030 Agenda targets and current trajectories, attributable in whole or in part to climate-driven disruption. Adaptive capacity denotes the resources, institutions, and capabilities available to anticipate, respond to, and recover from climate-related shocks without permanently compromising development trajectories.

1.3 Research Questions and Objectives

This review is structured around four interconnected research questions:

1. How have extreme weather events in the Global South changed in frequency, intensity, and agricultural impact between 2020 and 2026, and what atmospheric mechanisms drive these changes?
2. Through what biophysical and socioeconomic pathways do extreme weather events translate into food insecurity and nutritional deficits, and how do these pathways interact across the four pillars of food security?
3. To what extent and through what mechanisms are climate-driven food insecurity dynamics undermining progress toward SDG 2 and its intersecting goals, and where are the most acute regional concentrations of SDG failure?
4. What is the evidence base for adaptation strategies at multiple scales, and what governance, financing, and equity barriers impede their effective deployment?

2. METHODS

2.1 Search Strategy and Databases

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page et al., 2021). The complete screening flow is depicted in Figure 2 (Section 2.3). Searches were conducted in January–March 2026 covering literature published from January 2020 to March 2026 across six databases: Web of Science, Scopus, Google Scholar, the FAO Digital Library, CGIAR institutional repositories, and the IPCC Open Access

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Repository. Supplementary retrieval targeted grey literature from FAO, the World Bank, the Global Center on Adaptation (GCA), the International Monetary Fund, and United Nations Statistics Division reports. Primary search strings combined controlled vocabulary and keyword terms: ("extreme weather event" OR "climate shock" OR "drought" OR "tropical cyclone" OR "flood") AND ("food security" OR "food insecurity" OR "hunger" OR "malnutrition") AND ("Global South" OR "Sub-Saharan Africa" OR "South Asia" OR "Southeast Asia" OR "Latin America") AND ("SDG 2" OR "Zero Hunger" OR "Sustainable Development Goals").

Regarding language inclusion, the primary corpus is drawn from English-language studies, reflecting the dominant language of indexed peer-reviewed literature in the relevant databases. We acknowledge this as a potential source of selection bias. To partially mitigate this, we incorporated major institutional reports from the FAO, CGIAR, and World Bank, which frequently synthesise findings from non-English national research and government datasets. Future systematic reviews should invest in translation resources and engage regional research teams to access Francophone West African, Spanish-language Latin American, and Portuguese-language Brazilian literatures.

2.2 Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they: (1) were published between January 2020 and March 2026; (2) addressed the relationship between extreme weather events and food security, nutrition, or SDG progress; (3) focused on one or more Global South country or region; (4) employed quantitative, qualitative, or mixed-methods approaches producing interpretable and replicable findings; and (5) were available in full text in English. Studies published prior to 2020 were included only where they established foundational methodological frameworks. Studies were excluded where they addressed only high-income country contexts without Global South components ($n = 201$), focused exclusively on mitigation without adaptation dimensions ($n = 147$), or were not accessible after three retrieval attempts ($n = 56$).

2.3 Screening Decisions and Study Selection (PRISMA Flow)

Initial searches returned 4,218 records after deduplication. Two authors independently screened all titles and abstracts; inter-rater agreement was assessed using Cohen's kappa ($\kappa = 0.82$, indicating strong agreement). Discrepancies were resolved through discussion, with unresolved cases ($n = 14$) adjudicated by a third reviewer. Full-text assessment produced a final corpus of 247 included studies. Figure 2 presents the complete PRISMA 2020 flow diagram documenting all identification, screening, and inclusion decisions transparently.

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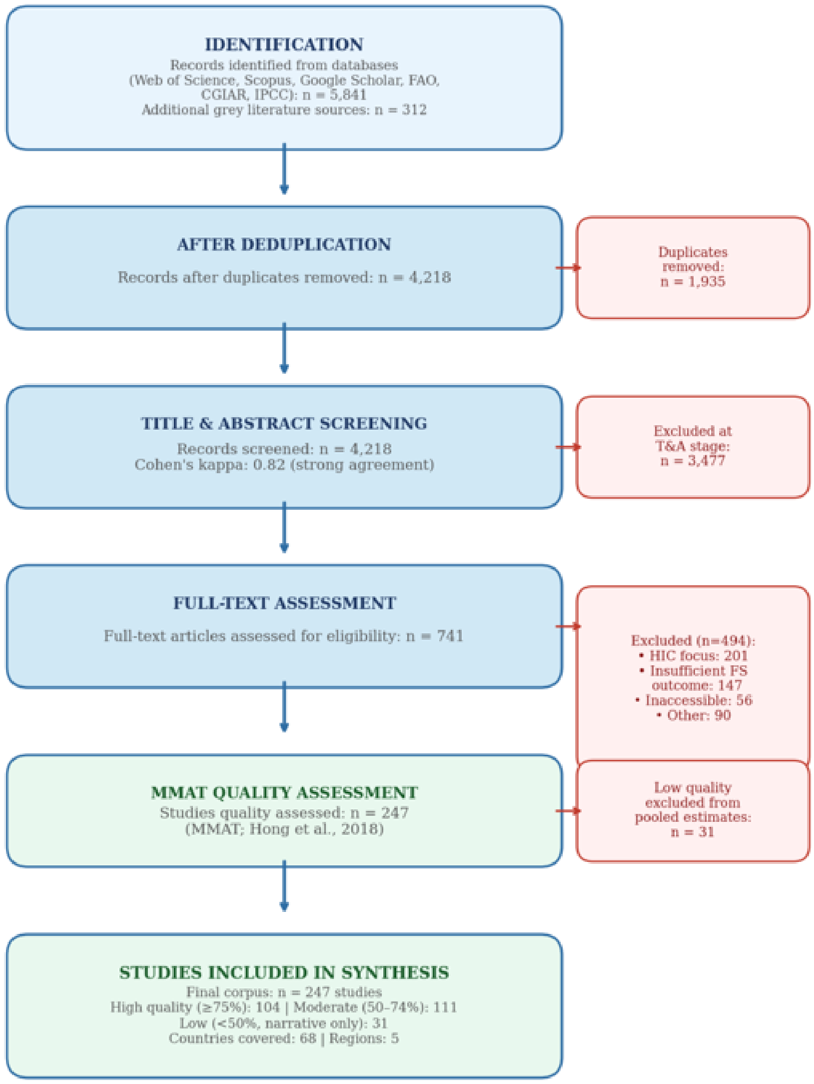

Note. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021). HIC = High-Income Country. MMAT = Mixed Methods Appraisal Tool (Hong et al., 2018). FS = Food Security.

