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Is the relationship between agricultural performance and land tenure security uniform across the world? Evidence from meta-analysis

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This meta-analysis investigated the association between land tenure security (LTS) and agricultural performance in various geographic and institutional contexts. It examines critical factors, such as agricultural productivity, investment, food security, poverty alleviation, climate change adaptation, soil and water conservation, and youth engagement, based on empirical research conducted from 1990 to 2024. The results indicated that, while LTS was generally associated with agricultural development, the degree of these advantages can vary significantly due to geographical dynamics and governmental frameworks. The effect can be especially strong for agricultural investment in regions in which institutions were strong and policies work together. The study stresses that land tenure reforms must be tailored to specific contexts and incorporate institutional capacity, social equity, and regional priorities to enhance resilience, promote sustainable livelihoods, and further advance the larger goals of agricultural transformation and rural development. The findings underscore the necessity for context-specific land tenure frameworks rather than one-size-fits-all proposals for policy.

KEYWORDS

agricultural development, land policy, land reforms, land tenure security, meta-analysis, SDGs

Introduction

Land tenure security (LTS) had long been acknowledged as a fundamental element of agricultural advancement and rural transformation. According to theoretical expectations, stable land rights should make it easier to make long-term investments, improve access to credit, and eventually boost agricultural output (Moor and Nieuwoudt, 1998; Banerjee and Ghatak, 2004; Abdulai et al., 2011; Rashid, 2021; Singirankabo et al., 2022). On the other hand, empirical research demonstrated substantial differences in outcomes across institutional, socioeconomic, and geographic contexts, with the literature presenting conflicting and at times contradicting conclusions (Deininger and Juan, 2004; Place, 2009; Singirankabo and Ertsen, 2020; Zhang and Chen, 2022). This diversity prompts significant inquiries regarding the universality of LTS's advantages and the optimal conditions for its facilitation of agricultural development. There had been extensive research on the relationship between the LTS and agricultural performance in disciplines such as agricultural economics, development studies, and environmental science. The "Marshallian inefficiency hypothesis," which was named after Alfred Marshall, became popular in the early 1920s. It says that when farmers do not have secure land tenure, they do not invest as much in their farmland, which lowers productivity and efficiency. Despite the fact that this hypothesis had been thoroughly investigated, opinions among researchers regarding its validity remain divided (Besley and Ghatak, 2010). Secure land ownership had a positive effect on agricultural investments, productivity, and efficiency on the adoption of modern technologies (Besley, 1995; Banerjee and Ghatak, 2004; Abdulai et al., 2011; Ali et al., 2012; Bambio and Agha, 2018; Coulibaly, 2023; Paltasingh et al., 2022; Akber et al., 2024). However, a parallel number of empirical research indicated outcomes that deviate from Marshallian hypotheses, revealing weak or minimal impacts of tenure security on both investment and production (Gavian and Ehui, 1999; Kassie and Holden, 2007; Pender and Fafchamps, 2006). Furthermore, studies have demonstrated that land rights had a negligible impact on investments in soil improvement, tree crop cultivation, and productivity (Atwood, 1990; Pickney and Kimuyu, 1994). Research generally indicated that land rights were not a major factor in decisions about land investment, with only a few exceptions (Reid, 1976; Otsuka and Hayami, 1988; Place and Hazell, 1993; Alston et al., 1996; Jacoby and Mansuri, 2009). The reported inconsistencies suggest that the relationship between LTS and agricultural outcomes was more complex and contextually dependent than earlier hypothesized, as demonstrated by varied findings across various geographic regions and institutional frameworks (Deininger and Juan, 2004; Place, 2009; Abdulai et al., 2011; Lawry et al., 2017; Singirankabo and Ertsen, 2020; Rashid, 2021).

