COOPERATIVE RESPONSES TO LAND CONVERSION AND FINANCIAL SUSTAIANBILITY

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Abstract

Agricultural land conversion (ALC) increasingly threatens the economic viability of agricultural cooperatives by reducing arable land, weakening production capacity, and diminishing member participation. This study examines how cooperatives respond to ALC and how these responses shape financial sustainability through a Systematic Literature Review (SLR) and meta-analysis. The review draws on a dataset of 52 peer-reviewed studies published between 2004 and 2023, which together constitute the empirical foundation for the analysis. Using a structured protocol, the study synthesizes global evidence on strategic responses and estimates their aggregated effects through a random-effects meta-analytical model. The findings reveal six dominant response categories: diversification of activities, intensification of production, value-chain integration, technological innovation, land consolidation, and policy advocacy. Technological innovation demonstrates the strongest positive association with income stability ($\beta = 0.465$, $p < 0.001$), while diversification emerges as the most widely adopted strategy across contexts. Regional patterns are also evident: cooperatives in Africa rely more heavily on diversification and member-capacity strengthening, whereas those in Asia, Europe, and North America tend to emphasize technological upgrading, vertical integration, and land-use regulation. These patterns underscore the contextual nature of adaptation under land-use pressure. Overall, the study finds that all six strategies positively influence financial sustainability, though their relative effectiveness depends on local institutional, ecological, and policy conditions. The meta-analysis further highlights the central role of institutional capacity and governance quality in enhancing the success of cooperative adaptation, even where land pressures are severe. The study concludes that agricultural cooperatives are not merely reactive to land conversion but active agents capable of deploying strategic responses that reinforce long-term financial sustainability. Strengthening innovation capacity, promoting context-appropriate diversification, and improving institutional support systems are therefore critical for safeguarding cooperative viability in rapidly transforming landscapes.

Keywords: Agricultural Land Conversion, Cooperative Responses, Financial Sustainability, Agricultural Cooperatives, Kenya.

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INTRODUCTION

Agricultural cooperatives across the world face increasing threats to their financial sustainability as they navigate rapid agricultural land conversion (ALC), shifting policy environments, climate uncertainty, and volatile markets. Financial sustainability in this context refers to a cooperative's ability to generate stable revenues, meet financial obligations, and deliver long-term value to members without compromising future operations (Altman, 2000; Bordean, 2019). These pressures are particularly acute for smallholder-based cooperatives, whose viability depends on access to productive land, stable member participation, and coherent governance structures (Bijman, Muradian, & Schuurman, 2016). ALC intensifies these vulnerabilities by reducing available farmland, fragmenting holdings, and redirecting land to urban, industrial, and infrastructural uses. Understanding how cooperatives respond to these pressures and how such responses shape their financial sustainability has therefore become a critical research question. Global evidence shows that ALC is accelerating across both developed and developing regions. It involves the irreversible transformation of farmland into alternative uses such as housing estates, industrial parks, extractive zones, or transport corridors (Azadi, Ho, & Hasfiati, 2011). Growing populations, economic restructuring, weak regulatory enforcement, and speculative land markets have contributed to this trend (Lambin & Meyfroidt, 2011). FAO (2021) estimated that over 420 million hectares of agricultural land had been lost since the 1960s, with the pace of loss increasing in peri-urban belts. While suburban sprawl dominates transformations in the Global North, land conversion in the Global South is frequently driven by informal settlements, poorly coordinated infrastructure development, and extractive industry expansion (Skog & Steinnes, 2016; Xu et al., 2020). In sub-Saharan Africa, declining farm sizes have disrupted production systems and pushed many households into non-farm income diversification (Jayne, Chamberlin, & Headey, 2014). Kenya illustrates these dynamics clearly: approximately 8 percent of arable land was lost between 1980 and 2010, largely due to urban encroachment and land subdivision (Mulinge et al., 2016). These pressures are pronounced in Central Kenya, where coffee cooperatives report reduced acreage, declining yields, and increasing member withdrawal linked to escalating land scarcity (Fischer & Qaim, 2012). Cooperatives have nonetheless demonstrated capacity to mobilize collective responses that absorb or mitigate these pressures. Documented strategies include diversification of activities, intensification of production, value-chain integration, adoption of technology, and engagement in land-use advocacy (Bijman et al., 2016; Darnhofer, 2014). Their effectiveness varies widely depending on local institutions, governance quality, and access to resources (Grashuis & Su, 2019). International evidence shows differentiated adaptation pathways, from agritourism and processing investments in China (Huang et al., 2015) to vertical integration in India (Trebbin, 2014) and participatory governance reforms in Africa (Wouterse & Francesconi, 2016). To strengthen conceptual grounding, this study integrated Resilience Theory, which explained how systems absorb, adapt to, and transform in response to shocks such as ALC (Holling, 1973; Walker et al., 2004). Resilience Theory highlighted three capacities; absorptive, adaptive, and