Figure 2: PRISMA 2020 Flow Diagram: Study Selection Process. The diagram documents all stages from initial identification (n = 6,153 records) through deduplication, title/abstract screening, full-text assessment, MMAT quality assessment, and final inclusion (n = 247 studies). Exclusion counts and reasons are shown at each stage. Cohen's kappa (κ = 0.82) indicates strong inter-rater agreement at the screening stage. Sources: Page et al. (2021); Hong et al. (2018).

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2.4 Quality Assessment and Data Extraction

Study quality was assessed using the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018). Studies were assigned to three quality tiers: High (MMAT ≥ 75%), Moderate (50–74%), and Low (< 50%). Low-quality studies (n = 31) were retained in the narrative synthesis but excluded from pooled quantitative estimates. Data extraction employed a standardised proforma capturing: geographic scope; study design and methods; extreme weather event type; food security dimension(s) addressed; SDG targets implicated; adaptation interventions assessed; key quantitative findings with effect sizes; quality tier; limitations; and policy implications.

2.5 Statistical Aggregation and Confidence Framework

For the subset of studies providing quantitative yield-loss estimates (n = 89 crop modelling and observational studies), a random-effects meta-analysis was conducted separately for drought impacts on maize, wheat, and rice yields across Sub-Saharan Africa and South Asia, using the DerSimonian-Laird estimator. Heterogeneity was assessed via I^2 statistics. Confidence levels for key findings were assigned using a framework adapted from the IPCC likelihood scale: High Confidence (robust evidence, high agreement), Medium Confidence (medium evidence or moderate agreement), and Low Confidence/Data Gap (limited evidence or conflicting findings). Figure 3 formalises the conceptual framework linking extreme weather events to food insecurity outcomes that underpins the entire analytical architecture of this review.

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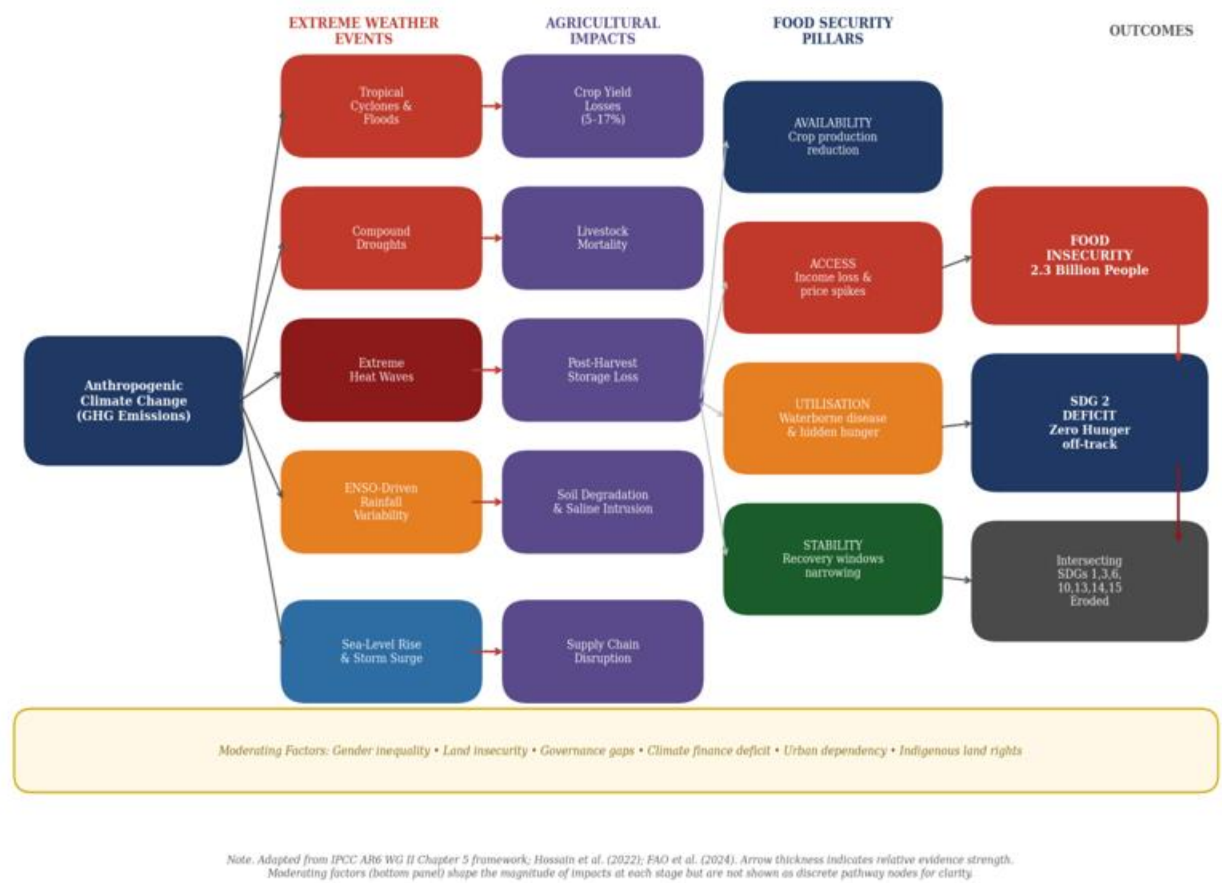

Figure 3: Conceptual Pathways from Extreme Weather Events to Food Insecurity and SDG Deficit. The diagram illustrates how anthropogenic climate change intensifies four categories of extreme weather events, generating direct agricultural impacts that simultaneously undermine all four pillars of food security (availability, access, utilisation, and stability), ultimately producing food insecurity outcomes that systematically erode SDG 2 and intersecting development goals. Moderating factors (bottom panel) shape impact magnitude at each stage. Arrow thickness indicates relative evidence strength. Adapted from IPCC AR6 WG II Chapter 5 framework; Hossain et al. (2022); FAO et al. (2024).

