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Resources and Capabilities for Climate Resilience among Smallholder Cocoa Farmers: A Systematic Literature Review

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ABSTRACT

This study reviews the resources and capabilities associated with climate resilience among smallholder cocoa farmers in developing countries using the Resource-Based View (RBV). A PRISMA-guided systematic literature review of Scopus-indexed articles published between 2015 and 2025 identified 30 eligible studies. Thematic analysis revealed four key themes: social and digital learning, strategic adoption, livelihood stability, and climate resilience. Resilience depends on combinations of human, social, financial, informational, physical, and natural resources, as well as farmers' ability to mobilise them within specific institutional and market conditions. Although social and digital learning may support technology adoption and adaptation, current evidence does not confirm a universal causal pathway linking learning, adoption, income stability, and resilience. Evidence on Digital Farmer Influencers remains limited and is therefore proposed as a future research construct. The study recommends construct validation, longitudinal and mixed-method research, and cross-country comparisons.

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1. Introduction

Climate change is intensifying production uncertainty and livelihood risks across agricultural systems, making climate resilience a central concern for smallholder farming. Smallholders commonly operate on less than two hectares, yet their farming activities support the livelihoods of approximately 2.5 billion people and are closely connected to global food security and environmental sustainability (Cohn et al., 2017; Matous & Bodin, 2024). For these farmers, resilience is not limited to recovering from a single climatic shock; it also involves the capacity to absorb recurring stresses, adjust farming practices, and transform livelihood strategies under long-term uncertainty (Teklu et al., 2023).

These pressures are particularly consequential in the cocoa sector. Cocoa is a major commercial crop that provides employment, household income, and raw materials for the global chocolate industry (Anning et al., 2022). Indonesia is recognised as the world's fifth-largest cocoa producer, with annual production of approximately 240,000 tonnes (ICCO, 2018), and cocoa farming has the potential to increase rural household income and reduce poverty (Rauf et al., 2019). Nevertheless, smallholder cocoa enterprises face interacting constraints, including climate variability, land degradation, pest and disease outbreaks, low productivity, weak agronomic practices, and growing sustainability pressures associated with cocoa-driven deforestation (Akrofi-Atitianti et al., 2018; Nasser et al., 2020). These conditions make the capacity to mobilise and combine available resources a practical requirement for farm continuity and livelihood stability.

Climate Smart Agriculture (CSA) provides an important pathway for responding to these challenges because it promotes farm-level innovation, resource efficiency, and sustainable production under climate change (Agbenyo et al., 2022). However, the recognition of CSA benefits does not automatically result in adoption, and the uptake of sustainable agricultural innovations remains below expected targets (Rizzo et al., 2023). The empirical problem is therefore not simply whether climate-adaptation technologies or practices are available, but why smallholders with apparently similar exposure adopt, combine, and sustain such practices differently. Explaining this variation requires attention to farmers' knowledge, skills, financial access, social relationships, information channels, and capacity to translate these resources into strategic action.

Knowledge and learning are especially important because possessing agricultural information does not necessarily mean that farmers can apply it effectively. Smallholder cocoa farmers may report adequate knowledge while continuing to experience weaknesses in the practical implementation of farming practices (Boateng et al., 2023). Social learning can reduce this knowledge-to-practice gap: exposure to social learning has been associated with a 10.3% increase in the direct adoption of cooperative sustainable farming practices, although participation is also shaped by income and farm size (Li et al., 2024). Farmers' preference for fellow farmers as trusted sources of information further indicates that adoption decisions are socially embedded rather than based solely on formal expert advice (Rust et al., 2022).

Digital platforms extend these socially embedded learning processes beyond face-to-face interaction. Facebook, WhatsApp groups, mobile applications, online forums, and YouTube can facilitate the exchange of climate-smart practices and farming experience (Zhang & Wang, 2024; Daum, 2025). At the same time, the effects of digitalisation depend on technology design, farmers' digital literacy, and the surrounding social context. Digital literacy can strengthen pro-environmental behaviour (Lu et al., 2024), while the digital economy may support sustainable agriculture through innovation, resource optimisation, and data-driven decision-making (Kuang et al., 2025). Thus, digital access should not be treated as a resource in isolation; its strategic value depends on farmers' capacity to interpret information, establish trust, and convert digital learning into appropriate farming decisions.

This development points to the possible role of the Digital Farmer Influencer (DFI), defined in this study as a farmer or farming actor who uses digital platforms to shape other farmers' perceptions and adoption decisions. However, the current evidence supporting this construct is indirect rather than conclusive. Rust et al. (2022) show that farmers often trust peer farmers more than experts, whereas Matous and Bodin (2024) demonstrate that central opinion leaders can shape and homogenize farming practices within Indonesian cocoa networks. These studies establish the relevance of peer trust and network influence, but they do not conceptualize DFI as a digital strategic resource, test its moderating role in social digital learning, or examine its contribution to climate resilience among smallholder cocoa farmers. The DFI gap is therefore not merely the absence of the term; it concerns the absence of an integrated explanation of how digitally mediated peer influence may strengthen or constrain the conversion of learning into strategic adoption behaviour.

Previous reviews provide important foundations but do not resolve this problem. Cohn et al. (2017) review the broad vulnerability and adaptive capacities of smallholder agriculture, Grigorieva et al. (2023) map agricultural adaptation strategies across contexts, and Rizzo et al. (2023) synthesise psychological, social, economic, and innovation-related factors influencing sustainable innovation adoption. These reviews are valuable, but their analytical scope is broader than smallholder cocoa enterprises and they do not integrate social digital learning, digitally mediated farmer influence, strategic adoption behaviour, income stability, and climate resilience within one explanatory framework. Cocoa-specific studies likewise tend to examine separate elements, such as CSA determinants and outcomes (Akrofi-Atitianti et al., 2018), farmer perceptions and adaptation practices (Anning et al., 2022), or discourse, governance, and equity concerns (Nasser et al., 2020). Consequently, the evidence remains fragmented across technological, behavioural, economic, and institutional perspectives, which justifies a focused systematic synthesis.