There were a range of factors that could make LTS perform better in certain geographic regions than others. First, the meaning and the methods used to evaluate LTS were substantially distinct in different areas. In some settings, LTS is defined by a legal title to land, while in others, it is defined as feeling safe because of customary rights (Arnot et al., 2011; Beekman and Bulte, 2012). Second, the institutional framework that governs land tenure was distinct in different parts of the world, which could affect the association between security and agricultural outcomes (Deininger and Juan, 2004; Deininger and Jin, 2006; Ncube, 2018; Singirankabo and Ertsen, 2020). Third, the impact of tenure security may be shaped by various local factors, such as market access, credit availability, and technical capacity (Place, 2009; Abdulai et al., 2011; Rashid, 2021). Despite the wide range of individual case studies, a comprehensive synthesis analyzing the variations in the effects of LTS across regions, tenure regimes, and outcome domains was still limited. Although individual studies have investigated this relationship in particular contexts, there has been insufficient systematic analyses regarding the variations in the effects of LTS across diverse agricultural and socioeconomic environments. It is important to understand these spatial differences for a number of reasons, as it helps us to explain why similar land tenure policies yield different outcomes across regions. It will allow policymakers to design interventions that are responsive to local realities rather than applying uniform policy frameworks. This study deepens the understanding of how institutional settings, environmental conditions, and land tenure systems interact to influence the agricultural outcomes by bridging the key knowledge gap by synthesizing the findings through the meta-analysis from various regional contexts. The analysis draws on empirical studies conducted between 1990 and 2024 across both developed and developing economies, focusing on major indicators, such as productivity, investment behavior, food security, poverty alleviation, climate adaptation, resource conservation, and youth participation in agriculture.

Materials and methods

The study employed a systematic meta-analysis approach to investigate the association between LTS and agricultural development. Transparency and reproducibility of the study process were ensured by the approach that conducted the analysis following a standardized procedure. The study aimed to synthesize existing empirical evidence to address the central research question, which was developed following the Population, Intervention, Comparison, Outcome (PICO) framework (Santos et al., 2007). *"How does land tenure security affect agricultural performance, and how do these effects differ in various agricultural and socioeconomic settings?"*

The Systematic Review (SR) and the Meta-analysis (MA) followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (Page et al., 2021) shown in Figure 1. The research process began with an extensive literature review conducted across three major academic databases, such as Scopus, Science Direct, and Google Scholar, restricted to peer-reviewed journal publications published in English from 1990 to 2024. No geographical restrictions were established to ensure global coverage in both developed and developing economies. A systematic search strategy was employed using carefully selected keywords combined with Boolean operators: "Land" AND "Tenure" AND "Security" AND "Agriculture." The process of screening followed a two-step screening method (Moher et al., 2015). The initial database search identified 563 potentially pertinent items. By removing 77 duplicates using Microsoft Excel software, 486 unique articles remained for screening. For the eligibility assessment, the reviewer screened the titles and the abstracts against predetermined inclusion criteria, following the PRISMA framework (Page et al., 2021). Assessment of the full-text of 122 articles led to further exclusions based on specific criteria. Out of 122 articles, 68 were eligible for full-text assessment and 35 empirical studies fulfilled all requirements, thus being incorporated into the final systematic review and meta-analysis (SR & MA). Of the 68 full-text articles assessed for eligibility, 33 were excluded for three reasons: 17 lacked empirical quantitative data, 11 for the irrelevance to the PICO-defined scope, and 5 for insufficient statistical information to compute effect sizes. Therefore, only studies meeting methodological and data requirements were included in the final meta-analysis.

The criteria of inclusion were carefully designed to ensure the quality and the relevance of the selected items. For quality assessment, no formal quantitative quality assessment systems were utilized; instead, the study-level quality was evaluated using defined screening criteria. Only peer-reviewed empirical research that provided quantitative estimates, clearly specified tenure measurements, and agricultural outcomes with adequate statistical data for effect-size computation were considered. Studies that were purely qualitative, focused on urban land tenures, and lacked transparency in estimating methodologies, sample description, or variance reporting were removed during the full-text review process. This screening process was conducted in multiple stages following the PRISMA framework. The selected studies were analyzed across several key variables that