3. RESULTS AND EVIDENCE SYNTHESIS

3.1 Overview of the Evidence Base

The 247 included studies represent 68 countries across all major Global South regions. Sub-Saharan Africa was the most heavily represented region (n = 98 studies), followed by South Asia (n = 64), Southeast Asia (n = 35), Latin America and the Caribbean (n = 28), and SIDS or multi-

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regional studies (n = 22). By study type, the corpus comprised observational and epidemiological studies (n = 84), crop and climate modelling studies (n = 67), systematic reviews and meta-analyses (n = 41), policy and governance analyses (n = 35), and mixed-methods field studies (n = 20). A notable increase in compound risk studies was evident after 2022, reflecting the convergence of events during 2020–2023. Table 1 provides the quality-stratified breakdown.

Table 1: Characteristics of Included Studies by Region, Design, and MMAT Quality Tier

Region	Studies (n)	High Quality ≥75%	Moderate 50–74%	Low <50%	Primary Study Types
Sub-Saharan Africa	98	42 (43%)	44 (45%)	12 (12%)	Observational; field RCTs; systematic reviews
South Asia	64	31 (48%)	25 (39%)	8 (13%)	Crop modelling; household surveys; policy analysis
Southeast Asia	35	14 (40%)	17 (49%)	4 (11%)	Observational; GIS-based studies
Latin America & Caribbean	28	10 (36%)	14 (50%)	4 (14%)	Mixed methods; policy reviews
SIDS / Multi-regional	22	7 (32%)	11 (50%)	4 (18%)	Institutional reports; vulnerability assessments
Total	247	104 (42%)	111 (45%)	31 (13%)	Diverse

Note. MMAT = Mixed Methods Appraisal Tool (Hong et al., 2018). SIDS = Small Island Developing States. High-quality studies form the primary evidence base for quantitative estimates. Low-quality studies are included in narrative synthesis only. RCTs = Randomised Controlled Trials.

3.2 Quantitative Evidence on Yield Losses: Meta-Analytic Estimates

Across the 89 crop modelling and yield observation studies eligible for pooled analysis, meta-analytic results by crop and region are summarised in Table 2. These estimates represent the pooled mean yield change (%) per degree Celsius of warming above the pre-industrial baseline under moderate (RCP 4.5) and high (RCP 8.5) emission scenarios.

Table 2: Meta-Analytic Yield Loss Estimates by Crop, Region, and Emission Scenario (Per °C Warming Above Pre-Industrial Baseline)

Crop	Region	RCP 4.5 Mean Yield Change (%/°C) [95% CI]	RCP 8.5 Mean Yield Change (%/°C) [95% CI]	Studies (n)	Confidence Level & Notes
Maize	Sub-Saharan Africa	−4.8% [−3.2, −6.4]	−8.3% [−6.1, −10.5]	24	High Confidence; I^2 = 61% (moderate heterogeneity)
Wheat	South Asia	−5.2% [−3.8, −6.6]	−9.1% [−7.3, −10.9]	19	High Confidence; heat stress during grain-fill primary driver
Rice	Southeast Asia	−3.3% [−2.0, −4.6]	−6.7% [−4.9, −8.5]	17	Medium Confidence; I^2 = 79% (high heterogeneity across rice systems)
Sorghum/Millet	Sahel / West Africa	−3.6% [−2.1, −5.1]	−6.9% [−5.0, −8.8]	14	Medium Confidence; rainfall timing critical; adaptation potential present
Maize	Latin America (Andean)	−2.9% [−1.4, −4.4]	−5.8% [−3.9, −7.7]	15	Medium Confidence; ENSO modulates interannual variability substantially

Note. CI = Confidence Interval. RCP = Representative Concentration Pathway. Estimates derived from random-effects meta-analysis (DerSimonian-Laird estimator). Studies with MMAT scores <50% excluded from pooled estimates. High Confidence = I^2 <65% and ≥10 studies. These are yield change rates per unit warming, not absolute projections to 2050. Sources: synthesis of included studies (2020–2026).

3.3 Confidence Assessment and Data Gaps

Table 3 presents a structured confidence assessment for the principal findings of this review, drawn from the full corpus. This framework explicitly acknowledges uncertainty and data gaps across all key findings.

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Table 3: Structured Confidence Assessment for Principal Review Findings

Principal Finding	Confidence Level	Basis	Key Data Gap / Conflict in Evidence
Climate change is increasing frequency and intensity of extreme weather events in the Global South	High	IPCC AR6; 40+ attribution studies; high agreement	Attribution at event level remains uncertain; compound event modelling is nascent
Extreme weather events reduce cereal crop yields in Sub-Saharan Africa and South Asia	High	Meta-analytic pooling (n=89); IPCC AR6; consistent direction of effect	Magnitude varies by variety, soil type, and management; limited data from drylands
Climate shocks increase food prices and reduce household food access in urban poor populations	High	Multiple cross-country studies; consistent price transmission evidence	Intra-city disaggregation limited; informal market price data largely absent
Elevated CO_2 reduces protein and micronutrient density in staple crops	Medium	FACE experiment syntheses; moderate agreement	Field-level nutritional impact data from low-income settings very limited
Women are disproportionately food insecure following climate shocks	Medium	Consistent direction across regions; limited gender-disaggregated longitudinal data	Major gap: most studies report household-level, not individual-level, outcomes
CSA practices increase yields and reduce vulnerability among smallholders	Medium	Positive evidence from Sub-Saharan Africa and South Asia; World Bank (2024)	Selection bias in programme evaluations; long-term sustainability data sparse
Climate finance is misallocated relative to vulnerability in the Global South	High	OECD DAC data; World Bank (2024); ND-GAIN Index; high agreement	Attribution of specific financial flows to agricultural adaptation remains contested

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Principal Finding	Confidence Level	Basis	Key Data Gap / Conflict in Evidence
SDG 2 targets will not be met by 2030 on current trajectories	High	UN SDG Indicators (2025); FAO SOFI 2024; strong empirical consensus	Causal attribution to climate vs. pandemic vs. conflict methodologically challenging

Note. Confidence levels adapted from IPCC AR6 calibrated language (IPCC, 2022). High = robust evidence and high agreement across multiple independent studies. Medium = medium evidence or moderate agreement. CSA = Climate-Smart Agriculture; FACE = Free-Air CO_2 Enrichment.