The Resource-Based View (RBV) offers a basis for organizing this fragmented evidence, but its application at the smallholder level requires explicit justification. RBV was originally developed to explain how organizations achieve sustained advantage by deploying heterogeneous resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). In this study, the smallholder cocoa farm is treated as a micro-enterprise and the farmer or farm household as the strategic decision-making unit. Land, labour, farming knowledge, digital literacy, social networks, financial access, and technological capability constitute heterogeneous resource bundles whose value arises from how they are accessed, combined, and deployed. External support, including extension services, institutions, and digital technologies, contributes to resilience only when farmers possess the capacity to absorb and use it. Accordingly, RBV is applied here not to claim that smallholders seek competitive advantage in the same manner as large firms, but to explain why farmers facing comparable climate pressures may differ in adoption behaviour, income stability, farm continuity, and adaptive capacity.

Against this background, this Systematic Literature Review aims to synthesise the resource-based drivers of climate resilience among smallholder cocoa farmers in developing countries. Specifically, it examines the internal resources and strategic capabilities associated with climate adaptation, clarifies the pathway linking social digital learning to strategic adoption behaviour and income stability, critically assesses the potential position of DFI within that pathway, and explains how RBV can be meaningfully applied to smallholder cocoa enterprises. By comparing previously separated streams of research, the review seeks to provide a structured theoretical basis for future empirical testing and practical guidance for policymakers, extension agencies, development institutions, and cocoa-sector stakeholders.

2. Literature Review & Hypothesis Development

2.1 Resource-Based View (RBV)

The Resource-Based View (RBV) is a strategic management theory developed by Barney (1991), which posits that an organisation's competitive advantage derives from internal resources that are valuable, rare, inimitable, and non-substitutable commonly referred to by the acronym VRIN. In the context of smallholder agriculture, RBV can be applied to explain how smallholder cocoa farmers leverage their diverse resources including physical resources such as land quality and farming equipment, human resources such as knowledge and skills, and social resources such as community networks and information access to cope with increasingly complex environmental pressures arising from climate change.

2.2 Climate Resilience and Climate Smart Agriculture (CSA)

Climate resilience is defined as the capacity of an agricultural system to absorb and recover from climate shocks and stresses while positively adapting and transforming its structures and ways of life in the face of long-term change and uncertainty. It represents a combination of the absorptive, adaptive, and transformative capacities of the farming system (Teklu et al., 2023). Climate Smart Agriculture (CSA) is an approach developed by the FAO to promote farm-level innovation and sustainable practices in the context of global climate change, aimed at enhancing agricultural resource efficiency while minimising greenhouse gas emissions (Agbenyo et al., 2022).

2.3 Digital Farmer Influencer (DFI) and Social Digital Learning

A Digital Farmer Influencer (DFI) is defined as a farming actor who exerts social influence through digital platforms in shaping innovation adoption decisions and climate adaptation practices. DFIs function as digital opinion leaders capable of influencing farmers' behaviour, perceptions, and decisions through the dissemination of farming experiences, practices, and climate adaptation information via digital platforms. Social digital learning refers to the learning process obtained through socially mediated digital interactions, encompassing the use of social media, online forums, digital communication groups, and agricultural knowledge-sharing platforms (Daum, 2025; Li et al., 2024).

2.4 Conceptual Framework

The conceptual framework of this study posits that achieving climate resilience requires smallholder cocoa farmers to acquire appropriate knowledge both through conventional channels such as agricultural extension services and peer knowledge-sharing, and through digital platforms. Enhanced knowledge increases farmers' confidence in adopting and practising what they have learned. The adoption of innovations, technologies, and CSA practices subsequently increases farmers' income, thereby improving their preparedness to face climate change. In essence, the framework traces the transformation of knowledge into strategic adoption behaviour, which in turn generates greater income stability, with the ultimate output being enhanced climate resilience. DFIs function as a moderating factor strengthening the relationship between social digital learning and strategic adoption behaviour.

3. Methodology

3.1 Research Design and Review Questions

This study employed a Systematic Literature Review (SLR) guided by the PRISMA protocol to identify, appraise, and synthesize evidence on the resource-based drivers of climate resilience among smallholder cocoa enterprises. The unit of analysis was the peer-reviewed journal article. The review was guided by three questions: (1) Which internal resources and strategic capabilities are associated with climate adaptation and resilience among smallholder cocoa farmers? (2) How do social and digital learning, peer influence, strategic adoption behaviour, and income stability interact within the available evidence? and (3) What conceptual and empirical gaps remain for applying the Resource-Based View (RBV) and developing the Digital Farmer Influencer (DFI) construct at the smallholder level?

3.2 Database, Search Date, and Search Scope

Scopus was used as the primary bibliographic database. Publish or Perish was used only as an auxiliary tool for organizing exported records and supporting duplicate checking, rather than being treated as the source database. The final search was conducted on 28 June 2026. The search covered the title, abstract, and author-keyword fields and was limited to English-language journal articles and review articles published from 1 January 2015 to 31 December 2025. No geographical restriction was applied during the database search; relevance to developing-country and smallholder contexts was assessed during screening. The search output was exported with complete bibliographic metadata, including title, authors, year, source title, abstract, keywords, DOI, and document type.

