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Socioeconomic Adaptation of Rural Communities to Climate Change: A Systematic Review of Strategies, Determinants and Effectiveness (2022–2026)

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Abstract

Rural households dependent on rain-fed farming, livestock, fisheries and forests face growing climate risks, yet evidence on their social and economic adaptation remains fragmented. This systematic review synthesised empirical studies of rural households and communities published in 2022–2026 on the forms, determinants and effectiveness of socioeconomic adaptation. Following PRISMA 2020, we searched Scopus on 12 October 2026, added 12 records from other sources, screened 576 records and included 381 reports, which were coded with AI assistance, appraised with the Mixed Methods Appraisal Tool and synthesised by direction of effect. Evidence was concentrated in sub-Saharan Africa (68.5%) and crop farming (73.2%). Economic strategies dominated, led by climate-smart soil and water practices (33.6%), crop diversification and variety change (29.7%) and livelihood diversification (17.3%); social strategies appeared in 29.1%. Infrastructure, social capital, institutional support, income and credit were most consistently associated with adaptation. Of 128 outcome reports, 92 found positive associations with food security, income, productivity or resilience, 34 conditional and two adverse effects; reports comparing bundles mostly favoured combined practices. Certainty was low to moderate, given cross-sectional designs and abstract-based coding. We propose an integrative framework with five testable propositions. The review was not registered and received no external funding.

Keywords: Climate Change Adaptation; Socioeconomic Adaptation; Rural Communities; Adaptive Capacity; Livelihood Resilience; Socioeconomic Vulnerability; Sustainable Livelihoods; Systematic Review

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INTRODUCTION

Climate change affects rural livelihoods directly. Households that depend on rain-fed crops, livestock, inland and coastal fisheries or forest products experience shifts in rainfall, longer dry spells, floods and heat as shocks to production, income and food supply. The Working Group II contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) estimates that approximately 3.3–3.6 billion people live in contexts that are highly vulnerable to climate change, and it identifies smallholder farmers and natural-resource-dependent communities among the most exposed groups (IPCC, 2022). The scale of the problem follows from the structure of world agriculture: there are more than 570 million farms worldwide, most of them small and family-operated (Lowder et al., 2016). For such households, a failed season seldom remains an agricultural problem. It spills over into debt, reduced meals, distress sales of livestock, withdrawal of children from school and migration.

Rural households respond with a wide repertoire of measures, and a substantial body of research has examined what shapes these responses. Early studies in Ethiopia and South Africa showed that education, wealth, extension, credit and climate information condition the choice of adaptation methods (Bryan et al., 2009; Deressa et al., 2009). Recent work extends this agenda. In north-eastern Burundi, more than 80% of 200 smallholders used at least one adaptation strategy, and education, experience, livestock, climate information, credit and income shaped their choices (Batungwanayo et al., 2023). In South India, smallholders formed distinct adaptation intentions, ranging from innovation to contraction and non-adaptation (Mitter et al., 2024), consistent with cognitive models of private adaptation (Grothmann and Patt, 2005). National household surveys from Ethiopia and Nigeria indicate that income, plot size, extension and community networks shape adaptation related to climate-smart agriculture (Alhassan and Haruna, 2024), and evidence from Pakistan links coping mechanisms and their determinants to fewer climate impacts on rural livelihoods (Usman et al., 2024).

Indonesia, the setting in which this review was conceived, illustrates why these questions matter for policy. Its rural economy rests largely on smallholder rice, horticulture, estate crops and aquaculture. Studies document how drought in downstream irrigation areas and salinity intrusion alter farming decisions (Arifah et al., 2022a; Dewi et al., 2022), how education, farmer groups, risk perception, extension and crop–livestock integration shape on-farm and off-farm adaptation (Purwanti et al., 2022; Hasibuan et al., 2023; Purwanti et al., 2023), how agroforestry buffers food supply during prolonged dry seasons (Yusriadi et al., 2024) and how adaptation is linked to food security among shrimp farmers (Toiba et al., 2024). The

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national Climate Village Program has also revealed the difficulty of embedding community adaptation in regional development planning (Wiati et al., 2022). Yet Southeast Asian evidence is rarely synthesised alongside the much larger African and South Asian literatures, which limits what Indonesian policymakers can learn from comparative evidence.

The knowledge base is fragmented in three further respects. First, most syntheses examine one country, one strategy or one analytical lens. Recent reviews have addressed smallholder adaptation in Ghana (Opoku Mensah et al., 2025), climate-smart land management in Ethiopia (Asefa et al., 2025), livelihood vulnerability index studies (Zainab and Shah, 2024), women farmers in sub-Saharan Africa (Bugre et al., 2026), livelihood diversification for poverty alleviation (John Nyamamu et al., 2025) and farmers' adaptation practices in Asia (Shaffril et al., 2018). Second, social and economic adaptation are usually analysed separately. Economic measures such as crop diversification, irrigation or off-farm work are well documented, whereas the social mechanisms that enable them, including networks, collective action, local knowledge and household reorganisation, are seldom examined in the same frame. Third, evidence on effectiveness lags behind evidence on uptake. A global stocktake found that documented adaptation is mostly fragmented, local and incremental, with little evidence that it reduces risk (Berrang-Ford et al., 2021), and reviews of adaptation effectiveness and of development interventions warn that some responses redistribute or deepen vulnerability (Eriksen et al., 2021; Owen, 2020). Whether the strategies rural households adopt improve food security, stabilise income and reduce vulnerability therefore remains an open question.

This review addresses these gaps by systematically synthesising empirical studies published between 2022 and 2026 on the socioeconomic adaptation of rural communities to climate change. Its general objective is to analyse the forms, determinants and effectiveness of social and economic adaptation at the household and community levels. Five research questions (RQs) guide the review: (RQ1) How has the empirical literature developed in volume, geography, livelihood systems and research design? (RQ2) Which social and economic adaptation strategies do rural communities use, and how can they be classified? (RQ3) Which factors are associated with adaptive capacity and the uptake of adaptation strategies? (RQ4) How effective are these strategies for food security, income stability, vulnerability reduction and livelihood sustainability? (RQ5) Which research gaps remain, and what integrative framework can guide future research and policy?

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The review makes three contributions. It codes social and economic strategies jointly and places them on a continuum from erosive coping to transformative adaptation, building on established distinctions between incremental and transformational adaptation (Kates et al., 2012). It maps the factors associated with adaptive capacity onto livelihood capitals and institutions, separating how often a factor was examined from how consistently it was associated with adaptation. It then consolidates outcome evidence, graded by certainty, into an integrative framework with testable propositions that link capitals, institutions, adaptation pathways and outcomes, and it draws out implications for community-based adaptation policy in Indonesia and other countries with large smallholder populations.

CONCEPTUAL BACKGROUND

Four complementary theoretical perspectives informed the coding frame and the interpretation of the evidence.

Sustainable Livelihoods Framework

The sustainable livelihoods framework views households as combining human, natural, financial, physical and social capital to pursue livelihood strategies within a context of vulnerability and an institutional setting that mediates access to resources (Scoones, 2009). Diversification is a central livelihood strategy: rural households spread risk and smooth income by combining farm and non-farm activities, although the poorest are often pushed into low-return activities instead of being drawn into remunerative ones (Barrett et al., 2001; Ellis, 1998). The framework guided how determinants were grouped in this review and why diversification was treated as a strategy whose value depends on the assets behind it.

