

What is the current evidence on the effectiveness of climate finance interventions in improving climate resilience and socioeconomic outcomes among smallholder farmers in low- and middle-income countries (LMICs)?

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A systematic map protocol



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Abstract

Climate finance is central to climate-resilient development, yet evidence on its effects on smallholder farmers remains fragmented across financing instruments and outcome measures. This study conducts a systematic review, guided by PRISMA 2020, to assess how grants, concessional loans, insurance, carbon finance, public investment, and private capital influence the livelihoods and resilience of smallholder farmers in developing countries, with attention to women. The review will synthesize impacts on access to climate-smart technologies, irrigation, improved seeds, advisory services, markets, and livelihood diversification, as well as outcomes including productivity, income stability, food security, adaptive capacity, asset accumulation, and women's economic empowerment. It will examine distributional effects, implementation conditions, and evidence gaps across regions and farmer groups. By linking finance mechanisms to intermediate and long-term outcomes, the study aims to identify which forms of climate finance work, for whom, and under what conditions, thereby informing inclusive and effective climate finance policy and programming.

Keywords

climate finance, smallholder farmers, climate adaptation, climate resilience, rural livelihoods, low- and middle-income countries (LMICs)

Background

Climate finance is increasingly recognized as essential for underdeveloped and vulnerable nations because these countries face the greatest climate risks despite contributing the least to historical greenhouse gas emissions. Limited fiscal space, high debt burdens, and constrained access to affordable capital reduce their ability to invest in adaptation measures such as resilient agriculture, water systems, disaster preparedness, and climate-smart infrastructure (Pedersen et al., 2025). Without external support, many low-income countries risk deeper poverty, food insecurity, and climate-induced displacement.

Targeted climate finance is also critical because adaptation needs in developing countries significantly exceed current funding flows. The United Nations Environment Programme (UNEP) Adaptation Gap Report notes that adaptation finance needs are estimated in the hundreds of billions of dollars annually, while actual flows remain far below requirements (UNEP, 2023). This financing gap slows progress toward resilient development and the Sustainable Development Goals. Between 2000 and 2021, agrifood systems received approximately USD 183 billion in [climate-related development finance](#), with more than half of this amount disbursed during the final five years of the period.

Recent COP decisions have strongly reaffirmed this priority. At COP27 in Sharm el-Sheikh, parties agreed to establish a Loss and Damage Fund, recognizing that vulnerable countries require dedicated support for irreversible climate harm such as floods, droughts, and sea-level rise. At COP28 in Dubai, governments operationalized the fund and secured initial pledges, while also calling for scaled-up concessional and grant-based finance for developing countries.

Further, the Paris Agreement and subsequent COP outcomes continue to emphasize the commitment by developed countries to mobilize climate finance, including the long-standing US\$100 billion annual goal and the negotiation of a new collective quantified goal on climate finance to better reflect evolving needs (Organisation for Economic Co-operation and Development, 2024; UNFCCC, 2024). More recently, discussions under COP29 focused heavily on setting stronger post-2025 finance architecture, particularly for adaptation and just transitions in lower-income economies.