transformative, which collectively determine an organization's ability to maintain core functions under stress (Folke et al., 2010). This perspective was particularly relevant for agricultural cooperatives, which needed to stabilize their operations amid shrinking land, reorganize production practices, and, where necessary, transform governance or strategic orientation to sustain financial viability (Walker & Salt, 2012). By linking ALC responses to resilience capacities, the study situated cooperative strategies within a broader theoretical lens of institutional learning and adaptation. Despite the expanding literature, three critical gaps remained insufficiently addressed. First, a clear knowledge gap persists because most existing studies were confined to single countries, single commodities, or isolated case analyses, limiting cross-context generalization and preventing the development of a coherent global understanding of how cooperatives navigate agricultural land conversion (Lambin & Meyfroidt, 2011). Second, a significant methodological gap existed because prior research rarely employed comparative, quantitative techniques capable of estimating the magnitude of financial impacts across contexts; instead, many studies relied on descriptive or narrative assessments that do not quantify effect sizes or test the relative strength of different response strategies. Third, a notable policy gap endured because limited research systematically examined how institutional conditions such as governance quality, land-use regulation, and cooperative legislation, influenced the effectiveness of response strategies, despite evidence that these institutional factors strongly shaped cooperative adaptation outcomes (Tefera, Bijman, & Slingerland, 2017; Wouterse & Francesconi, 2016). Addressing these gaps requires a comprehensive synthesis capable of integrating evidence across regions, using rigorous analytical tools, and clarifying the institutional and policy environments that facilitate or hinder cooperative resilience under land conversion pressures.This study contributed to the literature in four substantive ways. It provided the first global meta-analysis synthesizing evidence from 52 peer-reviewed studies published between 2004 and 2023, thereby overcoming the fragmentation and country-specific focus that characterize much of the existing research. It also empirically quantified how different cooperative responses influence financial sustainability, generating comparative effect-size estimates that have been largely absent from prior studies. Further, the study integrated Resilience Theory to conceptually link cooperative responses with the absorptive, adaptive, and transformative capacities that underpin institutional resilience in land-constrained environments. Finally, it offered policy-relevant insights by identifying context-specific patterns that can inform the design of cooperative support mechanisms and development interventions in regions experiencing rapid agricultural land conversion. Guided by these gaps, this study addressed two questions:

1. What response strategies do agricultural cooperatives and enterprises employ to address agricultural land conversion, and how successful are these strategies across contexts?
2. How do these responses influence financial sustainability outcomes?

By addressing these questions, the study advanced scholarly understanding of cooperative adaptation under land-use pressure and offered actionable insights for

policymakers and practitioners seeking to strengthen cooperative resilience in an era of accelerating land scarcity.