Vulnerability and Adaptive Capacity

Vulnerability is commonly defined as a function of exposure, sensitivity and adaptive capacity, where adaptive capacity is the ability of a system to adjust, moderate potential damage, take advantage of opportunities or cope with consequences (Adger, 2006; Smit and Wandel, 2006). Composite indicators such as the Livelihood Vulnerability Index (LVI) operationalise these components at the household level (Hahn et al., 2009), and social science research shows that differential vulnerability reflects entitlements, power and social position as well as exposure (Thomas et al., 2019). This perspective informed the coding of vulnerability assessments and the distinction between capacity, which is a latent potential, and adaptation, which is an observed response.

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Social-Ecological Resilience

Resilience thinking treats rural communities as social-ecological systems that can absorb disturbance, adapt and, under some conditions, transform (Folke, 2006; Walker et al., 2004). Applied to livelihoods, resilience emphasises the capacity to buffer shocks, self-organise and learn (Ifejika Speranza et al., 2014) and the agency of people in shaping their own trajectories (Tanner et al., 2015). It also cautions that responses which secure short-term survival can erode future options, a pattern conceptualised as maladaptation (Barnett and O'Neill, 2010). These ideas underpinned the review's distinction between coping, incremental adaptation, livelihood restructuring and transformative adaptation.

Social Capital

Social capital theory explains how networks, norms of reciprocity and collective action enable households to share risk, pool resources and access information (Adger, 2003). Bonding, bridging and linking ties play different roles in disaster recovery and community resilience (Aldrich and Meyer, 2015), and studies of coastal communities show that social organisation, learning and agency matter for adaptive capacity alongside material assets (Cinner et al., 2018). In this review, social capital was treated both as a determinant of capacity and as the basis of the social strategies that households use.

Combined, these perspectives suggest that socioeconomic adaptation can be analysed as a chain that runs from exposure, through capitals, institutions and cognition, to strategies and outcomes, with feedback from outcomes to future capacity. The review used this chain as an analytical scaffold, and Section 5.1 revisits it in light of the evidence.

MATERIALS AND METHODS

Review Design, Protocol and Reporting Standard

This study is a systematic literature review with a thematic-narrative synthesis, reported in accordance with the PRISMA 2020 statement (Page et al., 2021) and, for the synthesis of effects, the Synthesis Without Meta-analysis (SWiM) guideline (Campbell et al., 2020). The review protocol consisted of a pre-specified outline (research questions, objectives, planned databases, search strings, eligibility criteria, review type and quality appraisal tool) and a screening and coding codebook; it was not prospectively registered. Four deviations from the protocol occurred and are reported for transparency: (i) the additional keywords listed in the protocol (social capital, institutional support, climate-smart agriculture, food security

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and coping strategies) were incorporated into the final search string after a first run showed low recall; (ii) Web of Science, Google Scholar and the other planned databases were not searched, for the reasons given in Section 3.2; (iii) because full texts were not accessible for most records, eligibility and coding relied mainly on abstracts (Section 3.5); and (iv) the evidence-type stratification, gender recoding, sample clustering, sensitivity analyses and certainty assessment described in Sections 3.5–3.8 were added post hoc, during synthesis, in response to an internal methodological audit. The protocol, the PRISMA 2020 checklist and all decisions are provided in Supplementary File S1. Table 1 summarises the research questions and the specific objectives they address.

Information Sources and Search Strategy

Scopus was the information source for database identification because it indexes the main peer-reviewed journals in environmental science, agricultural and social sciences and development economics. The search was executed on 12 October 2026 through the Elsevier Scopus Search service, restricted to the title, abstract and keyword fields and to publication years 2022–2026. The final English string combined three concept blocks, namely climate stress, rural population and socioeconomic adaptation, with the adaptation block extended by the protocol's additional keywords:

TITLE-ABS-KEY(("climate change adaptation" OR "climate variability" OR "climate resilience" OR "climate risk") AND ("rural communities" OR "rural households" OR "rural livelihoods" OR "smallholder farmers" OR "rural development") AND ("socioeconomic adaptation" OR "livelihood adaptation" OR "adaptive capacity" OR "livelihood resilience" OR "socioeconomic vulnerability" OR "livelihood diversification" OR "social capital" OR "institutional support" OR "climate-smart agriculture" OR "food security" OR "coping strateg*")) AND PUBYEAR > 2021 AND PUBYEAR < 2027

An equivalent Indonesian-language string was run to capture articles written in Bahasa Indonesia:

TITLE-ABS-KEY(("adaptasi perubahan iklim" OR "ketahanan iklim" OR "kerentanan iklim") AND ("masyarakat desa" OR "masyarakat perdesaan" OR "rumah tangga petani"))

The English string returned 793 records and the Indonesian string returned none. Web of Science was not searched because institutional access was unavailable, and Google Scholar was not used for identification because its results cannot be reproduced exactly. To partly offset the single-database design, 12

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records identified through other methods, namely four empirical studies cited in the review protocol and eight Indonesian studies identified during background reading on the review's application context, were screened against the same criteria. None of these 12 records was retrieved by the Scopus string, which indicates that the protocol-based string has limited sensitivity for studies that do not use its adaptation and livelihood terms (Section 5.5). Bibliographic metadata and digital object identifiers (DOIs) were verified against Scopus and Crossref. Because the available Scopus search output did not include abstracts, abstracts were retrieved from Crossref, Semantic Scholar, publisher landing pages or institutional repositories.

Eligibility Criteria

The eligibility criteria are listed in Table 2. Records were eligible if they were peer-reviewed journal articles published in 2022–2026 that reported primary empirical research on rural households, smallholder farmers or natural-resource-dependent communities and examined socioeconomic adaptation, adaptive capacity, socioeconomic vulnerability or livelihood resilience. The time window refers to the year of publication; the data analysed in some studies were collected earlier. Multi-country or mixed rural–urban surveys were eligible when rural households were analysed separately. Each exclusion was assigned a reason code so that decisions could be audited.

Table 2. Eligibility criteria and exclusion codes.

Criterion	Inclusion	Exclusion (code)
Publication type and date	I1. Peer-reviewed journal article published 2022–2026	Published before 2022; reviews, book chapters, conference papers, letters, notes, editorials, errata, retracted items and non-scholarly sources (removed before screening); duplicates
Design	I2. Primary empirical study using quantitative, qualitative or mixed methods	Conceptual papers, reviews, simulations or document analyses without household or community data (X2)

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Criterion	Inclusion	Exclusion (code)
Population and setting	I3. Rural households, smallholder farmers, pastoralists, fishers or other natural-resource-dependent rural communities exposed to climate change or variability	Urban or peri-urban populations without a rural link (X5); topics unrelated to the climate adaptation of rural people (X3)
Focus	I4. Socioeconomic adaptation strategies, adaptive capacity, socioeconomic vulnerability or livelihood resilience	Physical or biophysical climate impacts without a socioeconomic dimension (X4)
Reporting	I5. Methods, indicators and results identifiable	Methods or results not identifiable (X6)
Verifiability	I6. Primary source and metadata verifiable through a DOI or publisher record	Abstract and full text not retrievable (XL)
Quality and relevance	I7. Satisfies the MMAT screening questions and is relevant to the research questions	Fails the MMAT screening questions (X7)

MMAT = Mixed Methods Appraisal Tool; DOI = digital object identifier.