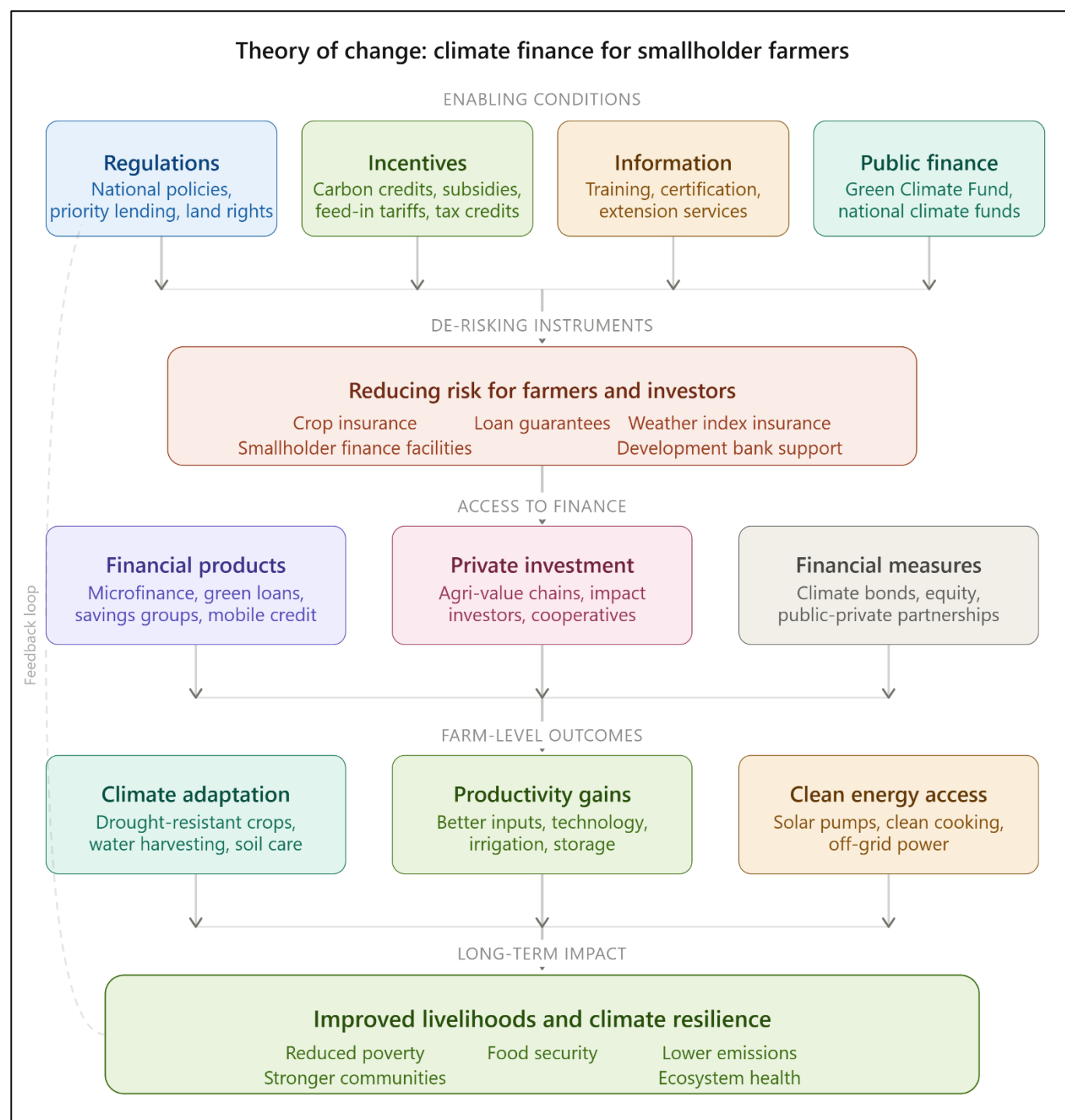
In summary, climate finance is not only an environmental necessity but also a development imperative. For underdeveloped nations, it enables resilience, protects livelihoods, supports clean growth pathways, and promotes climate justice by recognizing differentiated responsibilities. Despite the rapid expansion of climate finance architecture over the past two decades, the evidence on its impacts is dispersed across disciplines and methods. Some studies focus on macro-level effects such as emissions reduction, renewable energy investments, adaptation capacity building, or private investment mobilization, whereas others examine project- or community-level outcomes such as livelihood resilience, agricultural productivity, food security, access to energy, governance, or distributional effects (Bhandary et al., 2021; Wabwile & Ondabu, 2025).

A systematic review is therefore needed to bring together empirical literature in a transparent and reproducible way. The present protocol is structured in line with PRISMA 2020 reporting guidance for systematic reviews and is designed to support rigorous review conduct, transparent decision-making, and collaborative refinement before screening begins (Page et al., 2021).

Theory of change

Climate finance of all types, including grants, concessional loans, insurance, carbon finance, public investments, and private capital is expected to enable smallholder farmers to access climate-resilient technologies, improved seeds, irrigation, advisory services, and diversified livelihood opportunities, which they otherwise do not have access to. By reducing financial barriers and investment risks, climate finance strengthens adaptive capacity, enhances productivity, and improves access to markets and information. Increased resilience allows households to better anticipate, absorb, and recover from climate shocks such as droughts, floods, and heat stress and lead to positive welfare outcomes for households, particularly women. Over time, these investments improve food security, income stability, asset accumulation, and women's economic empowerment, contributing to more resilient and sustainable rural livelihoods. An illustration of our theory of change is presented in Figure 1.

Figure 1: Theory of change on climate finance and its impacts on smallholder farmers



Source: Authors' illustration

Objectives and review questions

Our primary question is: How effective are climate-finance interventions in improving climate resilience and socioeconomic outcomes among smallholder farmers in low- and middle-income countries?

Our sub-questions are:

1. What types, sources, instruments, and delivery mechanisms of climate finance for smallholder farmers have been evaluated in the existing literature?
2. Which agricultural sectors, geographical regions, countries, and smallholder farmer groups are represented in the evidence base?
3. What outcome domains and indicators are used to assess the effectiveness of climate-finance interventions for smallholder farmers?
4. How does the effectiveness of climate finance vary by farmer characteristics, financial instruments, sources of finance, agricultural sector, and country or implementation context?