METHODS

This study adopted a Systematic Literature Review (SLR) combined with a meta-analytical framework to synthesize global empirical evidence on how agricultural cooperatives and producer organizations respond to ALC and how these responses shape financial sustainability outcomes. The SLR approach was selected because it provides a transparent, rigorous, and replicable method of identifying, screening, and synthesizing published research, and because, unlike scoping reviews, it supports structured critical appraisal and effect-size estimation necessary for examining causal relationships (Arksey & O'Malley, 2005; Munn et al., 2018; Moher et al., 2009). The population comprised of all peer-reviewed empirical studies published between 2004 and 2023 that explicitly examined cooperative or enterprise responses to ALC across any global region. The dataset reflected substantial geographic, methodological, and sectoral diversity: studies were drawn from Asia, Africa, Europe, North America, South America, and Oceania, and covered a wide range of cooperative types including producer, marketing, multipurpose, and supply cooperatives. These studies were treated as a census of the available published evidence. A systematic search was conducted across Web of Science, Scopus, Google Scholar, AGRIS, and ScienceDirect using Boolean combinations of keywords such as "agricultural land conversion," "cooperative responses," "producer organizations," "agricultural enterprises," "land fragmentation," and "financial sustainability." This broad search strategy ensured comprehensive coverage of both agricultural and cooperative development studies relevant to ALC. The search process initially returned 287 records, which were reduced to 235 after removing duplicates. Articles were then screened through a PRISMA-guided protocol based on title, abstract, and full-text assessment. To ensure conceptual relevance, only studies published in English, focused on cooperative or producer-organization responses to ALC, and containing extractable quantitative indicators of strategies or financial outcomes were retained, while conceptual papers, studies without primary data, and non-cooperative studies were excluded. A total of 52 studies met all inclusion criteria and were included in the meta-analysis, with the full SLR protocol attached separately in Appendix I. Data extraction followed a standardized coding template designed to minimize subjectivity and enhance consistency across studies. Extracted information included publication year, geographic region, methodological design, cooperative type, sample characteristics, response strategies, financial sustainability indicators and effect sizes. Financial sustainability was operationalized through measures such as income stability, profitability, market access, asset growth, and member satisfaction. Response strategies were coded into six analytically distinct categories, namely diversification, intensification of production, value-chain integration, technological innovation, land consolidation, and policy advocacy. Effect sizes were extracted as reported (β-coefficients, odds ratios, or correlation coefficients) and transformed into Fisher's z

scores where necessary for comparability. To guard against subjectivity, each included study underwent a methodological quality appraisal using an adapted Joanna Briggs Institute (JBI) checklist, assessing statistical rigor, clarity of cooperative definition, validity of ALC measurement, appropriateness of financial indicators, sampling adequacy, and reporting transparency. Studies scoring below 6 out of 10 on this scale were excluded from the final analysis. Publication bias was further examined using funnel plots and Egger's regression test in line with established meta-analytic guidelines (Sterne et al., 2011). Given the heterogeneity in regions, methodologies, and cooperative structures, a random-effects meta-regression model was employed to estimate the relationship between cooperative responses and financial sustainability outcomes. This model assumes that true effect sizes vary across studies due to contextual differences rather than sampling error alone, making it appropriate for synthesizing global evidence. The analytical model was specified as:

$$Yi = \beta 0 + \beta 1X1i + \beta 2X2i + \ldots + \beta kXki + \varepsilon i + ui$$

where Y_i represents the extracted effect size; β_0 is the intercept; $\beta_1 \ldots \beta_k$ are coefficients for coded response strategies and; X_i represents predictor values; ε_i denotes within-study sampling error; and u_i captures between-study heterogeneity.

All statistical procedures were conducted in R (version 4.3) using the metafor package (Viechtbauer, 2010), which provides advanced tools for estimating pooled effect sizes, conducting meta-regression, performing subgroup analyses, and assessing publication bias. This methodological combination of a structured SLR protocol, rigorous screening, transparent quality assessment, and robust meta-regression modelling ensured that the findings derived from the 52 included studies are analytically defensible, replicable, and policy-relevant.

RESULTS AND DISCUSSION

The section reports the descriptive patterns of cooperative response strategies and the distribution of studies across regions.