To validate database eligibility, the indexing status of each retained source was checked by matching the journal title and ISSN against the Scopus source list applicable at the time of the search. The identity of each record was then cross-checked using the DOI, article title, authorship, publication year, and publisher metadata. Records with unverifiable Scopus coverage or inconsistent bibliographic information were excluded before final synthesis.

3.3 Search Strategy

The search was organised into complementary concept blocks rather than a single highly restrictive query. This approach was adopted because requiring every construct in one Boolean string, particularly the emerging term "Digital Farmer Influencer," could exclude relevant studies that examine the same mechanism using terms such as peer influence, opinion leadership, farmer-to-farmer learning, social networks, or digitally mediated knowledge exchange. The exact phrase "Digital Farmer Influencer" was therefore used as a supplementary search term and not as a mandatory eligibility condition.

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Search A: TITLE-ABS-KEY (("cocoa farmer*" OR "smallholder cocoa" OR "cocoa smallholder*") AND ("climate resilience" OR "climate adaptation" OR "climate-smart agriculture")).
Search B: TITLE-ABS-KEY ((smallholder* OR "cocoa farmer*") AND ("social learning" OR "digital learning" OR "digital literacy" OR "social media" OR "peer learning") AND (adoption OR adaptation OR resilience)).
Search C: TITLE-ABS-KEY ((smallholder* OR "cocoa farmer*") AND ("opinion leader*" OR "peer influence" OR "farmer-to-farmer" OR "social network*" OR "digital influencer*") AND (agriculture OR farming)).
Search D: TITLE-ABS-KEY ((smallholder* OR "cocoa farmer*") AND ("income stability" OR livelihood* OR "farm continuity") AND (climate OR adaptation OR resilience)).
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The four result sets and the supplementary exact-phrase search were merged into one search library. Duplicate records were identified first through DOI matching and then through normalised comparisons of title, first author, and publication year. The combined search produced 487 records before duplicate removal, consistent with the identification stage reported in Table 1.

3.4 Eligibility Criteria

Studies were included when they met all of the following criteria: (1) they examined cocoa smallholders or other smallholder agricultural commodity farmers whose findings were relevant to the mechanisms under review; (2) they addressed at least one focal domain—climate adaptation or resilience, Climate Smart Agriculture adoption, internal resources and capabilities, social or digital learning, peer or network influence, income stability, livelihood adaptation, or farm continuity; (3) they reported empirical research or a structured review with findings that could be extracted; (4) they were published in a Scopus-indexed journal between 2015 and 2025; (5) they were written in English; and (6) the full text was available. Cocoa-specific evidence was prioritised, while cross-commodity smallholder studies were retained only when they contributed transferable evidence about resource mobilisation, learning, adoption, livelihood stability, or climate resilience.

Studies were excluded when they: (1) did not concern smallholder farming; (2) focused solely on biophysical or technical outcomes without examining farmer resources, behaviour, adoption, livelihoods, or resilience; (3) discussed digital technologies without a relevant learning, adoption, or climate-adaptation dimension; (4) were conference proceedings, books, book chapters, technical reports, editorials, or other non-journal publications; (5) were duplicates; (6) were not verifiably indexed in Scopus; or (7) lacked sufficient full-text information for appraisal and extraction.

3.5 Study Selection and Resolution of Disagreements

All retrieved records were managed in a structured screening spreadsheet. After duplicate removal, titles and abstracts were independently screened by two reviewers (the lead reviewer and a second reviewer with expertise in agricultural sustainability and evidence synthesis). Potentially eligible articles were then retrieved in full text and assessed independently against the eligibility criteria. Before formal screening, the reviewers calibrated their interpretation of the criteria on a sample of records and refined the screening instructions where ambiguity occurred. Disagreements were resolved through discussion and consensus; unresolved cases were referred to a third senior reviewer. Reasons for full-text exclusion were recorded in the screening log.

The selection process proceeded sequentially from 487 identified records to 412 records after the removal of 75 duplicates. Title and abstract screening excluded 298 records, leaving 114 articles for full-text assessment. Eighty-four full-text articles were excluded because they did not satisfy one or more eligibility criteria, and 30 articles were retained for quality appraisal and qualitative synthesis.

3.6 Quality Appraisal

Methodological quality and relevance were assessed using eight criteria: (1) clarity of the research objectives; (2) adequacy of the literature review or conceptual grounding; (3) clarity and appropriateness of the research design; (4) appropriateness of data-collection procedures; (5) clarity and appropriateness of data analysis; (6) evidence of reliability, validity, credibility, or methodological rigour; (7) relevance of the findings to the review questions; and (8) contribution to the identified literature gap. Each criterion was scored as 1 when fully met, 0.5 when partially met, and 0 when not met, producing a maximum score of 8.

A study was considered eligible for final synthesis when it achieved a total quality score of at least 6.0 out of 8.0 (75%). Quality appraisal was conducted independently by the reviewers, and differences in item scores were resolved through consensus. The appraisal matrix recorded the score for each criterion, the total score, reviewer comments, and the final inclusion decision. The 30 articles included in the synthesis met the stated threshold. To fully support replication, the study-level quality scores should be reported in a supplementary appraisal table.

3.7 Data Extraction

A standardized data-extraction form was developed in a spreadsheet and applied consistently to all included articles. The form captured: bibliographic information; publication year; country and commodity context; study objectives; research design and sample; data-collection and analysis methods; internal resources and strategic capabilities; social and digital learning mechanisms; peer influence, opinion leadership, or DFI-related mechanisms; strategic adoption behaviour; income or livelihood outcomes; climate-resilience outcomes; principal findings; stated limitations; research gaps; and the quality-appraisal score. The extraction form was reviewed on an initial subset of studies to ensure that the categories were interpreted consistently before full extraction.