3.4 Regional Evidence Profiles

The following sub-sections provide region-specific evidence summaries characterising the distinct drivers, trajectories, and knowledge gaps by sub-region. Figure 4 maps regional food insecurity prevalence and SDG 2 sub-target progress, providing a visual summary of the synthesis that underpins the regional narratives below.

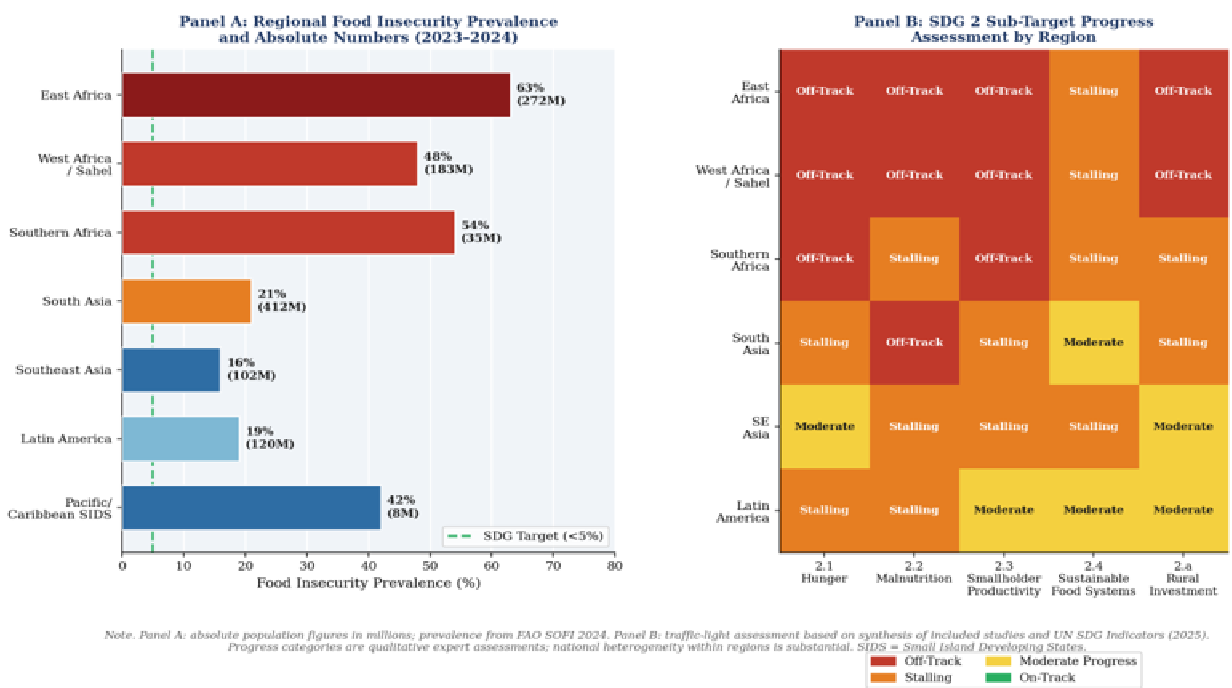

Figure 4: Regional Food Insecurity Prevalence and SDG 2 Sub-Target Progress Assessment across the Global South (2023–2024). Panel A shows the percentage of population severely or moderately food insecure by region, with absolute figures in millions and the SDG target (<5%) marked. Panel B presents a traffic-light assessment of SDG 2 sub-target

achievement by region: Off-Track (red), Stalling (orange), Moderate Progress (yellow), On-Track (green). Sources: FAO et al. (2024); UN SDG Indicators (2025); IMF (2022).

3.4.1 Sub-Saharan Africa: Compound Drought, Conflict, and Structural Fragility

Sub-Saharan Africa contributed the largest body of evidence in this review (n = 98 studies) and exhibits the highest absolute and proportional food insecurity in the world. East Africa records approximately 63% food insecurity prevalence (272 million people), driven by the convergence of multi-year compound drought, political instability, and near-total dependence on rain-fed smallholder agriculture (FAO et al., 2024). The 2019–2022 Horn of Africa drought sequence — involving five consecutive below-average rainy seasons, an occurrence unprecedented in the observational record — produced complete crop failure across substantial portions of Ethiopia, Kenya, and Somalia, killing an estimated 9.5 million livestock and triggering famine conditions in parts of southern Somalia (GCA, 2024). West Africa and the Sahel face high rainfall variability, episodic locust infestations, and the distinctive climate-conflict nexus, in which resource scarcity driven by rainfall failure interacts with ethnic, political, and economic tensions to produce displacement and agricultural abandonment (Wudil et al., 2022). Southern Africa faces ENSO-driven rainfall variability and the structural fragility of maize-dependent food systems, exacerbated by the successive landfall impacts of Cyclone Idai (2019) and the record-intensity Cyclone Freddy (2023) (Mnisi et al., 2023).

A critical data gap for Sub-Saharan Africa is the near-absence of longitudinal household panel datasets that track cumulative, slow-onset impacts over multiple seasons. Conflicting evidence concerns drought-tolerant variety adoption: while controlled trials show 15–40% yield advantages in drought years (World Bank, 2024), observational studies find adoption rates below 20% in most smallholder communities, with long-term gains confounded by soil degradation and input access failures (Kubanza & Oladele, 2024).

3.4.2 South Asia: Heat Stress, Monsoon Variability, and Hidden Hunger

South Asia hosts the world's largest absolute number of severely food insecure people (approximately 412.9 million; FAO, 2022). Pakistan's 2022 compound climate event provides a high-evidence illustration of cascading risk: following a severe heat wave that had already damaged wheat harvests, the monsoon delivered 190% of the 30-year average rainfall, inundating approximately one-third of the country's land area, destroying an estimated 2 million acres of crops, and killing over 800,000 livestock (Naeem & Ullah, 2023). For India, crop modelling studies project that a 1°C temperature increase is associated with a 3–5% reduction in wheat yields at the national level, with substantially larger sub-national losses in heat-exposed northern states (Rao et al., 2022). Barooah et al. (2023) found that women smallholders in India with access to climate-smart agricultural information services showed significantly improved food security

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outcomes, but only 23% of women in the study sample had received such services, highlighting persistent extension access gaps.