Selection Process

Selection followed three steps. First, records that were not journal articles according to their Scopus document type were removed before screening. Second, titles and abstracts were screened against the population and topic criteria (I3 and I4; codes X3–X5). Third, the remaining reports were assessed for eligibility against the design and reporting criteria (I2, I5 and I6) and the two MMAT screening questions, which ask whether a study has a clear research question and whether the collected data allow that question to be addressed (Hong et al., 2018). The selection process is summarised in Figure 1 (Section 4.1).

Screening and coding were performed with the assistance of a large language model (Claude, Anthropic; model claude-opus-5-5) operating within an agentic workflow on 12 October 2026. The model received the written protocol and codebook (File S1) as its instructions and processed records in batches of 56–70; every decision was logged with a reason code and a one-sentence justification. To test reliability, a second model instance, blind to the first decisions, re-screened two random samples of 60 records each, one drawn from the initial search and one from

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the records added by the extended search and other methods. Agreement on the final inclusion decision was 95.8% (115 of 120 records; Cohen's κ = 0.90). The five disagreements concerned borderline adoption studies and one report with thinly described methods, and the primary decisions were retained. A blind re-coding of the outcome and effect-direction fields for a random sample of 50 included reports agreed in 94.0% of cases (κ = 0.90). No human double-screening was performed; instead, every decision, reason code and extracted code is recorded in File S1 so that the selection and coding can be verified independently.

Data Items and Coding

A structured extraction form captured bibliographic data, country and region, livelihood system, climate hazards, research design, analytical methods and sample size. Substantive items were coded with controlled vocabularies derived from the conceptual background. Adaptation strategies were coded into twelve economic and seven social categories, defined in the codebook and listed in Section 4.3. Determinants were recorded with the direction of their association with adaptation or adaptive capacity (enhancing, constraining, or mixed, conditional or not reported). Because the direction of gender effects depends on how gender is coded, gender was recorded separately as a male advantage, a female advantage, no difference, or an intersectional or context-specific pattern. Outcomes were coded as food security, income or income stability, productivity, vulnerability reduction, livelihood resilience and poverty or wellbeing. Barriers, the reported role of institutions and a paraphrased key finding were also recorded.

Coding relied on the abstract for 370 of the 381 included reports (97.1%) and on the abstract plus accessible full-text excerpts for the remaining 11. Strategy, determinant and outcome frequencies are therefore conservative lower bounds of what the full texts report. Reports that appeared to analyse the same household sample (same authors or fieldwork, setting and similar sample size) were grouped into sample clusters so that they could be counted once in sensitivity analyses. Reports that compared outcomes across numbers or combinations of practices were flagged as bundle comparisons.

Quality Appraisal

Methodological quality was appraised with the MMAT version 2018, which provides five design-specific criteria for qualitative, quantitative non-randomised, quantitative descriptive and mixed-methods studies (Hong et al., 2018). A criterion was counted as met only when the report gave explicit supporting information, and the number of criteria met (0–5) was recorded. Given the reliance on abstracts, these counts reflect the transparency of reporting as much as the underlying rigour.

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Following MMAT guidance, scores were not used to exclude studies beyond the two screening questions; they informed the certainty assessment and the sensitivity analyses.

Synthesis Methods

Frequencies of characteristics, strategies, determinants and outcomes were tabulated in Python; studies conducted in several countries were counted once for each country. The qualitative synthesis followed the thematic synthesis approach (Thomas and Harden, 2008), moving from coded findings to descriptive themes (strategy families, determinant clusters and outcome patterns) and then to analytical themes that informed the integrative framework.

Because designs, indicators and outcome measures were heterogeneous, a meta-analysis was not appropriate. Effects were synthesised by vote counting based on the direction of effect, as recommended by SWiM (Campbell et al., 2020). An outcome was classified as positive when the report described a favourable association or effect of adaptation on the outcome, mixed or conditional when effects differed across outcomes, groups or settings or did not persist after adjustment, and negative or maladaptive when adaptation was associated with a worse outcome. For determinants, consistency was expressed as the share of reports examining a factor that found an enhancing association. Outcome evidence was stratified into three evidence types: selection-corrected or panel designs (matching or weighting estimators, endogenous switching regression, instrumental variables, selection models or panel data), other comparative quantitative or mixed-methods designs, and qualitative or perception-based evaluations. Five sensitivity analyses tested whether the direction of the outcome evidence changed when the synthesis was restricted to selection-corrected or panel designs, to reports meeting at least three MMAT criteria, to one report per sample cluster, to sub-Saharan Africa versus other regions, and to reports that were not eligibility edge cases.

Reporting Bias and Certainty of Evidence

The risk of reporting bias was assessed qualitatively. Abstracts tend to report statistically significant associations, and journals tend to publish positive findings, so the share of favourable results was compared across evidence types and quality strata. The certainty of key findings was rated as high, moderate, low or very low using an approach adapted from GRADE (Guyatt et al., 2008). Bodies of evidence that included selection-corrected or panel designs started at moderate certainty and other observational evidence at low certainty. Ratings were downgraded for serious risk of bias (most reports meeting two or fewer MMAT criteria), inconsistency,

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indirectness, imprecision or likely reporting bias, and upgraded when a dose–response pattern was observed, such as larger gains with more practices. For findings that rested mainly on qualitative evidence, the GRADE-CERQual domains of methodological limitations, coherence, adequacy and relevance were considered (Lewin et al., 2018).

RESULTS

Study Selection

Figure 1 summarises the selection process. The Scopus search returned 793 records. Before screening, 229 records were removed because they were not journal articles, including 114 reviews, 80 book chapters and 21 conference papers; no duplicates were found. Of the 564 records screened on title and abstract, 133 were excluded, mostly because they did not address the adaptation of rural people (n = 85) or examined only biophysical impacts (n = 46). Six of the 431 reports sought for retrieval had no accessible abstract or full text. Of the 425 reports assessed for eligibility, 55 were excluded, 46 because they were not primary empirical studies and nine because their methods or results could not be identified, leaving 370 reports. Of the 12 records identified through other methods, 11 met the criteria. The review therefore included 381 reports. Nineteen clusters, comprising 42 reports, appear to draw on shared household samples, so the evidence base corresponds to an estimated 358 distinct samples. All included reports, their full references and their coded characteristics are listed in Supplementary File S1, together with the reports excluded at the eligibility stage and the reasons for exclusion.

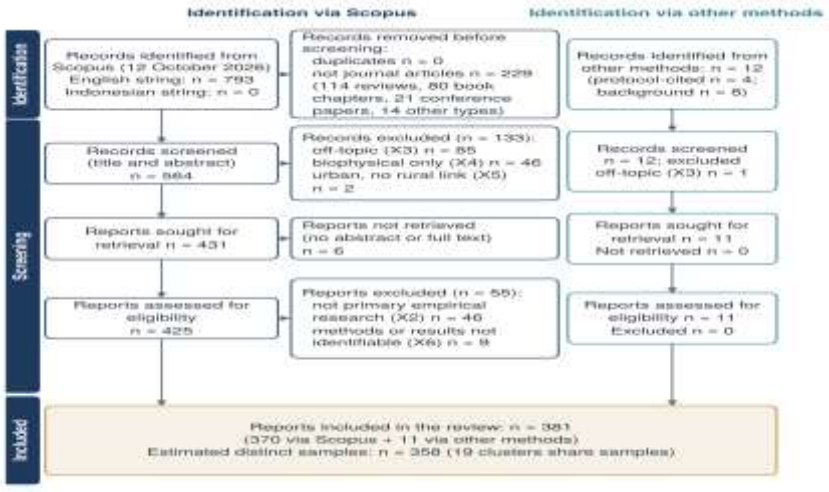


Figure 1. PRISMA 2020 flow diagram of record identification, screening and inclusion. Exclusion codes follow Table 2; the 14 other document types removed

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before screening comprised books, notes, short surveys, editorials, letters, a data paper, an erratum and a retracted item.