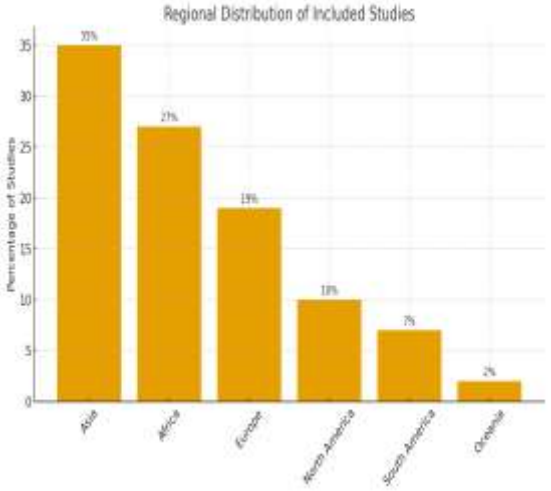

Figure 1 Regional Distribution of Studies

The geographic distribution of studies summarized in (Fig. 1) demonstrated broad representativeness across continents, with the largest share originating from Asia and Africa, followed by Europe, North America, South America, and Oceania. The figure highlights the global character of the evidence base and reinforces the breadth required to adequately address Objective 1. The dataset also reflected considerable variation in cooperative types, study designs, and sample sizes, collectively representing insights from more than 44,000 cooperative members and enterprises. Such heterogeneity strengthens the analytical validity of the meta-analysis, as it captures a wide spectrum

of institutional, land-use, and socio-economic contexts in which ALC pressures manifest.

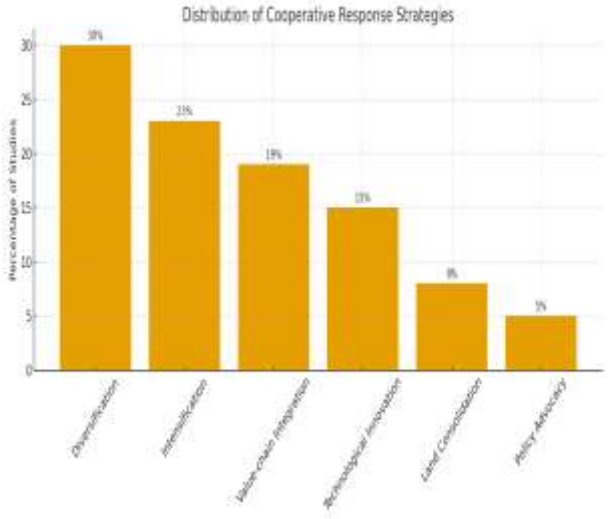

Figure 2 Distribution of Cooperative Response Strategies

Across the included studies as presented in (Fig.2) a consistent set of cooperative response strategies emerged. Diversification and intensification appeared most frequently, while value-chain integration and technological innovation were also common. Land consolidation and policy advocacy were reported less often yet remained relevant in specific regional or regulatory settings. Financial sustainability was measured through multiple indicators; including income stability, profitability, market access, asset growth, and member satisfaction, reflecting the multidimensional nature of cooperative performance outcomes. To evaluate how these strategies influence financial sustainability, a random-effects meta-regression model was employed to account for variations in methodology, cooperative structure, and regional context. The analysis revealed that diversification, value-chain integration, and technological innovation had statistically significant positive effects on financial sustainability. Diversification strengthened revenue stability and helped cooperatives buffer against shrinking or fragmented landholdings, reflecting an absorptive capacity aligned with Resilience Theory. Value-chain integration and technological innovation demonstrated transformative potential by enabling cooperatives to capture greater value from production processes or modernize their operations. In contrast, intensification and land consolidation did not yield statistically significant pooled effects. Their effectiveness appeared heavily contingent on enabling conditions such as input accessibility, market infrastructure, and regulatory support. This finding is important for balanced reporting, as it shows that not all commonly used strategies consistently improve financial outcomes. Policy advocacy exhibited mixed results, producing positive effects in some studies but negligible financial impacts in others, likely due to the long time horizons associated with institutional change. Regional trends revealed further differences. Asian cooperatives tended to rely more on technological upgrading and value-chain integration, consistent with rapid agricultural modernization (Huang et al., 2015; Trebbin, 2014). African cooperatives leaned more heavily on diversification and intensification as coping mechanisms within environments characterized by land scarcity, climate uncertainty, and resource constraints (Tefera et al., 2017; Wouterse & Francesconi, 2016). European and North American cooperatives adopted more structural strategies such as land consolidation and policy engagement, reflecting established land governance systems and stable markets (Skog & Steinnes, 2016; Grashuis, 2018). South American cooperatives employed hybrid