Data extraction was completed by the lead reviewer and independently checked by the second reviewer. Any discrepancies were resolved by returning to the full text and reaching consensus. This checking procedure was used to reduce transcription errors and prevent interpretive categories from being assigned solely by one reviewer.

3.8 Thematic Synthesis

Because the included studies differed in design, context, variables, and outcome measures, the evidence was synthesized through a qualitative thematic approach rather than meta-analysis. The synthesis combined inductive and deductive coding. First, the results and discussion sections of each article were read closely and coded for reported resources, capabilities, learning processes, adoption mechanisms, livelihood effects, and resilience outcomes. Second, related codes were compared across studies and grouped into provisional categories. Third, these categories were mapped deductively to the RBV lens and to the proposed pathway linking social digital learning, strategic adoption behaviour, income stability, and climate resilience. Fourth, similarities, differences, contextual conditions, and contradictory findings were compared across countries, commodities, and research designs. Finally, the categories were refined into five synthesis themes: Digital Farmer Influencer, Social Digital Learning, Strategic Adoption Behaviour, Income Stability, and Climate Resilience.

DFI-related evidence was coded conservatively. An article was assigned to this theme when it directly discussed digital farmer influence or provided relevant evidence concerning trusted peer farmers, opinion leaders, central network actors, farmer-to-farmer communication, or digitally mediated social influence. Proxy evidence was used to develop the construct conceptually but was not treated as direct empirical confirmation of a DFI effect. Coding decisions and theme assignments were compared by the review team and resolved through discussion to maintain consistency between the extracted evidence and the final thematic interpretation.

3.9 PRISMA Flow Diagram

The identification, screening, eligibility assessment, and final inclusion of studies are summarized in the PRISMA flow diagram presented in Table 1. The flow diagram reports the combined results of the complementary searches, duplicate removal, title and abstract screening, full-text eligibility assessment, quality appraisal, and the final set of 30 articles included in the qualitative synthesis. A study-level screening log was maintained to document the decision and reason for exclusion at the full-text stage.

Table 1. PRISMA Flow Diagram of Article Selection

IDENTIFICATION	Articles identified through Scopus database (n = 487)	
	Articles after duplicate removal (n = 412)	Duplicates removed (n = 75)
SCREENING	Articles screened by title & abstract (n = 412)	
	Articles excluded after title & abstract screening (n = 298)	Reason: not relevant to topic
	Full-text articles assessed for eligibility (n = 114)	
ELIGIBILITY	Full-text articles excluded (n = 84)	Reason: did not meet inclusion criteria
	Articles meeting quality criteria (n = 30)	
INCLUDED	Articles included in qualitative synthesis (n = 30)	
	Articles included in final SLR synthesis (n = 30)	

4. Result and Discussion

Result

4.1 Characteristics, Methodological Profile, and Quality Status of the Included Studies

The PRISMA process yielded 30 articles published between 2015 and 2025. The evidence base was geographically concentrated in Africa, particularly Ghana and Ethiopia, with additional studies from Indonesia, China, India, Iran, Tanzania, Cameroon, Vietnam, Cote d'Ivoire, New Zealand, and multi-country or global settings. Cocoa-specific evidence was strongest in Ghana and Indonesia, whereas several studies from other commodities were retained because they examined transferable mechanisms concerning learning, resource mobilization, innovation adoption, livelihood stability, or climate adaptation.

After standardizing the classifications used in the original extraction table, the corpus comprised 14 quantitative empirical studies, four qualitative empirical studies, five mixed- or multi-method studies, and seven review, scoping-review, or conceptual/perspective articles. This reclassification corrects the earlier treatment of review articles as qualitative empirical research and distinguishes publisher names from journal titles. Journal titles were also normalized, including Environmental

Management, Sustainability, Climatic Change, International Journal of Disaster Risk Reduction, Philosophical Transactions of the Royal Society B: Biological Sciences, Journal of Agriculture and Food Research, and PLOS ONE.

All 30 studies were reported as meeting the minimum quality-appraisal threshold of 6.0 out of 8.0. However, the manuscript file did not contain the original item-level appraisal matrix. To avoid retrospectively inventing numerical scores, the revised study-level table reports the confirmed eligibility status for each article and separately assesses the strength of evidence according to directness, contextual relevance, and research design. The completed eight-item scoring matrix should be submitted as Supplementary Table S1.

4.2 Study-Level Evidence, Quality Status, and Strength of Evidence

Table 2 presents a revised study-level synthesis. Evidence strength was classified as high when a study provided direct empirical evidence in a cocoa or closely aligned smallholder context using a sufficiently explicit empirical design; moderate when the evidence was empirical but cross-commodity, contextually indirect, or derived from a structured review; and low when the contribution was conceptual, broad in scope, or served only as proxy evidence for the proposed construct.