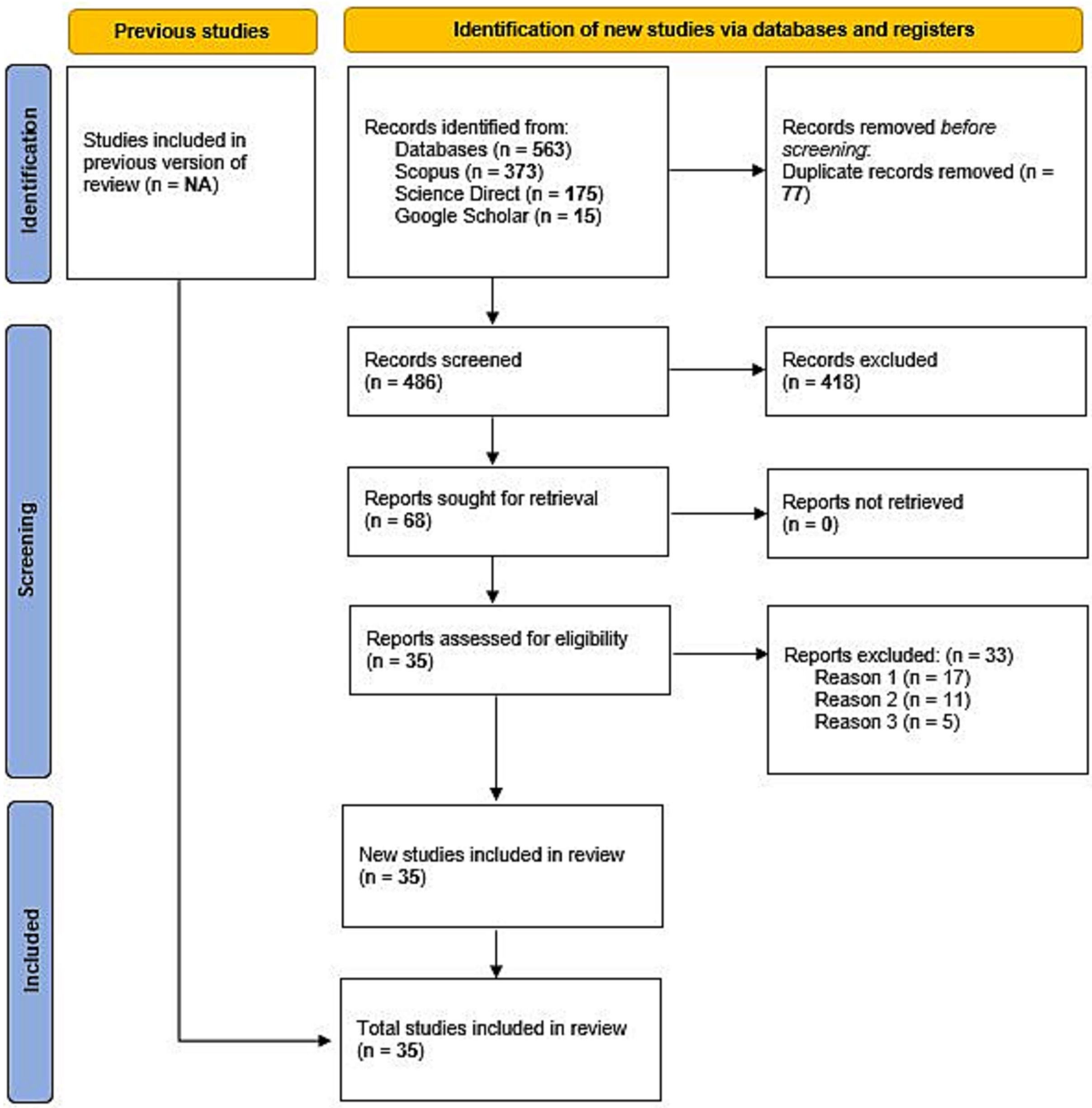

FIGURE 1
PRISMA protocol of the study selection process for the systematic review and meta-analysis of land tenure security and agricultural outcomes.

emerged from the literature: agricultural productivity, investments, food security and poverty, SDGs, climate change adaptation, soil conservation practices, and youth participation and employment, as given in Table 1. For each study, relevant data, such as effect sizes, standard errors, and sample characteristics, were extracted and coded. The analysis paid particular attention to the various dimensions of agricultural development and how they were impacted by different aspects of land tenure security. To address the heterogeneity in views of land tenure security, all studies included were categorized according to the type of LTS measurement, that is, legal/formal, perceived/de facto, customary, or hybrid. This classification was employed to cautiously interpret pooled data and to explicitly recognize the limitations of comparability among tenure regimes. In instances where the subgroup analysis was not statistically viable due to insufficient study number, heterogeneity was regarded as an essential empirical evidence rather than a mere statistical inconvenience.

Given the variability in outcome measures and empirical specifications among the included studies, effect sizes were standardized by transforming reported regression coefficients, standardized mean differences, odds ratios, and elasticity estimates into uniform effect sizes through inverse-variance weighting. In cases where coefficients were presented in different units, standard errors were utilized to estimate comparable standardized effects in accordance with established meta-analytic methodologies (Borenstein et al., 2009) using Equation (1). This approach facilitates the combination of diverse empirical designs while maintaining relative

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TABLE 1 Classification of empirical studies by land tenure security (LTS) measurement type, operational definition, agricultural outcome domain, functional association, and institutional limits of comparability.