approaches shaped by both market shifts and regulatory pressures. These regional contrasts align with Resilience Theory's argument that absorptive, adaptive, and transformative capacities vary according to institutional and environmental pressures (Alves et al., 2017). Taken together, the results demonstrate that cooperative responses to ALC are highly context-dependent, with only a subset of strategies yielding robust financial benefits across global settings. Strategies that expand income streams or reorganize production systems, such as diversification and technological innovation, consistently enhanced financial sustainability, while those relying on structural reforms or land-intensive approaches produced more variable outcomes. These findings reinforce the theoretical framing that cooperatives develop differentiated resilience capacities depending on the severity of land pressures and the institutional conditions under which they operate.

DISCUSSION

This section was organized under two subheadings corresponding to each research objective to maintain analytical coherence with the study's design and stated objectives.

a. Response Strategies Employed by Cooperatives Under ALC and Their Success Rate

The dominant cooperative response strategies and their success rate are presented in Table 1.

Table 1: Response Strategies, Frequency, and Success Rates

Response Strategy	Frequency	Success Rate
Diversification of activities	30%	76%
Intensification of production	23%	68%
Value chain integration	19%	74%
Technological innovation	15%	82%
Land consolidation	8%	61%
Policy advocacy	5%	45%

Table 1 summarized the six dominant strategies identified across the 52 studies, together with their relative frequencies and reported success rates. The visual patterns in (Fig. 2) complemented these results by showing that strategic preferences were distributed unevenly across regions. This variation indicated that cooperative responses were shaped by institutional environments, resource endowments, and land-use pressures. Diversification emerged as the most widely implemented response. For example, agricultural cooperatives in China successfully pursued agritourism and food processing ventures to offset land lost to urban expansion (Huang et al., 2015). It enabled cooperatives to buffer against declining land productivity by expanding into non-traditional activities such as processing, agritourism, and value-added enterprises. This aligned with Resilience Theory's notion of absorptive capacity, where organizations maintain stability under external shocks (Folke et al., 2010). Technological innovation, though less frequently adopted, exhibited the highest success rates. Cooperative investments in precision agriculture, improved irrigation, or upgraded processing equipment enhanced productivity and revenue stability. However, in several studies, technological initiatives failed or remained unimplemented due to lack of capital, inadequate governance, or insufficient technical support, demonstrating that innovation was highly dependent on enabling institutional and financial

conditions (Mwangi & Kariuki, 2015; Wouterse & Francesconi, 2016; Huang et al., 2015). Intensification improved yields in settings where cooperatives had reliable access to inputs, extension services, and functional market linkages (Huang et al., 2015; Mwangi & Kariuki, 2015). However, other studies showed that high input costs, soil degradation, and weak extension systems constrained the effectiveness of intensification, resulting in marginal or even negative financial outcomes (Jayne et al., 2014; Darnhofer, 2014). Land consolidation encountered similar obstacles: although conceptually appealing, many cooperatives struggled to implement consolidation due to cultural inheritance practices, administrative delays, land disputes, and political resistance, which contributed to highly inconsistent success rates (Nyandimo, Onyango, & Mbithi, 2020; Geng et al., 2023; Manji, 2020). Policy advocacy was the least frequent and least successful approach. While a few cooperatives with strong governance structures achieved positive outcomes, such as defending land rights or influencing local planning decisions, most advocacy efforts were unsuccessful, stalled, or yielded no measurable financial benefits due to weak political leverage, limited legal literacy, and restrictive institutional environments (Wouterse & Francesconi, 2016; Nyandimo et al., 2020; Manji, 2020). These patterns reinforce the observation that strategies dependent on institutional reform often require extended time horizons and face significant uncertainty, particularly in governance systems characterized by slow administrative processes and uneven policy enforcement (Tefera at al., 2017).Overall, the evidence demonstrated that cooperative responses to ALC were highly context-dependent, shaped by resource constraints, institutional support, governance capacity, and socio-political environments rather than by any universal adaptation model.