Table 2. Revised Study-Level Extraction, Quality Status, and Evidence Strength

Code	Study	Journal	Context	Design	Quality	Evidence	Key contribution
T1	Rust et al. (2022)	Environmental Management	UK/Hungary	Qualitative	Pass >=6/8	Low	Peer trust and social-media-enabled farmer learning; proxy evidence only for DFI.
T1	Daum (2025)	Outlook on Agriculture	Global	Perspective	Pass >=6/8	Low	Digitalisation can strengthen or weaken skills depending on design, literacy, and social context.
T1	Li et al. (2024)	Sustainability	China	Quantitative	Pass >=6/8	Moderate	Social learning is associated with cooperative pest-control adoption through trust and information sharing.
T1	Lu et al. (2024)	Frontiers in Sustainable Food Systems	China	Quantitative	Pass >=6/8	Moderate	Digital literacy is associated with pro-environmental behaviour through attitudinal and social mechanisms.
T1	Kuang et al. (2025)	Sustainability	China	Quantitative	Pass >=6/8	Moderate	Digital-economy participation is linked to sustainable agricultural development, but smallholder specificity is limited.
T2	Niles et al. (2016)	Climatic Change	New Zealand	Mixed methods	Pass >=6/8	Moderate	Intended and actual adoption have different drivers; perceived capacity and information contact are relevant.
T2	Rizzo et al. (2023)	Organic Agriculture	Multi-country	Systematic review	Pass >=6/8	Moderate	Adoption reflects interacting psychological, social, economic, and innovation-related determinants.
T2	Chetri et al. (2023)	Environmental Science & Policy	India	Quantitative	Pass >=6/8	Moderate	Weather information and communication resources are associated with adaptive capacity.
T2	Grigorieva et al. (2023)	Climate	Global	Scoping review	Pass >=6/8	Moderate	Maps multiple adaptation strategies but does not provide a unified resource-capability model.
T2	Nyasimi et al. (2017)	Climate	Tanzania	Mixed/ participatory	Pass >=6/8	Moderate	CSA adoption pathways depend on resource access, perceived benefits, skills, and institutions.
T3	Zerssa et al. (2021)	Agriculture	Ethiopia	Review	Pass >=6/8	Moderate	CSA may support yield, food security, carbon outcomes, and income, although household mechanisms remain unclear.
T3	Aniah et al. (2019)	Heliyon	Ghana	Qualitative case study	Pass >=6/8	Moderate	Households combine on-farm, off-farm, and indigenous-knowledge

Code	Study	Journal	Context	Design	Quality	Evidence	Key contribution
							strategies to manage climate variability.
T3	Nasrnia & Ashktorab (2021)	Ecological Indicators	Iran	Quantitative	Pass >=6/8	Moderate	Human, social, natural, physical, and financial capitals jointly shape household drought resilience.
T3	Agbenyo et al. (2022)	International Journal of Environmental Research and Public Health	Ghana	Quantitative	Pass >=6/8	High	CSA adoption is associated with farm income; credit, cooperative membership, and extension access matter.
T3	De Witt et al. (2016)	Environmental Science & Policy	Netherlands/USA	Quantitative	Pass >=6/8	Low	Worldviews influence climate attitudes, but the study is indirect to smallholder enterprise resilience.
T3	Hulke & Revilla Diez (2020)	International Journal of Disaster Risk Reduction	Vietnam	Mixed methods	Pass >=6/8	Moderate	Collective action and social capital support adaptive capacity, without direct income-stability testing.
T3	Teklu et al. (2023)	Sustainability	Ethiopia	Quantitative	Pass >=6/8	High	CSA innovation is associated with absorptive, adaptive, and transformative resilience capacities.
T4	Muluneh (2021)	Agriculture & Food Security	Global	Review	Pass >=6/8	Low	Establishes broad climate and food-security risks but provides limited farm-level resource evidence.
T4	Cohn et al. (2017)	Annual Review of Environment and Resources	Global	Review	Pass >=6/8	Moderate	Synthesises smallholder vulnerability and adaptation capacities, including diversification.
T4	Malhi et al. (2020)	Philosophical Transactions of the Royal Society B: Biological Sciences	Global	Review	Pass >=6/8	Low	Provides ecosystem-level climate threats and nature-based responses rather than household-level evidence.
T4	Maguire-Rajpaul et al. (2020)	Frontiers in Sustainable Food Systems	Ghana cocoa	Qualitative	Pass >=6/8	High	Agricultural information supports adaptive capacity, but information does not automatically become adaptive action.
T4	Akrofi-Atitianti et al. (2018)	Land	Ghana cocoa	Mixed methods	Pass >=6/8	High	CSA cocoa systems are linked to income, carbon, and conservation benefits; extension and tenure shape practice.
T4	Anning et al. (2022)	Current Research in Environmental Sustainability	Ghana cocoa	Mixed methods	Pass >=6/8	High	Documents farmer perceptions and adaptation practices such as intercropping, mulching, and diversification.
T4	Nasser et al. (2020)	Frontiers in Sustainable Food Systems	Ghana cocoa	Qualitative	Pass >=6/8	Moderate	Shows governance and equity risks that may constrain smallholder participation in climate-smart cocoa.
T4	Ameyaw et al. (2018)	Forests	Ghana cocoa	Mixed methods	Pass >=6/8	High	Farmer knowledge, communication, and tenure conditions influence mitigation perceptions and feasibility.
T4	Suh & Molua (2022)	Journal of Agriculture and Food Research	Cameroon cocoa	Quantitative	Pass >=6/8	High	Farm size, labour, capital, education, and management practices are associated with cocoa production under climate variability.
T4	Boateng et al. (2023)	Toxicology Reports	Ghana cocoa	Quantitative survey	Pass >=6/8	Moderate	Knowledge does not consistently translate into safe pesticide practice; associations improve access to training.
T4	Effendy et al. (2019)	PLOS ONE	Indonesia cocoa	Quantitative	Pass >=6/8	High	Farm efficiency is associated with seed quality, fertiliser, extension, and credit access.
T4	Matous & Bodin (2024)	People and Nature	Indonesia cocoa	Quantitative/multi-method	Pass >=6/8	High	Network centralisation and opinion leaders are associated with homogenised farming practices; proxy evidence for DFI.
T4	Knosslsdorfer et al. (2021)	Global Food Security	Cote d'Ivoire cocoa	Quantitative impact evaluation	Pass >=6/8	High	Fairtrade improves living-standard expenditure but does not

Code	Study	Journal	Context	Design	Quality	Evidence	Key contribution
							consistently improve food security.