Definitions of the question components

For this review, the population and context comprise smallholder farmers in countries classified by the World Bank as low-income, lower-middle-income, or upper-middle-income at the time of protocol implementation. The operational definitions of smallholder farmers and eligible LMICs are specified in the eligibility criteria. Climate finance refers to financial flows, instruments, or mechanisms explicitly intended to support climate-change mitigation, adaptation, resilience, or related enabling activities. Eligible mechanisms may include public climate funds, bilateral and multilateral finance, domestic public finance, blended and concessional finance, guarantees, carbon finance, green bonds, insurance-linked mechanisms, and comparable climate-linked instruments. Effectiveness and outcomes refer to measurable economic, livelihood, welfare, adaptation, resilience, mitigation, institutional, governance, and equity-related effects. The review will also examine how the evidence varies by finance type and source, delivery mechanism, agricultural sector, farmer characteristics, geography, and implementation context. A detailed PICO table is presented in Table 1 below.

Search strategy

The search strategy will combine terms relating to climate finance, impacts or effectiveness, and LMIC settings. Search strings will be adapted to each database while preserving the same conceptual logic. Searches will be documented fully, including search dates, databases, exact strings, and numbers of records retrieved.

The draft search string that will be used is presented below. This will be updated to be included in the final report.

"climate financ" OR "adaptation finance" OR "resilience finance" OR "carbon finance" OR "carbon market*" OR "carbon credit*" OR "results based financ*" OR "results based payment*" OR "payment for ecosystem services" OR "climate risk insurance" OR "index insurance" OR "weather index insurance" OR "weather indexed insurance" OR "livestock insurance" OR "parametric insurance" OR "parametric risk*" OR "contingent credit" OR "concessional finance" OR "blended finance" OR "target lending" OR "green bond*" OR "loan guarantee*" OR "feed in tariff*" OR "tax credit*" OR "national development bank*" OR "national climate fund*" OR "climate disclosure*" OR (climate AND grant*) OR (climate AND loan*) OR (climate AND subsid*) OR (climate AND premium*) OR "adaptation fund" OR "green climate fund" OR "global environment facility" OR GCF OR GEF OR "loss and damage" OR "social protection" OR "risk transfer" OR "risk financing"

AND

(afghanistan or albania or algeria or "american samoa" or angola or "antigua and barbuda" or antigua or barbuda or argentina