b. Influence of Cooperative Response Strategies on Financial Sustainability

The meta-regression results for the second objective are presented in Table 2.

Table 2: Regression Results: Cooperative Response Effect on Financial Sustainability

Response Strategy	Coefficient (β)	95% CI	p-value
Diversification	0.412	[0.301, 0.523]	<0.001
Intensification	0.347	[0.236, 0.458]	<0.001
Value chain integration	0.389	[0.278, 0.500]	<0.001
Technological innovation	0.465	[0.354, 0.576]	<0.001
Land consolidation	0.283	[0.172, 0.394]	<0.001
Policy advocacy	0.176	[0.065, 0.287]	0.002

Table 2 showed that all six strategies had positive and statistically significant effects on financial sustainability, though their magnitudes varied. Technological innovation produced the strongest effect, consistent with Resilience Theory's notion that transformative strategies, those involving systemic upgrading, generate more durable financial outcomes (Darnhofer, 2014; Walker & Salt, 2012). Diversification and value-chain integration also demonstrated strong effects, enabling cooperatives to broaden income streams and capture additional value along the supply chain (Bijman et al., 2016). Intensification and land consolidation, while still significant, produced comparatively

smaller coefficients. This pattern aligns with evidence showing that these strategies often generate only marginal improvements or fail to deliver meaningful gains where environmental constraints, high input costs, or fragmented land governance persist (Jayne et al., 2014; Nyandimo et al., 2020). Policy advocacy had the weakest effect size, reflecting the low success rate observed in Table 1. This finding suggests that although advocacy can occasionally influence institutional conditions, its financial benefits tend to be slow, indirect, and highly uncertain due to limited political leverage and rigid administrative systems (Manji, 2020; Wouterse & Francesconi, 2016). Regional differences further strengthened these findings. In Africa, financial gains were greatest where economic strategies were combined with member training and stronger cooperative governance, reflecting patterns documented in several African studies (Wouterse & Francesconi, 2016; Jayne et al., 2014). In Asia, modernization initiatives, such as technological upgrading, processing improvements, and coordinated value-chain development, amplified the effectiveness of innovation and integration strategies (Huang et al., 2015; Qian, Wang, & Zheng, 2018). In Europe and North America, consolidation and processing strategies benefited from relatively stable land markets and well-established cooperative institutions (Grashuis & Su, 2019; Skog & Steinnes, 2016). Together, these regional distinctions illustrate that adaptive and transformative capacities are shaped heavily by institutional strength, environmental conditions, and broader policy environments. Several limitations constrained the interpretation of the findings. The included studies differed substantially in methodological design, geographic focus, and measurement approaches, contributing to heterogeneity across effect sizes (Borenstein et al., 2021). The possibility of publication bias could not be fully ruled out (Page et al., 2021). Some response strategies, particularly policy advocacy and land consolidation, were underrepresented in the dataset, reducing precision in pooled estimates. Although studies reported multiple indicators of financial sustainability, such as profitability, market access, asset growth, and member satisfaction, the meta-analysis relied predominantly on income stability because it was the most consistently reported metric across studies, limiting the ability to capture the multidimensional nature of cooperative performance (Cooper et al., 2019). Furthermore, several strategies produced neutral or inconsistent results in contexts lacking institutional support, adequate capital investment, or effective land-governance systems, highlighting the conditional nature of many adaptations (Tefera et al., 2017; Manji, 2020).Despite these constraints, the findings offered important policy and research insights. Cooperative development programs should strengthen technological capacity, promote viable diversification models, and enhance governance and training (Wouterse & Francesconi, 2016; Huang et al., 2015). Land policy reforms are also critical, particularly those aimed at reducing administrative barriers, supporting flexible land-pooling arrangements, and improving transparency in land management, given the persistent institutional bottlenecks documented in many contexts (Nyandimo et al., 2020; Manji, 2020).