Note. T1 = social and digital learning resources; T2 = strategic adoption and capability deployment; T3 = income and livelihood stability; T4 = climate resilience and cocoa adaptation. "Pass >=6/8" reflects the eligibility threshold reported in the method; exact criterion-level scores should be provided in Supplementary Table S1. Evidence strength concerns directness and relevance to the review question and is not a substitute for methodological quality appraisal.

4.3 Coding Process and Development of the Synthesis Themes

The themes were generated through a documented coding sequence rather than by assigning articles directly to predetermined headings. First-order codes were extracted from the results and discussion sections of each article. Similar codes were then grouped into focused categories, compared across contexts and designs, and mapped to the RBV lens. A primary-theme code was assigned to each study for descriptive counting, while cross-codes were retained when a study contributed to more than one mechanism. Table 3 provides the coding audit trail used to generate the synthesis.

Table 3. Coding Audit Trail from First-Order Codes to Synthesis Themes

First-order codes	Focused category	Synthesis output	Analytical status
Knowledge, skills, digital literacy, information access, social learning, peer trust, social media	Learning and information resources	T1: Social and digital learning resources	Primary theme
Perceived capacity, adoption intention, actual adoption, CSA uptake, experimentation, resource access	Capability deployment and strategic action	T2: Strategic adoption and capability deployment	Primary theme
Farm income, food security, credit, certification, livelihood capital, diversification, collective action	Economic buffering and livelihood continuity	T3: Income and livelihood stability	Primary theme
Absorptive, adaptive, and transformative capacity; cocoa management; agroforestry; drought response; farm efficiency	Climate adaptation and resilience outcomes	T4: Climate resilience and cocoa adaptation	Primary theme
Trusted peer farmers, opinion leaders, network centrality, digitally mediated influence	Peer-influence mechanism	DFI-related proposition	Cross-cutting, provisional; not a primary finding

4.4 Distribution and Strength of the Primary Themes

The revised synthesis retains four primary themes. The former DFI theme was removed from the primary distribution because no included study directly defined or empirically tested DFI as proposed in this review. Rust et al. (2022) provide evidence on peer trust and social-media-enabled learning, while Matous and Bodin (2024) provide evidence on opinion leaders and network centralisation. These studies support the plausibility of a digitally mediated peer-influence mechanism, but they do not establish DFI as a strategic resource, a moderator, or a determinant of climate resilience.

Table 4. Distribution and Overall, Strength of the Revised Synthesis Themes

Nu.	Revised theme	Studies	Percentage	Overall strength	Interpretation
1	Social and digital learning resources	5	16.7%	Moderate	Evidence spans digital literacy, social learning, and peer trust, but cocoa-specific digital evidence is limited.
2	Strategic adoption and capability deployment	5	16.7%	Moderate	Consistent evidence that capacity, information, resources, and institutions shape adoption; mechanisms vary by context.
3	Income and livelihood stability	7	23.3%	Moderate to high	Multiple empirical studies link CSA, livelihood capitals, finance, and diversification to economic buffering.
4	Climate resilience and cocoa adaptation	13	43.3%	Moderate to high	Largest evidence base, including direct cocoa studies, but resilience definitions and outcome measures remain heterogeneous.
	Total primary classification	**30**	**100%**		
	DFI-related cross-cutting proposition	**2 proxy studies**	**Not included in total**	**Very limited**	**No direct empirical test of DFI; retained only as a future research proposition.**

4.5 Synthesis of the Main Findings

The strongest and most recurrent finding is that climate resilience is associated with combinations of human, social, financial, informational, physical, and natural resources rather than with a single strategic asset. Cocoa-specific studies show that information access, extension, farmer knowledge, labour, capital, farm management, agroforestry, credit, and diversification can support adaptive action, but the value of these resources depends on farmers' ability to mobilize them under specific institutional and livelihood conditions.

Evidence on social and digital learning is promising but heterogeneous. Quantitative studies associate social learning and digital literacy with adoption-related or pro-environmental outcomes, while qualitative cocoa evidence shows that access to information does not automatically produce adaptive action. This indicates that learning resources should be interpreted as enabling conditions whose effects depend on skills, trust, socio-economic position, technology design, and opportunities for implementation.

The evidence also suggests an association between the adoption of CSA or related practices and income, livelihood stability, and adaptive capacity. Nevertheless, the included studies use different commodities, countries, designs, and outcome measures. The review therefore supports a conceptual sequence linking learning, capability deployment, livelihood outcomes, and resilience, but it does not establish a universal causal pathway among these constructs.

DFI should consequently be treated as an under-researched conceptual proposition rather than a principal result of the review. The available literature supports only component mechanisms - peer trust, farmer-to-farmer communication, opinion leadership, and network centrality. Direct empirical research is still required to define DFI, distinguish digital from non-digital influence, assess its VRIN attributes, and test whether it strengthens, weakens, or otherwise conditions the relationship between social digital learning and strategic adoption behaviour.

Discussion

A. Social and Digital Learning as Context-Dependent Resources

The reviewed literature supports interpreting social and digital learning as enabling resources rather than universal determinants of adoption. Li et al. (2024) and Lu et al. (2024) report positive associations in China between social learning or digital literacy and cooperative or pro-environmental behaviour. However, these studies concern pest control and general pro-environmental action rather than cocoa-specific climate-resilience outcomes. Daum (2025) further cautions that digitalisation may strengthen or erode farmers' skills depending on technology design, literacy, and social context. Evidence from one country, commodity, or behavioural outcome therefore cannot be transferred directly to smallholder cocoa enterprises without considering differences in infrastructure, extension systems, market access, and institutional support.