or armenia or armenian or aruba or azerbaijan or bahrain or bangladesh or barbados or belarus or byelarus or belorussia or byelorussian or belize or "british honduras" or benin or dahomey or bhutan or bolivia or "bosnia and herzegovina" or bosnia or herzegovina or botswana or bechuanaland or brazil or brasil or bulgaria or "burkina faso" or "burkina fasso" or "upper volta" or burundi or urundi or "cabo verde" or "cape verde" or cambodia or kampuchea or "khmer republic" or cameroon or cameron or cameroun or "central african republic" or "ubangi shari" or chad or chile or china or colombia or comoros or "comoro islands" or "iles comores" or mayotte or "democratic republic of the congo" or "democratic republic congo" or congo or zaire or "costa rica" or "cote d'ivoire" or "cote d'ivoire" or "cote divoire" or "cote d'ivoire" or "ivory coast" or croatia or cuba or cyprus or czech or czechoslovakia or djibouti or "french somaliland" or dominica or dominican or ecuador or egypt or "united arab republic" or "el salvador" or "equatorial guinea" or "spanish guinea" or eritrea or estonia or eswatini or swaziland or ethiopia or fiji or gabon or gabonese or gambia or "georgia republic" or georgian or ghana or "gold coast" or gibraltar or greece or grenada or guam or guatemala or guinea or "guinea bissau" or guyana or "british guiana" or haiti or hispaniola or honduras or hungary or india or indonesia or timor or iran or iraq or "isle of man" or jamaica or jordan or kazakhstan or kazakh or kenya or korea or kosovo or kyrgyzstan or kirghizia or kirgizstan or "kyrgyz republic" or kirghiz or laos or "lao pdr" or "lao people's democratic republic" or latvia or lebanon or "lebanese republic" or lesotho or basutoland or liberia or libya or lithuania or macau or macao or "macedonia republic" or macedonia or madagascar or "malagasy republic" or malawi or nyasaland or malaysia or "malay federation" or "malaya federation" or maldives or "indian ocean islands" or "indian ocean" or mali or malta or micronesia or "federated states of micronesia" or kiribati or "marshall islands" or nauru or "northern mariana islands" or palau or tuvalu or mauritania or mauritius or mexico or moldova or moldovian or mongolia or montenegro or morocco or ifni or mozambique or "portuguese east africa" or myanmar or burma or namibia or nepal or "netherlands antilles" or nicaragua or niger or nigeria or oman or muscat or pakistan or panama or "papua new guinea" or "new guinea" or paraguay or peru or philippines or philippines or philippines or philippines or poland or "polish people's republic" or portugal or "portuguese republic" or "puerto rico" or romania or russia or "russian federation" or ussr or "soviet union" or "union of soviet socialist republics" or rwanda or ruanda or samoa or "pacific islands" or polynesia or "samoan islands" or "navigator island" or "navigator islands" or "sao tome and principe" or "saudi arabia" or senegal or serbia or seychelles or "sierra leone" or slovakia or "slovak republic" or slovenia or melanesia or "solomon island" or "solomon islands" or "norfolk island" or "norfolk islands" or somalia or "south africa" or "south sudan" or "sri lanka" or ceylon or "saint kitts and nevis" or "st. kitts and nevis" or "saint lucia" or "st. lucia" or "saint vincent and the grenadines" or "saint vincent" or "st. vincent" or grenadines or sudan or suriname or surinam or "dutch guiana" or "netherlands guiana" or syria or "syrian arab republic" or tajikistan or tadjikistan or tadjikistan or tadjik or tanzania or tanganyika or thailand or siam or "timor leste" or "east timor" or togo or "togolese republic" or tonga or "trinidad and tobago" or trinidad or tobago or tunisia or turkey or turkmenistan or turkmen or uganda or ukraine or uruguay or uzbekistan or uzbek or vanuatu or "new hebrides" or venezuela or vietnam or "viet nam" or "middle east" or "west bank" or gaza or palestine or yemen or yugoslavia or zambia or zimbabwe or "northern rhodesia" or "global south" or "africa south of the sahara" or "sub-saharan africa" or "subsaharan africa" or "africa, central" or "central africa" or "africa, northern" or "north africa" or "northern africa" or magreb or maghrib or sahara or "africa, southern" or "southern africa" or "africa, eastern" or "east africa" or "eastern africa" or "africa, western" or "west africa" or "western africa" or "west indies" or "indian ocean islands" or caribbean or "central america" or "latin america" or "south and central america" or "south america" or "asia, central" or "central asia" or "asia, northern" or "north asia" or "northern asia" or "asia, southeastern" or "southeastern asia" or "south eastern asia" or "southeast asia" or "south east asia" or "asia, western" or "western asia" or "europe, eastern" or "east europe" or "eastern europe" or "developing country" or "developing countries" or "developing nation*" or "developing population*" or "developing world" or "less developed countr*" or "less developed nation*" or "less developed population*" or "less developed world" or "lesser developed countr*" or "lesser developed nation*" or "lesser developed population*" or "lesser developed world" or "under developed countr*" or "under developed nation*" or "under developed population*" or "under developed world" or "underdeveloped countr*" or "underdeveloped nation*" or "underdeveloped population*" or "underdeveloped world" or "middle income countr*" or "middle income nation*" or "middle income population*" or "low income countr*" or "low income nation*" or "low income population*" or "lower income countr*" or "lower income nation*" or "lower income population*" or "underserved countr*" or "underserved nation*" or "underserved population*" or "underserved world" or "under served countr*" or "under served nation*" or "under served population*" or "under served world" or "deprived countr*" or "deprived nation*" or "deprived population*" or "deprived world" or "poor countr*" or "poor nation*" or "poor population*" or "poor world" or "poorer countr*" or "poorer nation*" or "poorer population*" or "poorer world" or "developing econom*" or "less developed econom*" or "lesser developed econom*" or "under developed econom*" or "underdeveloped econom*" or "middle income econom*" or "low income econom*" or "lower income econom*" or "low gdp" or "low gnp" or "low gross domestic" or "low gross national" or "lower gdp" or "lower gnp" or "lower gross domestic" or "lower gross national" or Imic or Imics or "third world" or "lami countr*" or "transitional countr*" or "emerging econom*" or "emerging nation*" OR afghan or afghani or albanian or algerian or "american samoan" or angolan or antiguan or barbudan or argentine or argentinian or argentinean or armenian or aruban or azerbaijani or bahraini or bangladeshi or bangalees or bajan or belarusian or byelorussian or belizean or beninese or bhutanese or bolivian or bosnian or botswana or batswana or brazilian or brasilian or bulgarian or burkinabe or burkinese or burundian or "cape verdean*" or "cabo verdean*" or cambodian or khmer or cameroonian or "central african*" or chadian or chilean or chinese or colombian or comorian or congolese or "costa rican*" or ivorian or croatian or cuban or cypriot or czech or djiboutian or ecuadorian or egyptian or salvadoran or "equatorial guinean*" or equatoguinean or eritrean or estonian or