3.4.3 Southeast Asia: Coastal Vulnerability and Rice System Disruption

Southeast Asia faces tropical cyclone risk, sea-level rise and saline intrusion in major delta rice systems, and ENSO-driven rainfall variability affecting both rainfed and irrigated agriculture. The Mekong Delta in Vietnam and the Irrawaddy Delta in Myanmar are particularly exposed to saline intrusion as rising sea levels allow saltwater incursion into rice paddies, permanently degrading soil quality (IPCC, 2022). Meta-analytic results for rice yields show medium confidence in negative yield responses (−3.3% per °C; Table 2), with high heterogeneity reflecting genuine diversity across irrigated, rainfed lowland, and upland rice systems.

3.4.4 Latin America and the Caribbean: ENSO Variability and Urban Hunger

Latin America and the Caribbean face a food security situation characterised by moderate but persistent prevalence (approximately 19%), with marked sub-regional heterogeneity. Central America's Dry Corridor experiences high ENSO-linked rainfall variability and recurrent drought that drives both food insecurity and climate migration (FAO et al., 2024). Commodity price spikes following climate-driven supply disruptions disproportionately affect urban poor households where food expenditures account for 50–70% of household income (Onyeaka et al., 2024). A key data gap is the near-absence of quantitative food security outcome data specific to indigenous communities, who are systematically underrepresented in national household survey samples.

3.4.5 Small Island Developing States: Structural Vulnerability and Existential Risk

SIDS in the Pacific and Caribbean face qualitatively different climate-food security risks: sea-level rise, coral bleaching, and cyclone intensification threaten to permanently eliminate the productive resource base — arable land, coastal fisheries, and freshwater supplies — upon which national food systems depend. Fisheries represent both the most critical food security resource and the most threatened in Pacific SIDS. Coral bleaching events documented in 2016, 2019–2020, and 2023 have reduced reef fish biomass and catch productivity in ways that directly threaten the animal protein supply of island communities with limited alternatives (IPCC, 2022).

4. DISCUSSION

4.1 The Accelerating Frequency and Impact of Extreme Weather Events

The IPCC AR6 synthesis is unequivocal: human-induced climate change has progressively warmed the atmosphere, ocean, and land surface, with each of the last four decades being successively warmer than any preceding decade since 1850 (IPCC, 2022). By 2024, the global mean temperature anomaly reached approximately 1.55°C above pre-industrial levels (UN SDG

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Indicators, 2025). In Sub-Saharan Africa, a 1°C temperature increase is associated with a 3 percentage point reduction in agricultural output, transmitting directly to a 1.3 percentage point GDP decline (IMF, 2022). Kornhuber et al. (2020) demonstrated that amplified Rossby wave patterns increase the probability of simultaneous heat stress across multiple global breadbasket regions — a mechanism with direct implications for global food price stability that operates independently of region-specific impacts. The 2019–2020 desert locust infestations across the Horn of Africa affected 1.25 million hectares of cropland and added approximately USD 70 million to regional humanitarian financing requirements (IMF, 2022).

4.2 Mechanisms of Food Insecurity: From Weather Shock to Hunger

The pathways from extreme weather events to food insecurity operate simultaneously across multiple pillars as formalised in Figure 3. On availability, the meta-analytic results in Table 2 quantify yield losses across major crop-region combinations. On access, post-harvest losses in Sub-Saharan Africa average approximately 9% annually as a consequence of structural storage infrastructure deficits — losses amplified when floods destroy warehouses and road networks (IMF, 2022). Price spikes disproportionately affect urban poor households who spend 50–70% of their income on food, with a 10% increase in global staple prices translating directly into reduced caloric and nutritional intake (Onyeaka et al., 2024). On utilisation, flooding promotes waterborne disease — including cholera, typhoid, and diarrhoeal illness — impairing nutrient absorption (Deglon et al., 2023). Elevated CO_2 concentrations reduce protein and micronutrient density in wheat, rice, and legumes, worsening hidden hunger (Fanzo et al., 2025). On stability, extreme weather events precipitate asset liquidation — the sale of livestock, seed stock, and productive equipment — creating poverty traps from which households cannot escape without external support (Hossain et al., 2022).

4.3 The SDG Deficit: Regional Trajectories and Failure Modes

The global prevalence of moderate or severe food insecurity stood at 28.9% in 2023 (2.33 billion people), with a marginal decline to 28.0% in 2024 still leaving approximately 2.3 billion food insecure — 683 million more than when the 2030 Agenda was launched (FAO et al., 2024). The SDG 2 sub-target architecture is failing across virtually all dimensions in climate-exposed Global South countries. Table 4 maps regional food security status, primary climate drivers, and SDG 2 failure modes, synthesising the regional evidence profiles presented above.

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Table 4: Regional Food Security Status, Primary Climate Drivers, SDG 2 Failure Modes, and Intersecting Goals (2023–2024 Data)

Region	Prevalence (% Severely Food Insecure)	Primary Weather Driver	Key SDG 2 Failure Mode	Evidence Confidence	Intersecting SDGs
East Africa	~63% (272M)	Multi-year compound drought; ENSO variability	Chronic hunger; severe child stunting; livestock mortality; SDG 2.1, 2.2 failure	High	SDG 1, 3, 13
West Africa / Sahel	~48% (183M)	Rainfall variability; locust invasions; heat stress	Conflict-climate nexus; crop failure; forced displacement; SDG 2.1 failure	High	SDG 1, 10, 16
Southern Africa	~54% (35M)	ENSO drought-flood cycles; Cyclones Idai & Freddy	Maize yield collapse; income loss; SDG 2.3 smallholder productivity failure	High	SDG 1, 13, 15
South Asia	~21% severely insecure (412M absolute)	Heat waves; monsoon flooding; Bay of Bengal cyclones	Hidden hunger; micronutrient deficiency; urban food access crisis; SDG 2.2 failure	High	SDG 2, 3, 6
Southeast Asia	Moderate; rising	Tropical cyclones; sea-level rise; ENSO flooding	Coastal farmland loss; post-harvest losses; water contamination; SDG 2.4 failure	Medium	SDG 2, 6, 14
Latin America	~19% (moderate)	ENSO drought; Amazonian fires; extreme rainfall	Indigenous food system disruption; urban hunger persistence; SDG 2.1 stagnation	Medium	SDG 1, 10, 15

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Region	Prevalence (% Severely Food Insecure)	Primary Weather Driver	Key SDG 2 Failure Mode	Evidence Confidence	Intersecting SDGs
Pacific / Caribbean SIDS	High; structurally constrained	Cyclone intensification; sea-level rise; coral bleaching	Permanent farmland loss; fisheries collapse; SDG 14 and 2 joint failure	Medium (limited data)	SDG 2, 14, 13

Note. Sources: FAO et al. (2024); IMF (2022); UN SDG Indicators (2025); regional synthesis (Sections 3.4.1–3.4.5). SIDS = Small Island Developing States; ENSO = El Niño-Southern Oscillation. Evidence confidence refers to the overall strength of the regional evidence profile in the included corpus.