Characteristics of the Evidence Base (RQ1)

The number of included reports increased over the review period, with a dip in 2024 (Figure 2a; Table 3): 49 reports were published in 2022, 64 in 2023, 56 in 2024 and 92 in 2025, and 120 had appeared in 2026 by the search date. Publication year follows the Scopus record. The reports were spread across 168 journals, and no outlet published more than 16, which indicates a dispersed field without a dominant disciplinary home.

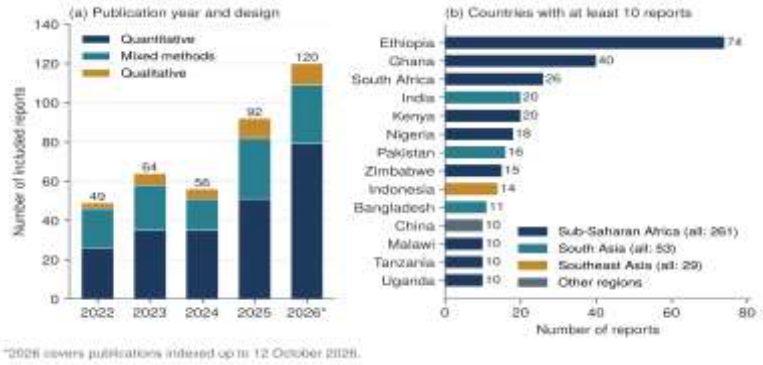


Figure 2. Development and geography of the evidence base: (**a**) included reports by publication year and research design; (**b**) countries with at least ten reports, coloured by region (region totals in the legend). Multi-country studies are counted in each country.

Within the literature retrieved by the search, the geography of evidence was highly uneven. Sub-Saharan Africa accounted for 261 reports (68.5%), South Asia for 53 (13.9%) and Southeast Asia for 29 (7.6%), while Latin America and the Caribbean, East Asia, the Middle East and North Africa, Europe and Central Asia and Oceania together contributed 38 reports, including two multi-region studies. Ethiopia alone was the setting of 74 reports, followed by Ghana (40), South Africa (26), India (20) and Kenya (20). Indonesia was the setting of 14 reports, which covered rice, horticulture, potato, sugarcane, agroforestry, small-scale fisheries and shrimp farming (Purwanti et al., 2022; Hasibuan et al., 2023; Toiba et al., 2024; Arifah et al., 2022b; Azhari et al., 2025; Killa et al., 2026; Purbawan et al., 2026).

Crop farming was the dominant livelihood system (279 reports; 73.2%), followed by mixed rural livelihoods (50; 13.1%) and mixed crop–livestock systems (41; 10.8%). Pastoral, fisheries and forest-based livelihoods together appeared in only 11 reports. Most reports addressed climate change in general or several

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hazards at once (228), but rainfall variability (104), drought (95) and rising temperatures (70) were named most often, whereas floods (36), storms (11) and salinity (8) received less attention.

Percentages are based on 381 reports. Hazard categories are not mutually exclusive. Multi-country studies are counted in each country. 2026 covers publications indexed up to 12 October 2026. LVI = Livelihood Vulnerability Index.

Methodologically, the field relies on household surveys. Quantitative designs accounted for 226 reports (59.3%), mixed methods for 120 (31.5%) and qualitative designs for 35 (9.2%). Among the 280 reports that stated a sample size, the median was 347 households, ranging from 10 participants in a qualitative study to 51,044 respondents in a pooled multi-country survey. At least 36 reports were built around composite vulnerability indices such as the LVI and its IPCC variant, typically comparing agro-ecological zones or districts (Ebrahim et al., 2022; Alemayehu et al., 2024; Maity et al., 2025; Debisa et al., 2026; Yacob et al., 2026). Sixty-one reports (16.0%) used selection-corrected or panel designs, of which 14 drew on panel data. The retrieved evidence is therefore rich in descriptions of who adapts and who is vulnerable, but thinner on evidence about what adaptation achieves.

Typology of Social and Economic Adaptation Strategies (RQ2)

Of the 381 reports, 258 (67.7%) documented at least one economic strategy and 111 (29.1%) at least one social strategy, while 74 (19.4%) documented both. The remaining 86 reports did not name specific strategies: 47 were vulnerability or resilience assessments and 39 analysed adaptation in aggregate. Table 4 and Figure 3 present the frequency of each strategy.

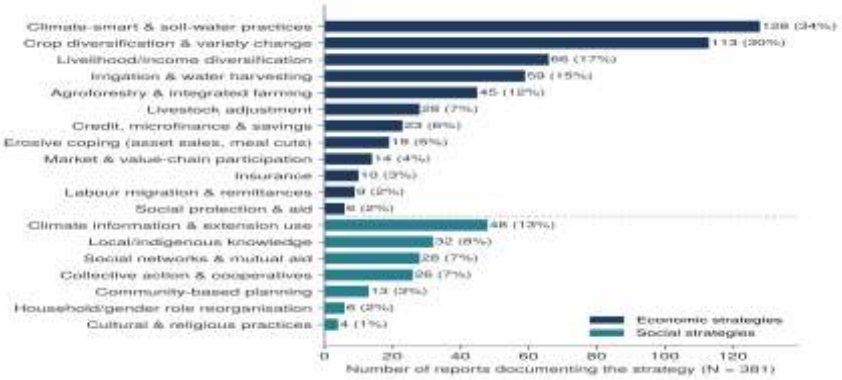


Figure 3. Frequency of economic and social adaptation strategies across the 381 included reports.

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Economic Strategies

Economic strategies fell into four families. The first, on-farm intensification and adjustment, was by far the most common. Climate-smart and soil–water practices (128 reports; 33.6%) ranged from terracing, bunds and conservation agriculture to manure use, mulching and residue management (Teklu et al., 2023; Belay et al., 2024; Enyew and Gobie, 2025; Abdallah, 2026). Crop diversification and variety change (113; 29.7%) included drought-tolerant, early-maturing, hybrid and salt-tolerant varieties and changes in planting dates (Gebre et al., 2023; Nhuong et al., 2025; Euler et al., 2026; Shanta et al., 2026). Irrigation and water harvesting (59; 15.5%) were among the most valued options but also among the least accessible: in Eswatini, small-scale irrigation was adopted by fewer than one in five households, although households perceived it as highly effective for food and water security (Maphalala et al., 2026). Agroforestry and integrated farming (45) combined income generation with ecosystem services (Yusriadi et al., 2024; Tega and Bojago, 2023; Demie and Lojka, 2025; Gezahegn et al., 2025), and livestock adjustment (28) included a shift to drought-tolerant species such as goats and fodder diversification (Hussein et al., 2024; Manyike et al., 2026).