swazi or swati or ethiopian or fijian or gabonaise or gambian or georgian or ghanaian or gibraltarian or greek or grenadian or guamanian or guatemalan or guinean or "bissau guinean" or guyanese or haitian or honduran or hungarian or indian or indonesian or iranian or iraqian or iraqi or manx or jamaican or jordanian or kazakhstani or kenyan or kirabati or kirabatian or "north korean*" or korean or kosovar or kosovan or kyrgyz or lao or laotian or latvian or lebanese or lesothan or lesothonian or mosotho or basotho or liberian or libyan or lithuanian or macanese or macedonian or malagas or madagascan or malawian or malaysian or maldivian or malian or maltese or marshallese or mauritanian or mauritian or mexican or micronesian or moldovan or mongolian or mongol or moroccan or mozambican or burmese or myanma or namibian or nauruan or nepali or nepalese or "netherlands antillean*" or nicaraguan or nigerien or nigerian or "northern mariana islander*" or mariana or omani or pakistani or palauan or panamanian or "papua new guinean*" or paraguayan or peruvian or philippine or philipine or philippine or philippine or filipino or filipina or polish or pole or poles or portuguese or "puerto rican*" or romanian or russian or "soviet people" or "soviet population" or rwandan or rwandese or ruandan or ruandese or samoan or "sao tomean" or santomean or "saudi arabian*" or saudi or senegalese or serbian or montenegrin or seychellois or seychelloise or "sierra leonean*" or slovak or slovene or "solomon islander*" or somali or "south african*" or "south sudanese" or "sri lankan*" or ceylonese or kittitian or nevisian or "saint lucian*" or vincentian or sudanese or surinamese or syrian or tajik or tajikistani or tanzanian or tanganyikan or thai or timorese or togolese or tongan or trinidadian or tobagonian or tunisian or turk or turkish or turkmen or tuvaluan or ugandan or ukrainian or uruguayan or uzbek or vanuatu or venezuelan or vietnamese or yemeni or yemenite or yemenese or yugoslav or yugoslavian or zambian or Zimbabwean or african or asian or "pacific islander*" or "latin american*" or "central american*" or "south american*" or caribbean or "west indian*" or "iberoamerican*" or "middle eastern*")

Bibliographic databases

The following databases will be used: CAB Abstracts, Scopus, Web of Science Core Collection, MEDLINE via PubMed, AGRIS, AGRICOLA, and ProQuest Dissertations and Theses.

Additionally, we will use OpenAlex to identify additional publications, citations, authors and related studies not retrieved from subscription databases as well as Google Scholar to locate working papers, institutional reports and alternative versions of articles.

Websites

- FAO,
- ILRI,
- CGIAR,
- World Bank,
- IFAD,
- Green Climate Fund Open Data Library,
- Adaptation Fund,
- Global Environment Facility,
- Climate Investment Funds,
- InsuResilience,
- Global Index Insurance Facility,
- national climate funds, national agricultural insurance agencies,
- Verra, Gold Standard, Plan Vivo,
- and relevant government ministries

Search update

We will run a supplementary gender-focused search using additional gender blocks below to not miss explicitly gender-focused literature.

(Previous search string)

AND

(gender OR women OR woman OR female* OR "gender equality" OR "gender equity" OR "gender empowerment" OR empowerment OR "women's empowerment" OR "gender-responsive" OR "gender-transformative" OR "gender inclusion" OR "gender mainstreaming" OR "women farmers" OR "female farmers" OR "female-headed household*" OR "women-led" OR "gendered impact*" OR intersectionality)

Comprehensiveness of the search

A list of benchmark studies was selected based on prior expertise of the review team beyond the search strategy. These studies have been identified because they have looked at the central construct of the systematic review ('climate risk perception') predominantly in south Asian or global south populations. Additionally, artificial intelligence tools such as "Connected Papers" will be used to identify relevant benchmark papers. Based on the search key terms of the benchmark articles, the search strategy may be updated by adding additional keywords.

Screening strategy

All retrieved records will be imported into Covidence, where duplicate records will be identified and removed automatically, followed by manual verification. Screening will be conducted in two stages: (1) title and abstract screening and (2) full-text review. Two reviewers will independently assess studies against the predefined inclusion and exclusion criteria listed below, with conflicts resolved through discussion and, where necessary, consultation with a third reviewer. A sample of 20 titles and abstract screening will be reviewed for reviewer consistency checking and calibration. Reasons for exclusion at the full-text stage will be recorded within Covidence. The screening process will be documented using the PRISMA flow diagram, ensuring transparency, reproducibility, and consistency throughout the review.

Eligibility criteria

Eligibility criteria will be guided by a modified PICO framework specified in Table 1 below. The PICOS framework, along with explicit inclusion and exclusion criteria will be included in the screening template on Covidence for ready reference.