4.4 Comparing Regions and Contexts: What Can and Cannot Be Generalised

Several patterns emerge from cross-regional comparison. First, the four-pillar food security framework provides a consistent analytical organiser across regions, but the relative primacy of specific pillars differs: availability failures dominate in Sub-Saharan Africa's rain-fed smallholder systems; access failures are most acute in South Asian and Latin American urban settings; utilisation failures associated with waterborne disease are most prevalent in monsoon-flooded settings; and stability failures are most structurally pronounced in SIDS. Second, women, children under five, indigenous communities, and urban informal settlement residents consistently face the greatest vulnerability across all regions — assessed here at Medium Confidence, reflecting consistency in direction but inadequacy in gender-disaggregated longitudinal data. Third, direct cross-regional comparisons of adaptation effectiveness are problematic due to methodological heterogeneity, explicitly reflected in the I^2 statistics in Table 2. Fourth, the conflict-climate nexus in West Africa represents a fundamentally different causal context to the primarily climate-agricultural dynamics of Southeast Asia and the Pacific, requiring governance and humanitarian system perspectives that purely agronomic frameworks cannot capture.

4.5 Climate Finance Inequity and Governance Deficit

Despite agrifood systems accounting for approximately one-third of global greenhouse gas emissions, they receive only 4% of global climate finance; of this modest allocation, only one-fifth reaches smallholder farmers (World Bank, 2024). As of May 2025, only 22 countries had submitted updated NDCs ahead of the 2035 planning cycle (UN SDG Indicators, 2025). Figure 5 visualises the structural mismatch between climate vulnerability and finance received for selected Global South countries, identifying the most acute financing equity gaps in the upper-left quadrant.

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Figure 5: Climate Finance Received versus Climate Vulnerability for Selected Global South Countries. Countries in the upper-left quadrant (shaded red) — high vulnerability and low finance — represent the most acute financing equity gap. Bubble size is proportional to food insecurity prevalence (%). Countries in the lower-right quadrant receive relatively more finance despite lower vulnerability. Sources: ND-GAIN Country Index; OECD DAC Climate Finance Statistics; World Bank (2024); FAO et al. (2024).

Loss and damage finance — formally recognised at COP28 in 2023 — remains underfunded and operationally untested at scale. This governance architecture — fragmented across climate, agricultural, and humanitarian ministries, inadequately funded at both national and international levels, and poorly integrated with SDG monitoring — constitutes a systemic failure of institutional design that technical adaptation solutions alone cannot overcome (Olabanji & Chitakira, 2025).

4.6 Adaptation Evidence: CSA, Agroecology, Early Warning, and Social Protection

World Bank investment in CSA reached nearly USD 3 billion per year by fiscal year 2023, with climate finance constituting 62% of total World Bank agricultural lending by FY2024 (World

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Bank, 2024). Meta-analyses of CSA adoption in Sub-Saharan Africa find that combined practices including improved crop rotations and precision irrigation can reduce emissions by up to 30% while increasing yields by an average of 20% (Mnisi et al., 2023). In South Africa, agroecological practices including indigenous crop cultivation, conservation agriculture, and intercropping produced measurable improvements in crop resilience and soil fertility among smallholder farmers (Zenda & Rudolph, 2024). Ethiopia's Productive Safety Net Programme, covering approximately 8 million food-insecure households, has demonstrated drought-contingent benefit delivery and watershed rehabilitation components that address both acute insecurity and longer-term resilience (Toromade et al., 2024). Figure 6 presents CSA effectiveness evidence and adoption barriers, providing the evidentiary foundation for the ranked policy recommendations in Section 5.