Cocoa-specific studies reinforce this conditional interpretation. Maguire-Rajpaul et al. (2020) indicate that access to agricultural information can support adaptive capacity in Ghana, whereas Boateng et al. (2023) identify a gap between reported knowledge and actual pesticide practices. Rust et al. (2022) similarly show that farmers may trust fellow farmers more than experts, but trust alone does not establish the accuracy, relevance, or practical feasibility of the information exchanged. Social and digital learning should therefore be understood as resource inputs whose value depends on farmers' absorptive capacity, implementation opportunities, and the credibility of information sources.

B. Strategic Adoption as Capability Deployment Across Contexts

The evidence also challenges a simple progression from information to adoption. Rizzo et al. (2023) identify interacting psychological, social, economic, institutional, and innovation-specific determinants, while Nyasimi et al. (2017) show that Climate Smart Agriculture (CSA) uptake depends on resource access, perceived benefits, skills, and institutional arrangements. Chetri et al. (2023) associate weather information and communication resources with adaptive capacity, but such associations do not demonstrate that information alone produces sustained practice change. Across the corpus, adoption is measured variously as intention, reported use, participation, experimentation, or observed practice, which limits direct comparison.

Several findings also reveal tensions rather than uniform reinforcement. Matous and Bodin (2024) show that network centralisation and opinion leaders can homogenise farming practices, which may accelerate the diffusion of accepted practices while reducing exploration of alternatives. Nasser et al. (2020) likewise demonstrate that climate-smart cocoa initiatives may marginalise smallholders when governance and equity concerns are overlooked. Social networks and institutions can therefore operate as both enabling and constraining conditions. From an RBV perspective, strategic adoption is better interpreted as the deployment of capabilities under specific resource and institutional constraints, rather than as an automatic response to possessing information or technology.

C. Income, Livelihood Stability, and Resilience as Related but Non-Equivalent Outcomes

Evidence linking CSA and related practices to economic and resilience outcomes is generally favorable but not uniform. Agbenyo et al. (2022) associate CSA adoption with farm income, Akrofi-Atitianti et al. (2018) report income and environmental benefits in Ghanaian cocoa systems, and Teklu et al. (2023) associate CSA innovation with absorptive, adaptive, and transformative capacities. Zerssa et al. (2021) similarly identify potential gains for yield, food security, carbon outcomes, and income. Nevertheless, these studies use different designs, outcome definitions, time horizons, and institutional settings, preventing their results from being interpreted as a single effect.

Income improvement should also not be treated as equivalent to climate resilience. Knößlsdorfer et al. (2021) find that Fairtrade improves some living-standard expenditures without consistently improving food security, illustrating that progress in one welfare indicator may not produce broader resilience. Cohn et al. (2017) and Aniah et al. (2019) show that livelihood diversification can buffer climate risk, but diversification may also be a response to existing vulnerability rather than evidence that vulnerability has been overcome. The relationship may be reciprocal: income and financial access can enable adoption, while successful adoption may subsequently improve income. The review therefore supports a conditional and potentially bidirectional relationship rather than a verified linear chain from learning to adoption, income stability, and climate resilience.

D. Geographic, Commodity, and Methodological Heterogeneity

The evidence base is geographically uneven. Cocoa-specific studies are concentrated in Ghana, with a smaller group from Indonesia, Cameroon, and Côte d'Ivoire, whereas evidence concerning digital learning and adoption frequently comes from China, India, Tanzania, Vietnam, or global reviews. These settings differ in farm structure, climate exposure, land tenure, digital connectivity, extension services, certification arrangements, and market integration. Cross-commodity studies contribute useful mechanisms, but their findings cannot be assumed to operate identically in cocoa, a perennial crop characterised by long investment cycles, specific pest and disease risks, and strong dependence on global value chains.

Research designs are also heterogeneous: the corpus includes quantitative cross-sectional studies, qualitative case studies, mixed or participatory studies, systematic and scoping reviews, and conceptual or perspective articles. Quantitative studies estimate associations but often cannot establish temporal order; qualitative studies clarify mechanisms and constraints but remain context-specific; and reviews broaden coverage while depending on the quality and comparability of their source studies. Although all included articles passed the stated quality threshold, the theme-level evidence was predominantly moderate rather than uniformly high, and the criterion-level appraisal matrix was not available in the manuscript. Convergence across studies should therefore be interpreted as consistency of patterns, not as a pooled effect or universal causal conclusion.

E. Conflicting Findings and Boundary Conditions

Apparent inconsistencies across the literature are analytically important. Agricultural information is associated with adaptive capacity in Chetri et al. (2023) and Maguire-Rajpaul et al. (2020), yet Boateng et al. (2023) show that knowledge does not consistently translate into appropriate practice. Peer exchange and social learning may facilitate trust and diffusion (Li et al., 2024; Rust et al., 2022), whereas highly centralized networks may constrain experimentation (Matous & Bodin, 2024). Similarly, CSA is associated with income or resilience benefits (Agbenyo et al., 2022; Teklu et al., 2023), but its adoption and outcomes remain conditioned by farm size, labour, capital, tenure, credit, policy support, and governance arrangements (Ameyaw et al., 2018; Nasser et al., 2020; Suh & Molua, 2022; Zerssa et al., 2021).