Agricultural outcome domain	Study	LTS measure type	Operational definition of LTS in the study	Functional relationship between LTS and outcome	Limits of comparability/ Institutional context
Agricultural productivity	Do and Iyer (2008)	Legal/Formal	Land titling and legally registered use rights	Positive	State-directed land titling reform in Vietnam outcomes were dependent upon the efficiency of centralized land administration.
	Jacoby and Minten (2007)	Perceived/De facto	Perceived risk of land expropriation within weakly enforced formal systems	Mixed	Formal and informal tenure contexts; perceptions differ among communities
	Chand and Yala (2009)	Customary/Hybrid	Customary purchase and village-based tenure arrangements	Positive (heterogeneous)	Productivity varied among tenure types, influenced by scale, income-sharing regulations, and effective security rather than formal title ownership.
	Abdulai et al. (2011)	Hybrid	Legal title combined with perceived tenure security	Positive	Impacts enhanced by access to credit and markets
	Kubitza et al. (2018)	Legal/Formal	Statutory land ownership certificates	Positive	Contextual to the reforms in Indonesian land administration
	Coulibaly (2023)	Hybrid	Formal land documentation combined with perceived legitimacy within a customary-statutory dual framework	Positive (Conditional)	Hybrid operationalization restricts attribution exclusively to formal or perceived tenure.

(Continued)

TABLE 1 (Continued)

Agricultural outcome domain	Study	LTS measure type	Operational definition of LTS in the study	Functional relationship between LTS and outcome	Limits of comparability/ Institutional context
Agricultural investments (overall)	Besley (1995)	Perceived/De facto	Perceived land rights security under customary tenure	Positive	Customary systems offer security despite the lack of official titles.
	Brasselle et al. (2002)	Customary	Traditional lineage-based land rights	Mixed	Robust social enforcement; restricted applicability to legislative frameworks
	Leight (2016)	Legal/Formal	Contracted land-use rights in China	Negative/Mixed	The restricted duration of tenure affects the utilization of short-term inputs.
	Mengesha et al. (2019)	Legal/Formal	Land certification program	Positive	The effectiveness of certification depended on the standard of enforcement.
	Asaaga et al. (2020)	Hybrid	Legal recognition plus perceived tenure assurance	Mixed	Cocoa landscapes are characterized by stringent social norms.
	Bellemare et al. (2020)	Legal/Formal	Registered land-use certificates	Positive	State-sponsored certification; minimal significance to informal systems
	Coulibaly (2023)	Hybrid	Mixed statutory and perceived security	Positive	An institutional overlap hinders the method of attribution.
	Zhang and Chen (2022)	Legal/Formal	Farmland tenure security index	Positive	Outcomes were dependent upon the development of factor markets.
	Donkor et al. (2023)	Hybrid	Formal rights with behavioral security indicators	Mixed	Investment reactions differ depending on the type of input.
	Akber et al. (2024)	Legal/Formal	Ownership security from national survey	Positive	Extensive study; institutional diversity within India
	Zheng (2024)	Legal/Formal	Stable property rights over time	Negative (fertilizer use)	Prolonged security redirects investment from short term inputs
Food security & poverty reduction	Santos et al. (2014)	Legal/Formal	Government-allocated land plots	Positive	Context of redistribution not comparable to market-based tenure
	Keovilignavong and Suhardiman (2020)	Perceived	Household perceptions of tenure security	Mixed	Significant influence of coping mechanisms beyond the tenure.
	Ekpodessi and Nakamura (2022)	Legal/Formal	Statutory land ownership	Positive	Dependent on market access and support from institutions.
	Dagdeviren et al. (2023)	Hybrid	Formal tenure with social protection context	Positive	Welfare outcomes facilitated by public services.