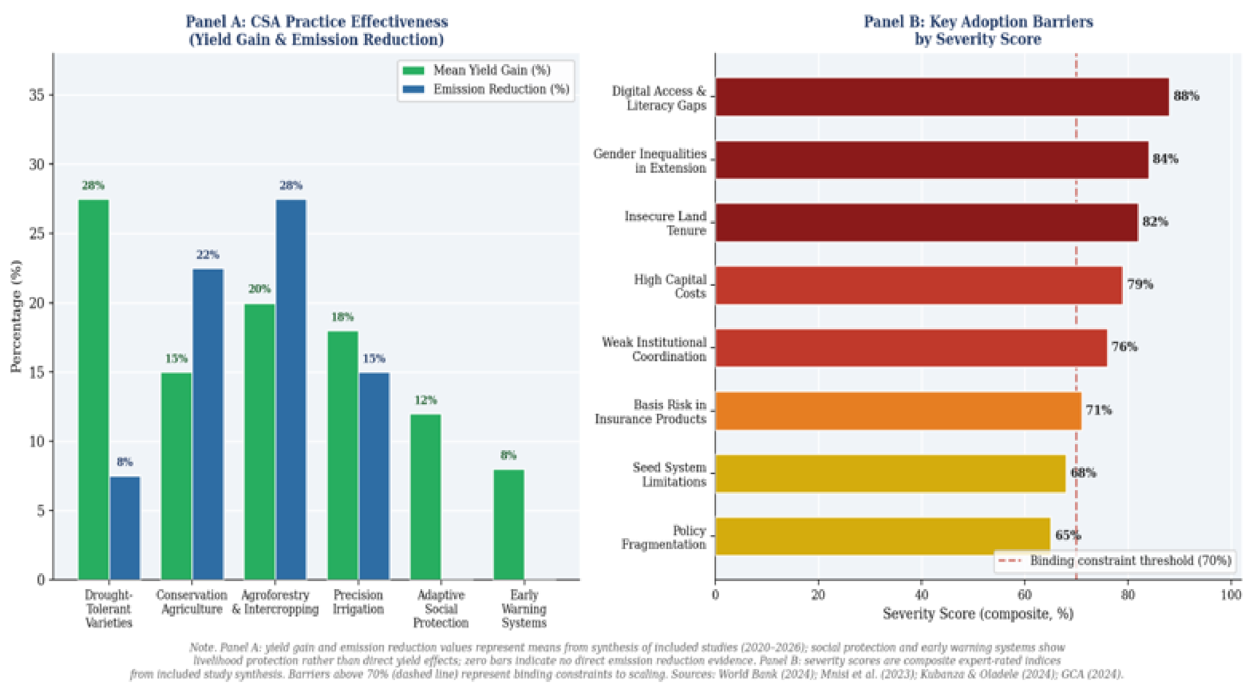

Figure 6: Climate-Smart Agriculture Effectiveness Evidence and Key Adoption Barriers in the Global South. Panel A compares mean yield improvement and greenhouse gas emission reduction potential across major CSA and adaptation practices from the included study corpus. Social protection and early warning systems show livelihood protection effects rather than direct yield impacts. Panel B ranks key adoption barriers by composite severity score; barriers above the 70% threshold (dashed line) represent binding constraints to widespread scaling. Sources: World Bank (2024); Mnisi et al. (2023); Kubanza & Oladele (2024); GCA (2024); Antwi-Agyei et al. (2021).

Table 5 synthesises adaptation effectiveness evidence, scalability, and equity considerations across major practice categories.

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Table 5: Adaptation Practice Evidence Synthesis: Effectiveness, Scalability, Adoption Barriers, and Equity Considerations (2020–2026 Corpus)

CSA/Adaptation Practice	Evidence Summary	Confidence Level	Key Adoption Barriers	Evidence Quality Caveat	Equity Consideration
Drought-tolerant crop varieties	+15–40% yields in drought years (World Bank, 2024)	Medium-High	Seed system access; variety-locality mismatch; extension reach	Most evidence from programme contexts; lower in real-world settings	Can be gender-equitable if extension explicitly reaches women
Conservation agriculture	+15% average yields; soil carbon gains (Mnisi et al., 2023)	Medium	Labour for residue management; mechanisation access	Benefits accumulate over years; short-term evals may underestimate	High transition cost disadvantages poor households without support
Agroforestry and intercropping	Diverse income streams; soil health (Zenda & Rudolph, 2024)	Medium	Land tenure insecurity; long payback periods	Mostly observational; limited RCT evidence at scale	Benefits indigenous & smallholder communities; gendered land access barrier
Early warning systems	Significant crisis cost reduction; lead time gains (GCA, 2024)	High (cost reduction); Medium (uptake equity)	Last-mile connectivity; digital literacy; gender gaps	Evidence on crisis cost reduction strong; nutrition outcomes limited	Must explicitly include women and marginalised groups
Index-based drought insurance	Reduces income volatility (Antwi-Agyei et al., 2021)	Medium	Basis risk; trust deficits; premium affordability	Selection bias; wealthier farmers more likely to participate	Uptake consistently lower among women; gender-sensitive design required

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CSA/Adaptation Practice	Evidence Summary	Confidence Level	Key Adoption Barriers	Evidence Quality Caveat	Equity Consideration
Adaptive social protection	Effective when pre-positioned (Toromade et al., 2024)	Medium-High	Beneficiary identification; fiscal space; coordination	Evidence from specific national programmes; transferability uncertain	Critical for most marginalised households; exclusion errors a concern

Note. Evidence confidence rated following Table 3 framework. CSA = Climate-Smart Agriculture. RCT = Randomised Controlled Trial. Sources: World Bank (2024); Mnisi et al. (2023); Antwi-Agyei et al. (2021); Zenda & Rudolph (2024); GCA (2024); Toromade et al. (2024); Kubanza & Oladele (2024).

4.7 Cross-Cutting Dimensions: Gender, Indigenous Communities, and Urban Vulnerability

Gender is among the most consistent predictors of differential food insecurity within climate-affected populations. Women typically hold less secure land rights, smaller landholdings, lower access to credit and agricultural inputs, more limited mobility, and higher unpaid care burdens. Climate change amplifies each of these structural disadvantages as drought and flooding increase labour demands that fall disproportionately on women (Barooah et al., 2023). Women smallholders are systematically less likely to be reached by extension services and face greater barriers to digital agricultural advisory services due to gender gaps in digital literacy and mobile phone ownership (Nchanji et al., 2023). Indigenous peoples rely on food systems that are highly sensitive to ecological disruption — traditional fisheries, forest-based food gathering, pastoralism, and diverse rain-fed polycultures — while simultaneously possessing traditional ecological knowledge representing an underutilised resource for climate adaptation (Branca & Perelli, 2020). Urban food security is disproportionately affected by climate-driven food price spikes, since urban households lack productive assets to buffer against price shocks. Several Global South cities including Nairobi, Lusaka, Kampala, and Accra have established urban agriculture policy frameworks, though these remain nascent relative to the scale of urban food insecurity (Asante et al., 2024).

4.8 Strengths and Limitations of the Evidence Base

Strengths of the evidence base include the integration of IPCC AR6 multi-model ensembles, FAO national food security monitoring, satellite-derived agricultural productivity data, and a rapidly growing corpus of field-based adaptation studies, providing convergent, multi-source evidence. Gender-disaggregated data remain inadequate in the majority of food security studies, masking intra-household inequality. Longitudinal datasets tracking cumulative slow-onset climate change impacts on food security and nutrition are rare in low-income country contexts. Rigorous causal attribution of SDG progress specifically to climate factors — as distinct from pandemic effects,

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geopolitical shocks, or governance change — is methodologically challenging and rarely achieved. The English-language restriction introduces selection bias, as discussed in Section 2.1.

5. POLICY IMPLICATIONS, EVIDENCE LINKAGE, AND PRIORITY RANKING

The following six policy recommendations are explicitly linked to the evidence reviewed in preceding sections and ranked in order of estimated urgency and scalability based on the synthesis presented in Tables 2–5 and Figures 4–5.