Social Strategies

Social strategies were reported less often but frequently enabled economic responses. The use of climate information and extension services was the most common social strategy (48 reports). Information reached farmers through radio, television, extension agents, farmer field schools, farmer-to-farmer exchange and community organisations, and its use was associated with adopting more adaptation practices (Ogundeji et al., 2022; Ndwiga et al., 2025). Local and indigenous knowledge (32 reports) included biological and astronomical indicators for forecasting rainfall and traditional water and pest management (Guodaar, 2025; Tirivangasi and Kontinen, 2026; Mushimbei and Libanda, 2023), while community seed banks conserved locally adapted varieties (Andersen et al., 2026). Several studies argued that combining indigenous indicators with scientific forecasts produces more usable information than either source alone (Tirivangasi and Nyahunda, 2026; Mushimbei and Libanda, 2023).

Social networks and mutual aid (28 reports) and collective action through groups and cooperatives (26 reports) enabled risk-sharing, labour exchange and access to credit and inputs. In Nepal, members of producer and multipurpose cooperatives adopted about 0.73 and 0.77 more adaptation practices than non-members (Kandel et al., 2026). In Turkey, bonding ties mainly helped disadvantaged farmers cope with sudden-onset events, whereas bridging and linking ties supported

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adaptation to slow-onset change among better-off farmers, and every form of social capital had limits (Gören, 2026). Community-based planning (13 reports), household and gender role reorganisation (6) and cultural and religious practices (4) were reported least often. Examples included participatory community resilience planning (Mweemba et al., 2025; Tanwattana and Toyoda, 2025), women's participation in food-security programmes (Moyo et al., 2026) and rainmaking rituals and sacred-forest protection (Tirivangasi and Kontinen, 2026).

From Coping to Transformation

The strategies also differ in depth. At one end, erosive coping trades future capacity for present survival. Incremental on-farm adaptation adjusts crops, water and soil management within the existing livelihood system. Livelihood restructuring changes the composition of household income through diversification, migration and market engagement. Transformative adaptation, which alters the structure of livelihoods and the institutions that govern them, was rarely documented. One study in Zimbabwe described transformative pathways that combined diversification, disaster-resistant infrastructure, collaboration between government, non-governmental organisations and communities, and the integration of indigenous and digital forecasting (Tirivangasi and Nyahunda, 2026). Many households combined responses from several levels, and in several studies the composition of these portfolios distinguished better-off from worse-off households (Adelhart Toorop et al., 2023; Etana et al., 2023; Núñez et al., 2023).

Factors Associated with Adaptive Capacity and Strategy Uptake (RQ3)

Determinants were analysed in 239 reports (62.7%). Figure 4 and Table 5 group the factors by livelihood capital and show how often each was examined and how consistently it was associated with adaptation or adaptive capacity.

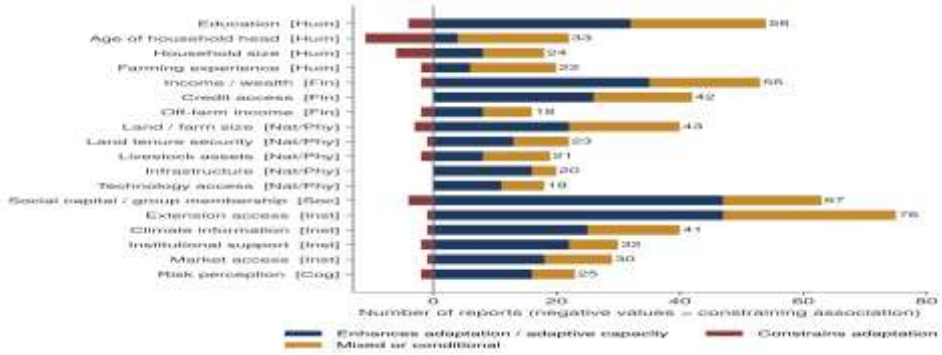


Figure 4. Factors associated with adaptive capacity and strategy uptake by livelihood capital and direction of association; bar labels give the number of reports

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examining each factor. Hum = human; Fin = financial; Nat/Phy = natural and physical; Soc = social; Inst = institutional and informational; Cog = cognitive.

n = reports examining the factor; + = enhancing association; ± = mixed or conditional; − = constraining association; % + = share of reports with an enhancing association. Gender is reported separately in Section 4.4 because the direction of its association depends on how gender is coded.

Frequency and consistency did not coincide. The factors examined most often were extension access (76 reports), social capital or group membership (67), education (58) and income or wealth (55). The most consistently enhancing factors were infrastructure (16 of 20 reports; 80%), social capital or group membership (47 of 67; 70%), institutional support (22 of 32; 69%), income or wealth (35 of 55; 64%), risk perception (16 of 25; 64%), credit (26 of 42; 62%), extension (47 of 76; 62%) and climate information (25 of 41; 61%). Education was positive in just over half of the reports that examined it (32 of 58), whereas age was more often constraining than enhancing (11 against 4), and household size, farming experience and livestock holdings had mixed associations. Land size and tenure security were associated with adaptation investment and resilience (Das et al., 2025; Yang et al., 2026b).

Financial and institutional constraints dominated the barriers, which were reported in 202 reports. Lack of money, credit or capital was cited in 78 reports, institutional weaknesses, including limited extension and government support, in 54, and gaps in information, knowledge or skills in 46. Shortages of inputs and technology (31), restrictive gender and cultural norms (29), water scarcity (29), land constraints (27), poor markets and roads (22) and labour, age or health limitations (19) followed. In northwestern Bangladesh, an average finance gap of about USD 125 per acre separated farmers from drought-tolerant crops and irrigation (Shanta et al., 2026), and in India, finance shortages were the main barrier to climate-smart agriculture (Mishra et al., 2026).

Institutional and informational factors formed a distinct cluster. Early warnings were associated with more than double the odds of reported climate preparedness among 517 households in northern Ghana (Pienaah et al., 2023), and participation in farmer field schools and climate action planning was associated with better resilience in the same region (Pienaah et al., 2024). Institutional trust was linked to adaptation intentions in Egypt and to resilience in South Africa (Abu Hatab et al., 2026; Bahta et al., 2026). Institutional failures also appeared as barriers: local government capacity to support smallholders in Ghana was undermined by climate politics, centralised planning, narrow funding and a shortage of skilled staff (Tweneboah-Koduah, 2025),

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and in Tanzania, top-down interventions benefited only 16.2% of youth respondents, whereas 87.6% engaged in indigenously led adaptation (Solar and Mabhuye, 2024).

Cognitive factors acted as filters between resources and action. Risk perception was positively associated with adaptation in 16 of 25 reports (Purwanti et al., 2023; Manyike et al., 2026; Yang et al., 2025), but perception alone was not sufficient. In India, only 13% of farmers had adopted any adaptation measure although 97% reported income losses from extreme events (Kasana et al., 2025), and in the Philippines, ageing rice farmers with strong risk appraisal did not act because they had little confidence in their ability to cope (Preña and Labayo, 2026).

Effectiveness of Adaptation Strategies (RQ4)

Outcomes of adaptation were measured in 128 of the 381 reports (33.6%); the others described adoption, determinants or vulnerability. Of these 128, 92 (71.9%) reported positive associations, 34 (26.6%) mixed or conditional effects and two (1.6%) negative or maladaptive effects. Among the 46 reports with selection-corrected or panel designs, 38 reported positive and eight conditional effects. Table 6 summarises the evidence by outcome and evidence type, and Figure 5 cross-tabulates strategies and outcomes.

Cells give positive / mixed or conditional / negative counts. A report may assess several outcomes.