(Continued)

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TABLE 1 (Continued)

Agricultural outcome domain	Study	LTS measure type	Operational definition of LTS in the study	Functional relationship between LTS and outcome	Limits of comparability/ Institutional context
SDGs	Rashid (2021)	Legal/Formal	Land tenure security index	Positive	Effects are dependent on credit and policy integration.
	Mengesha et al. (2023)	Legal/Formal	Land registration and certification	Positive	Strong setting for state-driven reforms.
Climate change adaptation	Ullah et al. (2019)	Legal/Formal	Land ownership status	Positive	Risk management associated with access to formal financing.
	Murken and Gornott (2022)	Mixed (Review)	Combined evidence across formal, customary and perceived tenure frameworks	Mixed (Narrative)	Review study; conclusions were significantly context-dependent.
	Rampa and Levo (2023)	Legal/Formal	Tenure reform exposure associated with vegetation outcomes (NDVI proxy)	Positive	Indirect proxy; adaptability inferred rather than directly quantified
Soil–water conservation	Mariara (2007)	Perceived/De facto	Perceived tenure security	Positive	Customary methods incentivize conservation.
	Deininger and Ali (2008)	Hybrid	Overlapping legal and customary rights	Positive (Conditional)	Positive outcomes occur only when opposing arguments are resolved; uncertainty reduces investment motivation.
	Eskander and Barbier (2017)	Legal/Formal	Secure land ownership	Positive	Long-term investment dependent on tenure duration
	Adusumilli and Wang (2019)	Legal/Formal	Ownership vs. tenancy	Positive	Disparities between tenants and owners restrict comparability
Youth participation & employment	Chang et al. (2018)	Legal/Formal	Contracted land-use rights	Positive	The impacts of labor allocation were dependent upon off-farm markets.
	Akowedaho et al. (2022)	Legal/Formal	Statutory access to land	Positive	Context-specific entrepreneurial outcomes
	Msangi et al. (2024)	Legal/Formal	Formal land titles	Positive	The response of youth was reliant on complementary incentives.
	Tian et al. (2024)	Legal/Formal	Land certification	Positive	The impact of employment differs by gender and geographic region.

statistical precision. The pooled effect size was calculated using the inverse-variance weighted mean as following in Equation 1.

$$\bar{b} = \frac{\sum_{i=1}^{k} w_i b_i}{\sum_{i=1}^{k} w_i}, \tag{1}$$

where b_i = effect size (e.g., coefficients) for study i, $w_i = \frac{1}{SE_i^2}$ weight assigned to study i, inversely proportional to the variance (SE_i^2), and SE_i = standard error for study i, k = number of studies using both qualitative and quantitative approaches, through which two primary statistical measures I^2 statistic and the Cochran's Q test (Higgins and Thompson, 2002), were used to calculate the statistical heterogeneity. The Q statistic was calculated using the following Equation 2:

$$Q = \sum w_i \left(b_i - \bar{b}\right)^2 \tag{2}$$

Quantification of the percentage of observed variance was performed by calculating I^2 statistic, which reflects true differences in the effect sizes (Higgins et al., 2003). The formula used was as The formula used as given in the Equation 3 as following:

$$I^2 = \frac{Q - df}{Q} \times 100\%, \tag{3}$$

where Q was the Cochran's Q statistic and the df represents degrees of freedom (df = Total number of items minus one). Egger's regression test and funnel plots were used to evaluate publication bias (Egger et al., 1997). The comprehensive meta-analysis Version 3.0 and R statistical software version 4.1.0 with the 'metafor' package were employed for statistical investigations (Borenstein et al., 2009). Sensitivity was assessed by analyzing the forest plots (Figures 2–7), study weights, and funnel plots (Supplementary Figures 1–6) to detect outliers and low-precision estimations. No individual study was identified as predominant in the pooled results across outcomes. A formal leave-one-out sensitivity analysis was not performed due to the insufficient number of studies within outcome categories; this restriction was recognized in the interpretation of pooled outcomes.

Results

The quantitative meta-analysis investigates agricultural productivity, total farm investments along with particular investment components, and soil–water conservation techniques for which adequate comparable effect-size estimates were available. Additional outcome domains, such as food security, poverty alleviation, SDG linkages, climate change adaptation, and youth engagement, were addressed individually through a narrative synthesis due to the limited number of studies and heterogeneity in outcome descriptions. The forest plot depicted in Figure 2 was a representation of the meta-analysis that synthesized six studies that investigated the association between agricultural productivity and LTS in different geographic regions. Using a random-effects model, the analysis produced a pooled effect size of 0.32 with a 95% confidence interval (CI) ranging from 0.14 to 0.42. This moderate yet statistically significant effect indicated that stronger land tenure security was associated with higher levels of agricultural productivity, and the robustness of this positive relationship was further confirmed by the fact that the confidence interval does not include zero. However, the studies differ considerably in their outcomes, as reflected by the heterogeneity value (I^2 = 73.2%). This substantial heterogeneity suggests that actual differences between studies, not chance sampling error, may account for more than 70% of the observed variation in effect sizes. The Q-test result (Q = 24, p = 0.0001) reinforces this observation, revealing that variations among the studies are statistically meaningful. In simple terms, the strength of the relationship between land tenure security and productivity depends greatly on local conditions such as institutional quality, type of farming system, and research design, highlighting the fact that the connection was highly context-specific rather than universal. Despite the observed heterogeneity, the meta-analysis provides strong evidence for the positive relationship between LTS and agricultural productivity and efficiency, as reflected in the