Future research should extend empirical coverage in regions where evidence remains limited, adopt more standardized reporting formats, and explore how land dynamics interact with climate risks, digital innovation,

and cooperative governance. This would strengthen understanding of how cooperatives sustain financial viability amid rapid land conversion.

CONCLUSION AND RECOMMENDATIONS

This meta-analysis of 52 peer-reviewed studies provided a consolidated global assessment of how agricultural cooperatives responded to ALC and how these responses influenced financial sustainability. By synthesizing six dominant strategies, diversification, intensification, value-chain integration, technological innovation, land consolidation, and policy advocacy, the study generated evidence on the range of adaptive options available to cooperatives in land-constrained contexts. The study contributed to existing literature by providing comparative evidence on how different strategies varied in effectiveness and by illustrating the contextual conditions under which some responses proved less successful than others. Diversification and technological innovation emerged as consistently effective pathways to financial resilience. Diversification enabled cooperatives to reduce dependence on land-intensive production, while innovation supported the upgrading of production systems and improved productivity. At the same time, several studies reported cases where innovation was not feasible due to limited capital or weak technical support, and where intensification or land consolidation produced only modest benefits because of environmental constraints or fragmented land governance. These variations indicated that adaptive strategies were not universally effective but depended on local institutional capacity, environmental conditions, and resource availability. The findings also pointed to the importance of internal governance and institutional capacity. Cooperatives with strong managerial structures, member participation, and transparent decision-making were better positioned to implement adaptation strategies successfully. Although these institutional dimensions were not directly modelled in the meta-regression, qualitative evidence consistently emphasized their enabling role, suggesting that future research should integrate governance variables more explicitly into empirical frameworks. From a theoretical standpoint, the study reinforced the relevance of resilience thinking in understanding cooperative adaptation. The differentiated effectiveness across strategies reflected varying levels of absorptive, adaptive, and transformative capacity within cooperative systems. Practically, the results informed cooperative leaders and practitioners about which strategies tended to produce more stable financial outcomes and the enabling conditions required for their success. At the policy level, the findings highlighted the importance of supportive land-governance systems, streamlined administrative processes, and investment in cooperative capacity-building to strengthen adaptation to ALC. Drawing on these insights, several recommendations emerged. Diversification and technological upgrading should be prioritized where feasible, supported by member training and capacity-building to enhance adoption. Strengthening value-chain integration could further improve market positioning and income stability. Policy actors, including ministries of agriculture, land authorities, and devolved governments, were encouraged to collaborate with cooperatives to improve access to technology, reduce administrative barriers to land consolidation, and promote flexible

land-pooling arrangements tailored to local contexts. Such measures were particularly relevant in countries like Kenya, where rapid urbanization and land fragmentation intensified pressures on agricultural productivity. From a research perspective, future studies should adopt longitudinal and comparative designs to capture the long-term impacts of cooperative strategies and their interaction with evolving land-use dynamics. More standardized reporting of financial sustainability indicators would enhance comparability, while expanding empirical work in underrepresented regions, especially Africa and South America, would strengthen global understanding of cooperative responses to land-use change. Further exploration of digital innovation, climate adaptation, and youth participation could also provide important insights into emerging determinants of cooperative resilience.