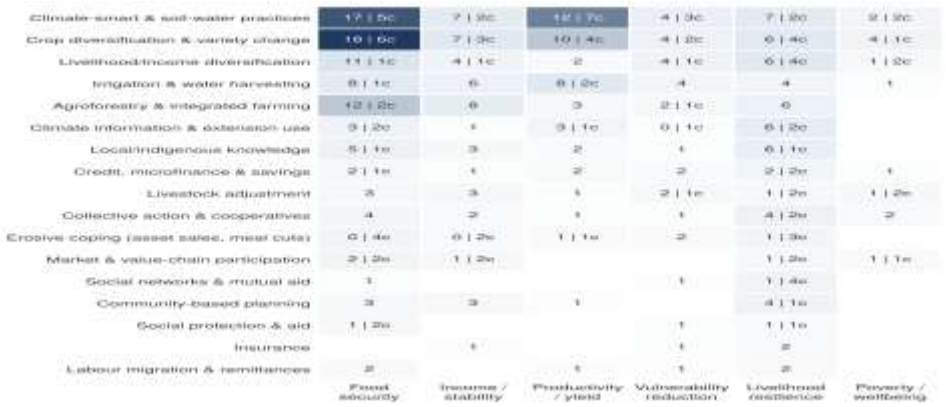


Figure 5. Strategy–outcome evidence map for the 114 of the 128 outcome reports that named specific strategies. Cell values give the number of reports with positive associations; "c" denotes reports with conditional or negative effects. Cells cross-tabulate each report's overall direction of effect with every strategy the report documents, so they are not strategy-specific effect estimates. Strategies documented in fewer than three outcome reports are omitted.

Food security was the most frequently assessed outcome (60 reports, 47 positive). Using selection-corrected estimators, adopters of climate-smart agriculture

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in southern Ethiopia had food consumption scores 6.27–8.15 points higher and farm income per hectare 20.30% higher than non-adopters (Belay et al., 2024), and in East Africa, adoption was associated with 19.5% higher dietary diversity and 41.6% lower food-insecurity scores (Gao, 2026). Agroecological practices were associated with better food security among 2,000 farm households in Burkina Faso, with larger benefits when practices were combined (Sawadogo et al., 2026). Livelihood restructuring showed similar associations: combining farm with off-farm or non-farm activities was associated with substantially higher food and nutrition security in West Shoa (Haile et al., 2025), and industrial-park employment was associated with a 64% lower sensitivity to climate shocks and a 0.49 standard deviation higher food security index, mainly through income stabilisation (Shumiye, 2026). In Indonesia, more intensive adaptation was associated with better food security among shrimp farmers, especially lower-income ones (Toiba et al., 2024), and adaptation among rice farmers in Lamongan was associated with higher food consumption scores (Purbawan et al., 2026).

Productivity and income outcomes pointed in the same direction (27 of 36 and 23 of 28 reports positive). Access to weather and climate services was associated with 27% higher maize and 17% higher wheat productivity across 3,799 Ethiopian households, an effect comparable to that of fertiliser or improved seed, although only 18% of farmers had access (Tamru et al., 2025). Climate advisory users in Senegal obtained higher millet and groundnut yields than matched controls (Joseph et al., 2026), and adapting rice growers in Punjab obtained about 24% higher yields than non-adapters (Khan et al., 2022). Cocoa farmers in Ghana who used a moderate or high number of strategies earned about 5–12% more per hectare than those who used few (Amoako et al., 2026).

The clearest pattern concerned bundles of practices. Sixteen reports compared the number or combination of practices adopted, and 14 of them found larger gains with more or combined practices. In north-eastern Ethiopia, the fully integrated bundle of improved varieties, diversification and soil–water management was associated with a 19.1% higher resilience index (Dessale et al., 2026); adopting one to four adaptation options was associated with progressively higher food security in Ethiopia and Kenya (Gebre et al., 2023; Bergene et al., 2025); and in Tanzanian panel data, joint adoption of resilience technologies and sustainable practices reduced the probability of poverty by 22 percentage points, with larger gains for cooperative members (Mushi, 2026). The other two found gains for some outcomes only: bundles raised maize yields and income but not food consumption in Malawi (Suh et al., 2026), and combining farm, off-farm and non-farm activities improved nutrition but not food security in Ethiopia (Haile et al., 2025).

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The 34 reports with mixed or conditional effects and the two with adverse effects define the limits of this evidence. Climate shocks raised distress coping and reduced household consumption in Malawi; savings and safety nets buffered these losses, whereas credit offered little protection (Ro and Lee, 2026). Coping through livestock and asset sales cushioned shocks but created long-term vulnerability (Bitana et al., 2023), and ex post coping could not offset crop losses for a quarter to half of households in Uganda (Wichern et al., 2023). Financial inclusion was associated with higher overall resilience in sub-Saharan Africa but with weaker transformative capacity (Ali, 2026). In Ghana, higher cocoa income did not help households meet critical needs during drought, whereas health care, clean water, food security and livestock did (Maguire-Rajpaul et al., 2025). Commercial farming built resilience mainly for better-off farmers, leaving poorer farmers in an "adaptation trap" (Newsham et al., 2024); stress-tolerant maize was associated with modest reductions in food insecurity during drought but did not protect against crop failure under extreme stress (Euler et al., 2026); and a climate service raised yields only when farmers were trained to use it (Bacci et al., 2023). The two adverse cases concerned Senegalese farmers abandoning drought-tolerant crops for water-demanding exotic crops under market and policy pressures (Porcuna-Ferrer et al., 2024) and household adaptation that largely failed against salinity in coastal Bangladesh, where community-level measures performed better (Lam et al., 2022).

Methodological Quality

Quantitative non-randomised (133) and descriptive (93) studies and mixed-methods reports (120) dominated, and 35 reports were qualitative. Reports explicitly satisfied a median of two of the five MMAT criteria for their design (mean 1.79): seven met none, 145 met one, 158 met two, 64 met three and seven met four. Because most ratings rested on abstracts, these counts indicate weak methodological reporting more than they demonstrate weak research; nevertheless, they caution against strong causal readings of the cross-sectional evidence.

Sensitivity Analyses and Reporting Bias

The direction of the outcome evidence was robust across sensitivity analyses. Positive associations made up 82.6% of outcome reports using selection-corrected or panel designs (38 of 46), 68.1% of other comparative reports (47 of 69) and 53.8% of qualitative or perception-based reports (7 of 13). Restricting the synthesis to reports meeting at least three MMAT criteria gave 24 positive of 31 (77.4%), and counting one report per sample cluster gave 89 positive of 124 (71.8%). The share was lower in sub-Saharan Africa (65 of 95; 68.4%) than in other regions (27 of 33;

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81.8%). Excluding three eligibility edge cases, namely a report in an institutional research series, an article on an open peer-review platform and a political-ecology account based largely on secondary sources, gave 90 positive of 125 (72.0%) and left one adverse case. No synthesis reversed in direction. The scarcity of null and negative results (two of 128 reports) and the reliance on abstracts, which tend to report significant associations, nevertheless indicate a high risk of reporting bias that favours positive findings.

Certainty of Evidence

Table 7 summarises the certainty of the main findings. Certainty was rated moderate for the positive associations of adaptation with food security, productivity and income and for the advantage of combined practices for food security and productivity, because these bodies of evidence included selection-corrected designs and showed a dose–response pattern, although they were downgraded for likely reporting bias. It was rated low for the associations of social capital, extension, climate information, income and credit with adaptation, which rest mainly on cross-sectional evidence coded from abstracts, for effects on livelihood resilience, vulnerability and poverty, and for the role of gender, and very low for transformative adaptation.