Table 6: Policy Recommendations: Evidence Linkage, Urgency-Scalability Ranking, and Target Institutions

Rank	Policy Recommendation	Supporting Evidence (This Review)	Confidence Level	Urgency	Target Institutions
1	Realign climate finance to direct majority of agrifood adaptation resources to the most climate-exposed Global South countries and smallholder communities, with gender equity conditionality	Table 3: Climate finance misalignment — High Confidence; Figure 5; World Bank (2024); Section 4.5	High	Urgent; structural	UNFCCC COP; World Bank; GCF; bilateral donors
2	Invest in integrated multi-hazard early warning systems with last-mile connectivity to smallholder farmers, explicitly including women and marginalised groups	Table 5: Early warning — High Confidence; Figure 6 Panel B barriers; GCA (2024); Section 4.6	High	Urgent; scalable	National met. agencies; WMO; UNDP; WFP
3	Operationalise and adequately capitalise the Loss and Damage Fund with agriculture-sector accounting frameworks for	Section 4.5; UN SDG Indicators (2025); governance deficit finding across corpus	Medium-High	Urgent; governance	UNFCCC COP; G77; Alliance of SIDS

Rank	Policy Recommendation	Supporting Evidence (This Review)	Confidence Level	Urgency	Target Institutions
	cumulative slow-onset losses				
4	Scale climate-responsive adaptive social protection with pre-positioned drought-contingent triggers (cash transfers, employment guarantees, index insurance)	Table 5: Adaptive social protection — Medium-High Confidence; Toromade et al. (2024); Section 4.6	Medium-High	High; scalable	National social protection ministries; WFP; UNICEF
5	Mainstream climate risk into SDG 2 monitoring with disaggregation by climate exposure class, gender, and indigenous community status	Table 3: SDG 2 failure — High Confidence; Figure 4; gender data gap identified in Table 3; Section 4.3	High	Medium urgency; foundational	UN Statistics Division; FAO; national stats offices
6	Reform land governance to protect smallholder, women's, and indigenous land rights as a precondition for CSA investment and agricultural resilience	Tables 3 & 5: land tenure as binding adoption barrier; Barooah et al. (2023); Nchanji et al. (2023); Section 4.7	Medium	Medium urgency; enabling condition	National governments; World Bank; IFAD; civil society

Note. Rankings reflect estimated combined urgency and scalability. Rankings are qualitative expert assessments in conjunction with evidence confidence ratings. GCF = Green Climate Fund; WMO = World Meteorological Organization; UNDP = United Nations Development Programme; WFP = World Food Programme; IFAD = International Fund for Agricultural Development; SIDS = Small Island Developing States.

6. RESEARCH GAPS AND FUTURE DIRECTIONS

6.1 Compound and Cascading Risk Quantification

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The interactions between simultaneous or sequential extreme weather events, market disruptions, conflict, and disease outbreaks — exemplified by the 2020–2022 convergence of COVID-19, the Horn of Africa drought, and the Russia-Ukraine food price shock — are inadequately characterised in existing risk models. Agent-based modelling, machine learning-enabled attribution science, and cross-scale network analysis offer promising avenues for advancing compound risk quantification at policy-relevant spatial and temporal scales (Kornhuber et al., 2020). This is identified as the most significant frontier in climate-food security science because governance frameworks and adaptation programmes designed around single-hazard assumptions will systematically underestimate risk.

6.2 Gender-Disaggregated Impact and Adaptation Outcomes

Gender-disaggregated longitudinal impact and adaptation assessment represents the most important methodological reform needed in food security research. The majority of studies still report aggregate or household-level outcomes, masking substantial intra-household inequality. Methodological innovation in feminist political ecology, participatory action research, and intersectional vulnerability frameworks is needed (Barooah et al., 2023; Nchanji et al., 2023).

6.3 Climate-Nutrition Linkage Studies

Climate-nutrition linkage studies are urgently needed to characterise the specific pathways from climate variability to micronutrient deficiency, dietary diversity loss, and child growth impairment. Longitudinal cohort studies in climate-exposed Global South communities, combined with agrifood system modelling, would substantially advance understanding of these linkages (Fanzo et al., 2025). The current evidence, rated as Medium Confidence in Table 3, represents a significant knowledge gap given the scale of hidden hunger in climate-exposed regions.

6.4 Non-English Literature Integration and Research Capacity

Future systematic reviews should invest in translation resources and engage regional research teams to access Francophone West African, Spanish-language Latin American, and Portuguese-language Brazilian and Mozambican literatures. Strengthening food security research capacity in the most climate-vulnerable countries — through long-term institutional partnerships, data infrastructure investment, and researcher mobility programmes — is itself a priority for the global scientific community.

7. CONCLUSION

The evidence reviewed in this paper is unambiguous in its broad contours, even as important uncertainties remain about specific magnitudes and timelines. Extreme weather events — intensified by anthropogenic climate change — are already a primary driver of food insecurity in the Global South, and their impacts are systematically undermining progress toward SDG 2 and its intersecting development targets. The 2024 global hunger situation, with 2.3 billion people moderately or severely food insecure, represents not a temporary setback but a structural trajectory away from Zero Hunger. As visualised across the six figures in this paper — from the diverging hunger trends in Figure 1, through the conceptual pathway framework in Figure 3, to the regional SDG assessment in Figure 4, the finance-vulnerability mismatch in Figure 5, the adaptation evidence in Figure 6, and the rigorous PRISMA selection process in Figure 2 — the evidence base for urgent, equitable, and transformative action is robust.

This review has provided a structured evidence synthesis distinguishing high-confidence from medium-confidence findings, identifying critical data gaps, and offering region-specific rather than uniform Global South conclusions. The meta-analytic yield loss estimates (Table 2), structured confidence framework (Table 3), and evidence-linked ranked policy recommendations (Table 6) are intended to advance the utility of systematic review for both scientific and policy audiences. Compound and cascading climate risks, which amplify pathways in ways that single-hazard analyses consistently underestimate, represent the most urgent frontier for both scientific investigation and governance reform. Adaptation is neither futile nor sufficient on its own: the resources needed to deliver effective adaptation to the communities that need it most are available globally but are not flowing to their destinations at the required speed, scale, or equity.

For the next generation of agricultural scientists, environmental engineers, climate researchers, and geoscientists — the intended audience for this review — the climate-food security nexus represents one of the defining professional challenges of the coming decades. Meeting it will require deep disciplinary expertise combined with the capacity to engage across scales, sectors, and epistemological traditions. The research agenda outlined here is an open invitation to that interdisciplinary engagement.

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