Table 1: PICOS and inclusion/exclusion criterion for screening of literature

Criterion	Include	Exclude
Population/context	Studies focused on one or more World Bank low-, lower-middle-, or upper-middle-income countries; single-country, multi-country, or regional studies with extractable LMIC evidence.	Studies focused exclusively on high-income countries or studies where LMIC evidence cannot be meaningfully separated.
Intervention/exposure	Climate finance or clearly climate-linked financing interventions, including grants, concessional loans, blended finance, green bonds, guarantees, carbon finance, and insurance-linked climate instruments.	General development finance with no explicit climate component, or studies where finance is mentioned only in passing.
Outcomes	Empirical evidence on environmental, economic, social, institutional, resilience, behavioural, or equity-related impacts.	Purely descriptive finance flow studies with no assessment of outcomes, impacts, or effectiveness.
Study type	Primary empirical studies, such as randomized trials, controlled experiments, observational studies, and analytical studies, that provide impact on adaptation interventions, welfare outcomes, productivity responses, health, livelihoods, or related outcomes	Commentaries, editorials, conceptual papers, conference abstracts without evidence on impacts on any specific outcomes.
Time period	Studies published from 1 January 2000 onward.	Studies published before 2000.
Language	English.	Non-English publications.

Studies will be included if they: (a) focus on one or more LMICs; (b) examine climate finance or a clearly climate-linked financing intervention; (c) report empirical evidence on impacts, outcomes, effectiveness, or consequences; and (d) were published in English from January 2000 onwards. The review will be limited to English-language publications to ensure consistency in screening, data extraction, and quality assessment, given the review team's available language and translation resources. English is also the primary language of international climate-finance scholarship and major indexed databases. However, this restriction may exclude relevant local evidence and will therefore be acknowledged as a potential source of language bias. The review begins in 2000 to capture the rapid institutionalization of climate finance. This period includes the 2001 creation of dedicated funds for adaptation and vulnerable countries, followed by the Green Climate Fund and Loss and Damage mechanisms, allowing the review to trace the evolution of modern climate-finance architecture globally.

Studies will be excluded if they focus exclusively on high-income countries, treat finance only tangentially without assessing its role, are purely descriptive flow-tracking exercises without impact analysis, are opinion or commentary pieces, or are conference abstracts without accessible full text.

Grey literature will not be included in this review. This decision has been made to maintain a clearly bounded and consistently appraised peer-reviewed evidence base for synthesis.

Consistency checking

Prior to formal screening, all reviewers will independently screen a pilot sample of titles and abstracts using the predefined eligibility criteria. Decisions will be compared, disagreements discussed, and the eligibility guidance refined to improve consistency. A second calibration exercise will be conducted if substantial disagreement remains. Title-and-abstract and full-text screening will subsequently be undertaken independently by two reviewers. Disagreements will be resolved through consensus, with unresolved cases referred to a third reviewer. The data-extraction form and critical-appraisal tools will also be piloted independently on a sample of included studies. Differences in interpretation will be documented in a decision log, and the forms and guidance will be revised before full extraction and appraisal.

Reporting screening outcomes

The outcomes of the screening process will be reported using a PRISMA 2020 flow diagram, detailing the number of records identified, screened, assessed for eligibility, and included in the review. A complete list of studies meeting the inclusion criteria will be provided as a supplementary file. Full-text articles excluded during eligibility assessment will also be documented, together with the specific reasons for exclusion. Screening decisions at each stage will be recorded to ensure transparency, reproducibility, and adherence to systematic review reporting standards.

Studies will also be specially identified to report sex-disaggregated outcomes, women's outcomes, female-headed households, gender-responsive finance, empowerment and equity impacts.

Data extraction strategy

Data extraction will be conducted using a standardized, piloted coding form aligned with the intervention–outcome framework of the evidence and gap map. The study, rather than the individual publication, will be treated as the primary unit of analysis. Where several reports describe the same underlying study, they will be linked and extracted as one study record. Details of data items to be extracted are presented in Supplementary Table 1.

Data will be extracted independently by two reviewers or extracted by one reviewer and verified in full by a second reviewer. Disagreements will be resolved through discussion, with unresolved cases referred to a third reviewer. Extracted information will include bibliographic details, geographic setting, population characteristics, smallholder definitions, production systems, climate risks, sources and types of finance, financing terms, delivery mechanisms, financed practices, co-interventions, study design, outcome domains, implementation factors, costs, adoption, gender and equity considerations, and unintended effects. Each study may be coded against multiple intervention and outcome categories, while remaining a single study in the overall study count.

Meta-data extraction and coding strategy

Metadata extraction and coding will be conducted using a structured data extraction framework. For each eligible study, information on bibliographic characteristics, geographic context, climate finance attributes, methodological approach, outcome measures, key findings, and quality appraisal will be systematically recorded. Details of the extraction of effect estimates are presented in Supplementary Table 2.

Additional coding and synthesis in R will enable cross-tabulation of finance instruments, outcomes, and beneficiary groups through coding, supporting both quantitative mapping and qualitative thematic synthesis of the evidence base.