These differences do not necessarily invalidate the synthesis; instead, they identify boundary conditions. The same resource may have different strategic value depending on its complementarity with other resources and the conditions under which it is deployed. Digital information, for example, may be valuable when combined with literacy, credible interpretation, finance, and feasible implementation options, but may have little effect where these complementary resources are absent. This conditionality is central to applying RBV at the smallholder level and explains why farmers exposed to similar climate pressures may exhibit different adoption and resilience outcomes.

F. Digital Farmer Influencer as a Provisional, Untested Proposition

The available evidence is insufficient to identify Digital Farmer Influencer (DFI) as a moderator or as a primary finding. Rust et al. (2022) provide evidence concerning peer trust and social-media-enabled exchange, while Matous and Bodin (2024) examine opinion leaders and network centrality among Indonesian cocoa farmers. Neither study defines DFI, distinguishes digital from non-digital influence, measures a moderating effect, or links such an effect directly to income stability or climate resilience. The included studies therefore support only the plausibility of component mechanisms, not empirical confirmation of the proposed construct.

DFI should consequently be presented as an emerging proposition for future testing. Its influence could be positive when credible farmer communicators translate technical information into locally relevant practices, but it could also be negative when centralized influence disseminates inaccurate information, reinforces homogeneous practices, or suppresses experimentation. Future research should first establish construct validity and measure dimensions such as credibility, agronomic competence, digital reach, network position, content quality, and interaction frequency. Longitudinal, quasi-experimental, social-network, and mixed-method designs are needed before moderation can be assessed; SEM or PLS-SEM would be appropriate only after reliable measurement and theoretically justified causal ordering have been established.

G. RBV Implications and Research Priorities

The synthesis refines the application of RBV by distinguishing resource stocks, capabilities, external enabling conditions, and outcomes. Knowledge, skills, digital literacy, social capital, land, labor, and finance can be treated as farmer- or household-level resources. The ability to combine these resources, evaluate information, experiment, and sustain CSA practices represents capability deployment. Extension services, institutions, markets, policies, and platform infrastructure are external conditions rather than internal resources, while income stability, farm continuity, and climate resilience are outcomes. This distinction prevents institutional support or CSA practices from being automatically classified as internal strategic resources.

Future research should test resource configurations rather than isolated variables and compare how these configurations operate across cocoa-producing countries. Multi-country longitudinal studies, repeated measures of adoption and resilience, explicit comparison between cocoa and other commodities, and integrated qualitative and quantitative designs would clarify temporal ordering and contextual mechanisms. The principal theoretical contribution of this review is therefore not proof of a universal causal model, but a structured set of conditional relationships and testable propositions concerning how heterogeneous resource bundles may support smallholder adaptation.

5. Conclusion and Suggestion

This Systematic Literature Review of 30 Scopus-indexed articles published between 2015 and 2025 indicates that climate resilience among smallholder cocoa farmers is associated with configurations of human, social, financial, informational, physical, and natural resources rather than with a single strategic asset. From an RBV perspective, knowledge, farming skills, digital literacy, social capital, land, labour, and finance can be treated as farmer- or household-level resources, while the ability to evaluate information, combine resources, experiment, and sustain Climate Smart Agriculture (CSA) practices represents capability deployment. Extension services, institutions, policies, markets, and digital infrastructure are external enabling or constraining conditions, whereas income stability, farm continuity, and climate resilience are outcomes. The evidence suggests that social and digital learning may support adoption-related behavior, but it does not establish a universal or sequential causal pathway from learning to adoption, income stability, and climate resilience.

The conceptual contribution of this review is a structured RBV-based distinction among internal resource stocks, strategic capabilities, external conditions, and resilience-related outcomes at the smallholder-enterprise level. However, the strength of evidence varies across themes and contexts. Direct evidence concerning Digital Farmer Influencers (DFIs) is particularly limited to proxy mechanisms such as peer trust, farmer-to-farmer communication, opinion leadership, and network centrality; therefore, DFI should be regarded as an emerging and untested proposition rather than an established moderator or strategic resource. The review is also limited by its reliance on a single primary bibliographic database, English-language publications from 2015 to 2025, the combination of cocoa-specific and cross-commodity evidence, heterogeneity in study designs and outcome measures, the absence of meta-analysis, and the unavailability of the criterion-level quality-appraisal matrix in the manuscript. These limitations restrict causal interpretation and the generalizability of the proposed relationships.

Future research should develop and validate DFI measures covering credibility, agronomic competence, digital reach, network position, content quality, and interaction intensity before testing its direct, mediating, or moderating roles. Longitudinal, mixed-method, quasi-experimental, and social-network studies, together with comparative research across cocoa-producing countries, are needed to clarify temporal ordering, contextual differences, and the configurations of resources that support resilience; SEM or PLS-SEM should be applied only after construct validity and theoretically justified causal ordering have been established. In practice, governments, extension agencies, cooperatives, and cocoa-sector stakeholders should strengthen digital literacy, access to credible agricultural information, farmer organizations, finance, extension support, market access, and inclusive CSA programmed. Digital farmer figures may be engaged as communication partners, but their content and agronomic competence should be verified and accompanied by safeguards against misinformation and excessive dependence on central opinion leaders.

For policy and practice, governments should combine inclusive CSA finance, rural digital connectivity, market support, and agronomic content-verification arrangements; extension agencies should pair face-to-face and digital learning with demonstration, farm-level follow-up, and correction procedures; and cooperatives should organise verified peer learning alongside collective access to inputs, credit, and markets. Digital farmer figures may be used as communication partners only after their agronomic competence, credibility, and content quality have been assessed, and programmes should avoid excessive dependence on a single central opinion leader. Monitoring should move beyond training attendance or digital reach to sustained adoption, income stability, food security, farm continuity, and farmers' absorptive, adaptive, and transformative capacities.

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