Discussion

An Integrative Framework of Rural Socioeconomic Adaptation (RQ5)

The synthesis supports an integrative framework that links climate stressors, livelihood capitals, institutions, adaptive capacity, adaptation pathways and outcomes (Figure 6). It draws on the four perspectives introduced in Section 2 and is organised around the empirical regularities identified in Sections 4.3–4.5. Five propositions summarise these regularities. They are stated probabilistically and with boundary conditions, and Table 8 lists the supporting and contrary evidence, the certainty of each proposition and a design that could test it.

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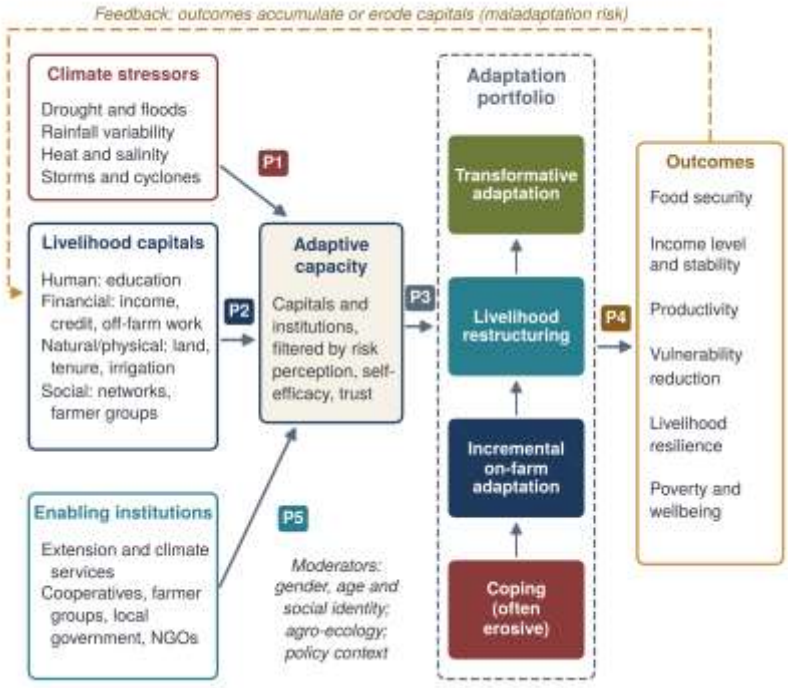


Figure 6. Integrative framework of rural socioeconomic adaptation to climate change. P1–P5 denote the propositions in Section 5.1. Each rung of the adaptation portfolio combines an economic strand (crops, water, trees, livestock, off-farm work, finance) and a social strand (networks, groups, local knowledge, information use).

Proposition 1 (exposure and capacity). Climate exposure is more likely to translate into adaptation than into erosive coping where adaptive capacity is higher. Shocks raised distress coping and reduced consumption in Malawi, while savings and safety nets buffered the losses (Ro and Lee, 2026); access to small dams was associated with less reliance on distress livestock sales and seasonal migration in northern Ghana (Madaki et al., 2025); and repeated drought and floods led Nepali households to retreat into farm income rather than diversify (Choquette-Levy et al., 2025). No included study tested the interaction between exposure and capacity directly, so this proposition remains a hypothesis.

Proposition 2 (capitals). Social capital is at least as consistently associated with adaptive capacity as financial capital, but its effect depends on the type of tie. Group membership and networks were positive in 70% of the reports that examined them, compared with 64% for income and 62% for credit (Table 5), and village savings groups were associated with lower food insecurity in Ghana (Pienaah and Luginaah, 2024). Bonding ties nevertheless offered limited help with slow-onset

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change (Gören, 2026), which suggests that bridging and linking ties to markets, extension and government are the components that matter most for adaptation.

Proposition 3 (capacity and pathways). Households with greater capacity tend to combine more strategies and to move from coping towards incremental adaptation and livelihood restructuring. Cooperative membership and climate information were each associated with a larger number of practices (Kandel et al., 2026; Ogundeji et al., 2022), and asset-rich households pursued diversified, higher-return portfolios (Adelhart Toorop et al., 2023; Etana et al., 2023; Núñez et al., 2023), whereas poorer farmers remained in an adaptation trap (Newsham et al., 2024). Better-off farmers do not always adapt, however (Kasana et al., 2025), so capacity is necessary but not sufficient.

Proposition 4 (portfolios and outcomes). Integrated portfolios that combine several practices are associated with larger gains in food security and productivity than single measures. Fourteen of the sixteen reports that compared bundles found larger gains for combined practices (Sawadogo et al., 2026; Dessale et al., 2026; Bergene et al., 2025; Mushi, 2026), but gains did not always extend to food consumption or nutrition (Haile et al., 2025; Suh et al., 2026), and evidence on resilience and income stability over time is still scarce.

Proposition 5 (institutions). Institutions convert capitals into capacity, and their design shapes whether adaptation reduces or redistributes vulnerability. Climate services combined with training, farmer field schools and cooperatives were associated with higher yields, resilience and welfare (Pienaah et al., 2024; Mushi, 2026; Bacci et al., 2023), whereas top-down or centralised interventions reached few households, delivered limited benefits or reduced diversification (Tweneboah-Koduah, 2025; Solar and Mabhuye, 2024; Liu et al., 2024; Siamabele and Manda, 2024). In the same climate service evaluation, information without training did not raise yields (Bacci et al., 2023), consistent with evidence that poorly contextualised adaptation can reinforce vulnerability (Eriksen et al., 2021).

The framework also includes a feedback loop. Outcomes accumulate or erode capitals and thereby shape future capacity. Debt and asset sales after shocks (Bitana et al., 2023; Bello et al., 2026) illustrate the downward spiral that the maladaptation literature warns against (Barnett and O'Neill, 2010), while income stabilisation through diversification and insurance illustrates an upward spiral (Shumiye, 2026; Han et al., 2026).

Comparison with Previous Reviews and Theoretical Implications

These findings align with, and extend, earlier syntheses. Consistent with the global stocktake of adaptation evidence (Berrang-Ford et al., 2021), the reviewed

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literature documents adaptation that is mostly incremental and local and offers little evidence of transformation. Unlike that stocktake, however, the 2022–2026 rural literature contains a growing body of outcome evidence, 46 reports of which used selection-corrected or panel designs, and this evidence points consistently towards positive associations between adaptation and food security and productivity, with moderate certainty. The dominance of on-farm practices and crop diversification mirrors earlier reviews of farmers' adaptation in Asia and Africa (Opoku Mensah et al., 2025; Shaffril et al., 2018; Abebaw, 2025), and the prominence of vulnerability index studies echoes a recent stocktake of livelihood vulnerability assessments (Zainab and Shah, 2024). Our results add that these indices are rarely connected to the strategies households adopt or to their outcomes.