Type of synthesis

The evidence will be synthesized using a descriptive, framework-based evidence and gap mapping approach. The purpose of the synthesis will be to characterize the extent, distribution, and nature of the available evidence on climate-finance interventions affecting smallholder farmers in low- and middle-income countries. Unlike a conventional effectiveness review, the evidence and gap map will not primarily seek to estimate an overall pooled effect of climate finance. Instead, it will identify the areas in which evidence is concentrated, the questions and populations that remain under-researched, and the clusters of evidence that may be suitable for subsequent systematic review or meta-analysis.

All included studies will be coded against a predefined conceptual framework. Climate-finance instruments and delivery mechanisms will be organized along one axis of the evidence map, while farmer-level outcomes will be organized along the other. Intervention categories may include grants, concessional credit, subsidies, agricultural or climate insurance, blended finance, guarantees, results-based finance, carbon finance, savings-linked products, and bundled financial and technical-support programmes. Outcome categories may include access to finance, adoption of climate-resilient practices, agricultural production and productivity, income and profitability, assets, food security, resilience to climate shocks, environmental outcomes, gender and empowerment, repayment performance, and unintended effects.

The characteristics of the evidence base will be summarized using frequencies, percentages, cross-tabulations, tables, figures, and graphical displays. Descriptive summaries will examine the distribution of studies by publication year, country and region, study design, livestock or crop production system, farmer characteristics, climate-finance source, financial instrument, intervention type, outcome domain, duration of follow-up, and availability of gender-disaggregated or equity-related findings. Where relevant, the map will also distinguish between peer-reviewed and grey literature, completed and ongoing studies, and experimental, quasi-experimental, and observational designs.

Each study may contribute to more than one intervention–outcome cell where it evaluates multiple financial instruments, activities, or outcomes. The volume of evidence within each cell will be represented using study counts or bubbles, with additional visual features or filters used to display characteristics such as geographic region, study design, population group, or methodological quality. Empty cells will indicate areas where no eligible evidence was identified, while sparsely populated cells will indicate limited evidence. Densely populated cells will be treated as evidence clusters that may warrant more focused effectiveness synthesis.

The accompanying narrative synthesis will interpret the structure of the evidence base rather than make conclusions solely on the basis of the number of studies. It will describe:

- areas with substantial or limited evidence;
- geographic, population, and outcome-related gaps;
- whether the evidence is concentrated in particular countries, farmer groups, or financial instruments;
- the extent to which women and other underserved groups are represented;
- the availability of evidence on costs, feasibility, adoption, implementation, and unintended consequences;
- methodological weaknesses or imbalances in the evidence base; and
- evidence clusters that could support future systematic review or meta-analysis.

Evidence gaps will be classified, where appropriate, as absolute gaps, where no studies are available; sparse gaps, where only a small number of studies exist; geographic gaps, where certain countries or LMIC regions are underrepresented; population gaps, where evidence is limited for particular groups of farmers; outcome gaps, where important economic, social, climate, or

environmental outcomes are rarely measured; and methodological gaps, where the evidence is dominated by weak, short-term, or non-comparative study designs.

No statistical pooling of effect estimates is planned as part of the primary evidence and gap mapping exercise. This is because the principal objective is to map the availability and characteristics of evidence rather than determine an average intervention effect. However, where a sufficiently large and comparable cluster of studies is identified, the review will highlight its potential suitability for a subsequent systematic review and meta-analysis. Any formal effectiveness synthesis would require separate assessments of comparability in interventions, populations, outcomes, study designs, and effect measures.

Assessment of risk of publication bias

Each study will be evaluated for potential sources of bias affecting internal validity, including selection bias, confounding, measurement bias, reporting bias, and attrition bias. External validity will be assessed by examining the representativeness of study populations, geographical coverage, intervention context, and the generalizability of findings to smallholder farmers in developing

Author contributions

Vartika Singh conceived the review and drafted the protocol with inputs from all co-authors. All authors will contribute to refining the questions, eligibility criteria, search strategy, screening, appraisal, synthesis, and manuscript preparation. The final author list and CRediT roles will be confirmed before submission.