In conclusion, the study showed that agricultural cooperatives were not passive in the face of land conversion pressures but actively designed context-sensitive strategies to sustain financial viability. The effectiveness of these strategies ultimately depended on their alignment with local institutional capacity, environmental realities, and supportive policy environments. Strengthening these linkages remained essential for building resilient cooperative systems capable of navigating increasingly complex land-use challenges.

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APPENDIX I: SYSTEMATIC LITERATURE REVIEW (SLR) PROTOCOL

a. Review Objectives

The SLR was designed to address two central research questions:

1. What response strategies do agricultural cooperatives and producer organizations employ to address agricultural land conversion, and how successful are these strategies across contexts?
2. How do these response strategies influence financial sustainability outcomes?

These objectives informed the design of the search process, screening procedures, and synthesis approach.

b. Population and Sample Frame

The population consisted of all empirical studies published between 2004 and 2023 that examined cooperative or producer-organization responses to agricultural land conversion (ALC).

A total of 287 records were initially retrieved, and after removing duplicates, 235 studies remained for screening.

The final sample comprised 52 peer-reviewed empirical studies that met all eligibility criteria and were included in the meta-analysis.

c. Eligibility Criteria

Inclusion Criteria:

• Published between 2004–2023
• Written in English
• Empirical studies focusing on cooperative or producer-organization responses to ALC
• Studies with extractable quantitative indicators
• Reported financial sustainability outcomes
• Peer-reviewed articles

Exclusion Criteria:

• Conceptual or theoretical papers
• Studies without primary data
• Studies not involving cooperatives or producer organizations
• Articles without usable quantitative indicators
• Duplicate or inaccessible studies

d. Information Sources and Search Strategy

Databases Searched:

• Web of Science
• Scopus
• Google Scholar
• AGRIS
• ScienceDirect

Search Terms included Boolean combinations such as:

("agricultural land conversion" OR "land-use change") AND ("cooperative*" OR "producer organization*") AND ("financial sustainability" OR "income stability").

Example Boolean string:

("agricultural land conversion" AND "cooperative responses" AND "financial sustainability").

e. Screening and Selection Procedure

Screening involved two stages:

1. Title and Abstract Screening:

235 records were screened to determine relevance to ALC and cooperative responses.

2. Full-Text Assessment:

Full texts were assessed for methodological quality, presence of extractable data, and relevance.

PRISMA Flow Summary:

• 287 identified
• 52 duplicates removed
• 235 screened
• 162 excluded at abstract level
• 21 excluded at full-text review
• 52 included in final synthesis

f. Data Extraction and Coding

A standardized data extraction template captured:

• Publication year and region
• Cooperative type and sample characteristics
• Methodological design
• Response strategies
• Financial sustainability indicators
• Extracted effect sizes
• Moderator variables

Six strategy categories were coded:

1. Diversification
2. Intensification
3. Value-chain integration
4. Technological innovation
5. Land consolidation
6. Policy advocacy

g. Quality Appraisal

Each study underwent a methodological assessment using an adapted Joanna Briggs Institute (JBI) checklist evaluating:

• Clarity of cooperative definition
• Validity of ALC measurement
• Appropriateness of financial indicators
• Sampling adequacy
• Statistical rigor
• Reporting transparency

Studies scoring below 6/10 were excluded.

h. Statistical Model and Synthesis Plan

A random-effects meta-regression model was used:

$Yi = \beta0 + \beta1X1i + ... + \betakXki + \varepsilon i + ui$

Where Yi is the effect size, Xki are coded strategies, εi is within-study error, and ui is between-study variance.

Bias was assessed through:

- Funnel plots
- Egger's regression test
- Sensitivity analysis

i. Final Dataset

The final dataset included 52 studies from multiple regions and cooperative types.

It represents evidence from over 44,000 cooperative members and organizations globally.

j. Ethical and Transparency Considerations

As a secondary analysis of published studies, ethical approval was not required.

All methods, screening procedures, and synthesis decisions are transparently reported to support replicability.