The coping-to-transformation continuum used here builds on the established distinction between incremental and transformational adaptation (Kates et al., 2012). What this review adds is joint coding of social and economic strategies across 381 reports, a strategy-by-outcome evidence map and a certainty-graded synthesis for the 2022–2026 period. Three theoretical implications follow. First, the sustainable livelihoods framework needs to treat diversification as conditional. Diversification was associated with better food security when it gave access to remunerative wage or self-employment (Musungu et al., 2024; Haile et al., 2025; Shumiye, 2026), but it coincided with lower preparedness or reflected distress when it was not (Maguire-Rajpaul et al., 2025; Choquette-Levy et al., 2025), echoing the distinction between diversification out of opportunity and out of necessity (Barrett et al., 2001; Ellis, 1998). Second, the vulnerability and adaptive capacity perspective benefits from adding cognition and institutions as explicit filters between capitals and action: resources were necessary but not sufficient, and perception, efficacy beliefs and trust shaped whether they were used (Grothmann and Patt, 2005; Kasana et al., 2025; Preña and Labayo, 2026). Third, the resilience perspective is strengthened by recognising that absorptive, adaptive and transformative capacities can move in different directions, as the evidence on financial inclusion suggests (Ali, 2026), which cautions against relying on single composite resilience scores.

The regional comparison also qualifies generalisations drawn from the African literature. In sub-Saharan Africa, climate-smart soil and water practices (41% of reports) and crop diversification (34%) dominated. In Southeast Asia, livelihood diversification was the most common strategy (21% of 29 reports), climate-smart practices were far less common (10%), social networks were reported about twice as often as in sub-Saharan Africa (10% against 5%), and social capital was the factor examined most frequently. Southeast Asian evidence on outcomes is still thin (10

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reports), so these contrasts should be read as hypotheses rather than established differences.

Policy Implications

Four implications for policy emerge. First, adaptation finance should be designed for smallholders. Finance was the most frequently reported barrier, and modest finance gaps can block the adoption of irrigation and drought-tolerant varieties (Shanta et al., 2026). Savings groups, social safety nets and insurance were associated with protected consumption and faster recovery after shocks (Pienaah and Luginaah, 2024; Han et al., 2026; Jafarov and Mammadov, 2026; Ro and Lee, 2026), and financial literacy was associated with the use of formal climate credit and savings in East Java (Retnoningsih and Chung, 2025). Second, collective institutions merit investment as part of adaptation infrastructure, because cooperatives and farmer groups were associated with greater adoption and larger welfare gains from adaptation (Kandel et al., 2026; Mushi, 2026). Third, climate services should be co-produced and paired with training: services delivered through trusted channels were associated with higher yields and preparedness, whereas information alone was not (Pienaah et al., 2023; Tamru et al., 2025; Bacci et al., 2023). Fourth, policies should promote and monitor portfolios rather than single practices and should track outcomes as well as adoption rates, so that erosive coping and maladaptive trade-offs can be detected early (Ro and Lee, 2026; Dessale et al., 2026; Porcuna-Ferrer et al., 2024).

For Indonesia, the evidence is limited but informative. Indonesian studies associate adaptation with education, farmer-group participation, infrastructure, extension and livelihood capitals (Purwanti et al., 2022; Hasibuan et al., 2023; Azhari et al., 2025), link more intensive adaptation to better food security (Toiba et al., 2024; Purbawan et al., 2026) and identify prior disaster experience and social protection as the strongest predictors of household adaptiveness in East Sumba (Killa et al., 2026). These findings suggest three practical entry points. Village-level development funds, whose role in post-disaster economic recovery has been examined in Aceh (Nugroho et al., 2022), could co-finance community water harvesting, seed banks and diversified enterprises. Farmer groups and extension services could deliver bundled advisory, credit and insurance services. And the Climate Village Program could provide a platform for community-based adaptation if it were integrated into regional medium-term development plans (Wiati et al., 2022).

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Research Gaps and Future Research Agenda

Table consolidates the main gaps and the research questions they imply. The most pressing gaps concern geography, outcomes and causality. Southeast Asia, Latin America and pastoral, fishing and forest-dependent communities are under-represented, which limits the generalisability of findings dominated by Ethiopian and Ghanaian crop farmers. Most studies stop at adoption or vulnerability scores, and few follow households over time. Social adaptation is under-measured, transformative adaptation is rarely studied, and gender is too often reduced to a household-head dummy variable.

Table 9. Research gaps and a future research agenda.

Gap	Evidence from this review	Priority research questions
Geographic concentration	261 reports (68.5%) from sub-Saharan Africa, 74 from Ethiopia alone; 29 from Southeast Asia, including 14 from Indonesia	Do the factors and pathways identified in African crop systems hold in archipelagic, coastal and upland Southeast Asia, including Indonesia?
Limited outcome evidence	Outcomes measured in 128 reports (33.6%); 14 reports used panel data	Which strategies and portfolios reduce vulnerability and stabilise income across several seasons and shocks?
Weak causal identification	Cross-sectional surveys dominate; 61 reports used selection-corrected or panel designs	What are the causal effects of adaptation bundles and of institutional interventions such as cooperatives, climate services and credit?
Under-measured social adaptation	Social strategies in 111 reports (29.1%); household reorganisation and cultural practices in six and four reports	How do networks, collective action and local knowledge interact with economic strategies, and how can social adaptation be measured reliably?
Maladaptation and trade-offs	34 reports with conditional and two with adverse effects; erosive coping in 19 reports	Under which conditions do coping, diversification, commercialisation or financial inclusion erode long-term capacity?

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Gap	Evidence from this review	Priority research questions
Transformative adaptation	Transformative pathways documented in a single report	Which institutional and policy conditions allow rural livelihoods to transform rather than merely adjust?
Gender and intersectionality	Gender examined in 60 reports, with divergent directions	How do gender, age, marital status, tenure and social identity jointly shape access to adaptation and its benefits?
Neglected livelihood systems	Pastoral, fisheries and forest-based livelihoods in 11 reports	How do pastoralists, fishers and forest-dependent communities adapt, and which institutions support them?
Disconnected vulnerability indices	At least 36 index-based vulnerability assessments, rarely linked to strategies or outcomes	How can vulnerability indices be linked to adaptation choices and tracked over time to evaluate interventions?

CONCLUSIONS

This systematic review synthesised 381 empirical reports published between 2022 and 2026 on the socioeconomic adaptation of rural communities to climate change. The retrieved literature has grown quickly but remains concentrated in sub-Saharan Africa, in crop-farming systems and in cross-sectional household surveys. Rural households rely mainly on economic strategies, especially climate-smart soil and water practices, crop and variety change, livelihood diversification and irrigation, while social strategies, notably climate information use, local knowledge, networks and collective action, often make these economic responses possible. Infrastructure, social capital, institutional support, income, credit and extension are the factors most consistently associated with adaptation, although with low certainty; age, household size and gender act in context-specific ways that intersect with social norms and tenure.

The evidence on effectiveness is growing and, with moderate certainty, favourable for food security and productivity. About seven in ten reports that measured outcomes found positive associations, the share was higher among selection-corrected and panel designs, and combined practices were associated with the largest gains, which cooperative membership amplified in one panel study. Conditional and adverse effects, such as erosive coping, trade-offs, adaptation traps for poorer farmers and crop choices that erode long-term resilience, show that

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adaptation can also redistribute vulnerability, and certainty for resilience, vulnerability and poverty outcomes remains low.

The integrative framework and its five propositions offer a basis for testing these relationships with longitudinal, comparative and experimental designs. For policymakers in Indonesia and other countries with large smallholder populations, the review supports a shift from promoting single practices to financing and monitoring adaptation portfolios through local institutions. Strengthening the social foundations of adaptation deserves the same attention as delivering technologies if rural livelihoods are to remain sustainable in a changing climate.

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