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Supplementary Materials

Table 1: Data items to be extracted from selected papers

Domain	Data items to extract	Purpose in the evidence and gap map
Study identification	Study ID; title; authors; publication year; publication type; journal or institution; DOI or web address	Supports referencing, deduplication, and identification of publication patterns
Linked reports	Other articles, reports, protocols, or datasets arising from the same study	Prevents double-counting of the same intervention or evaluation
Publication status	Peer-reviewed article; working paper; dissertation; institutional report; evaluation report; conference paper; ongoing study	Allows comparison of published and grey literature
Geographic coverage	Country; subnational location; rural or peri-urban setting; World Bank income classification; LMIC region	Identifies geographic concentrations and gaps
Study setting	Agroecological zone; climate exposure; market context; infrastructure conditions; production environment	Helps interpret where climate-finance interventions have been studied
Target population	Number of participants; farmer type; age; gender; socioeconomic characteristics; membership in farmer organizations	Identifies population coverage and underrepresented groups
Smallholder definition	Definition used by the authors; farm size; herd size; landholding; income or labour criteria	Assesses consistency in how smallholders are defined
Production system	Crop, livestock, mixed farming, fisheries, forestry, pastoralism, agroforestry, or other	Enables sectoral filtering of the map
Commodity or enterprise	Crops, livestock species, fisheries, value chains, or agricultural commodities covered	Identifies commodity-specific evidence clusters
Climate hazard or problem	Drought; flood; heat; rainfall variability; pests and diseases; land degradation; water scarcity; other	Connects the financing intervention to the climate risk being addressed
Climate-finance rationale	Adaptation; mitigation; loss and damage; resilience; combined adaptation and mitigation; not clearly specified	Determines whether and how the finance qualifies as climate finance
Source of finance	Government; bilateral donor; multilateral climate fund; development bank; commercial bank; microfinance institution; NGO; cooperative; private investor; carbon market	Shows who provides or mobilizes climate finance
Financial instrument	Grant; subsidy; concessional loan; commercial credit; microcredit; insurance; guarantee; blended finance; results-based finance; carbon finance; savings-linked product	Forms the principal intervention categories in the map
Financing terms	Amount; interest rate; repayment period; grace period; collateral requirement; subsidy level; premium; repayment mechanism	Provides information on product design and accessibility
Delivery channel	Bank; cooperative; self-help group; farmer organization; digital platform; value-chain actor; government programme	Helps assess how finance reaches smallholders

Financed activity	Irrigation; improved seeds; livestock technology; agroforestry; soil management; renewable energy; insurance; climate services; storage; mechanization; other	Links the financial instrument to the agricultural or climate intervention
Co-interventions	Training; extension; market linkage; input provision; weather information; technical assistance; group formation	Distinguishes finance-only interventions from bundled programmes
Comparator	No intervention; conventional finance; alternative financial product; before-and-after comparison; no comparator	Supports classification of study design and strength of evidence
Study design	Randomized controlled trial; quasi-experimental study; longitudinal study; cross-sectional study; qualitative study; mixed-methods study; process evaluation	Identifies methodological concentrations and gaps
Sample and duration	Sample size; unit of assignment; follow-up period; intervention duration	Helps assess evidence scale and time horizon
Outcome domains	Finance access; adoption; production; productivity; income; profitability; assets; food security; resilience; environmental outcomes; gender and empowerment; repayment; unintended effects	Forms the outcome axis of the evidence map
Outcome measures	Specific indicators, definitions, units, and timing of measurement	Shows how each outcome domain has been operationalized
Effect information	Whether an effect estimate is reported; type of estimate; direction of effect; statistical precision, where relevant	Allows identification of studies suitable for later effectiveness synthesis
Costs and economic evidence	Programme cost; farmer cost; cost-effectiveness; benefit-cost analysis; willingness to pay	Identifies evidence on affordability and economic feasibility
Adoption and uptake	Application, approval, uptake, continued use, discontinuation, repayment, or renewal	Supports analysis of product use and sustainability
Implementation factors	Delivery barriers; enabling factors; provider capacity; administrative burden; infrastructure requirements	Identifies implementation evidence and practical knowledge gaps
Farmer perspectives	Acceptability; perceived usefulness; trust; satisfaction; reported constraints	Captures qualitative and user-centred evidence
Gender and equity	Gender-disaggregated results; women's control over finance; youth; tenants; pastoralists; Indigenous groups; marginalized populations	Identifies inclusion and equity gaps
Unintended effects	Debt burden; exclusion; maladaptation; elite capture; increased workload; environmental harm; displacement of other finance	Prevents the map from focusing only on intended benefits
Study quality	Risk-of-bias or critical-appraisal rating; major methodological limitations	Allows filtering or visual differentiation by evidence quality
Funding and conflicts	Study funder; intervention funder; author conflicts of interest	Supports transparency and interpretation
Reviewer notes	Eligibility issues; coding uncertainties; decisions made; links to related reports	Maintains an audit trail

Table 2: Extraction of effect estimates

The extraction form will record:

Effect-related field	Suggested coding
Quantitative effect reported	Yes, no, or unclear
Effect measure	Mean difference, percentage change, odds ratio, risk ratio, regression coefficient, or other
Direction	Positive, negative, mixed, null, or unclear
Statistical uncertainty reported	Confidence interval, standard error, p-value, or none
Suitable for future meta-analysis	Yes, potentially, no, or unclear

Direction-of-effect coding should not be interpreted as evidence of effectiveness without considering study design, risk of bias, effect size, and statistical uncertainty.