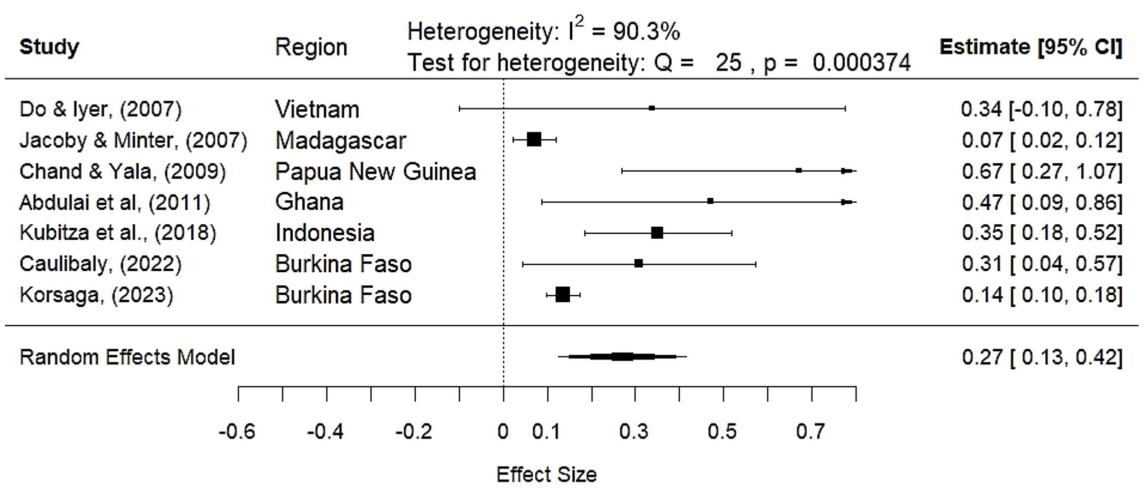

FIGURE 2
Pooled association between land tenure security (LTS) and agricultural productivity across empirical studies using a random-effects model.

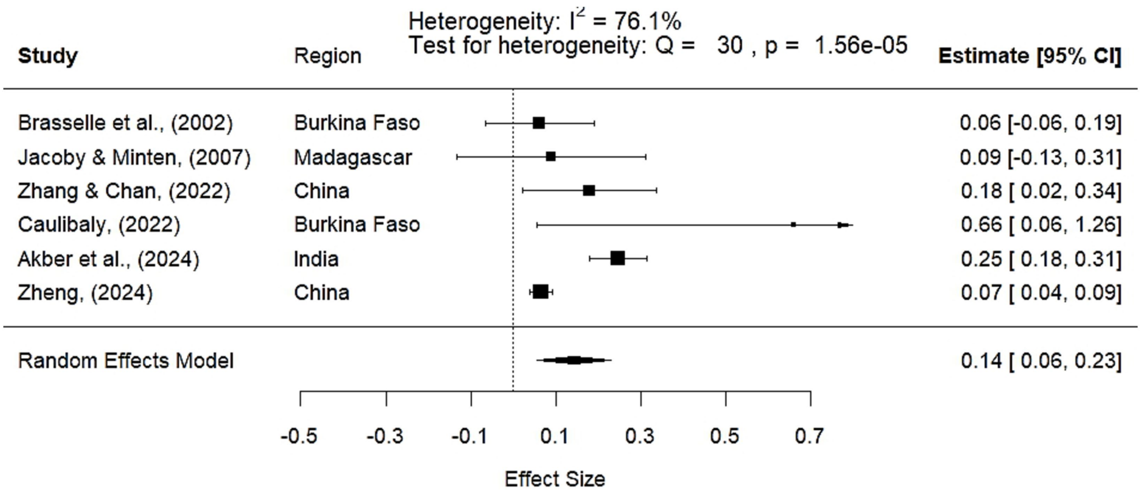

FIGURE 3
Pooled association between land tenure security (LTS) and overall agricultural investments under a random-effects framework.

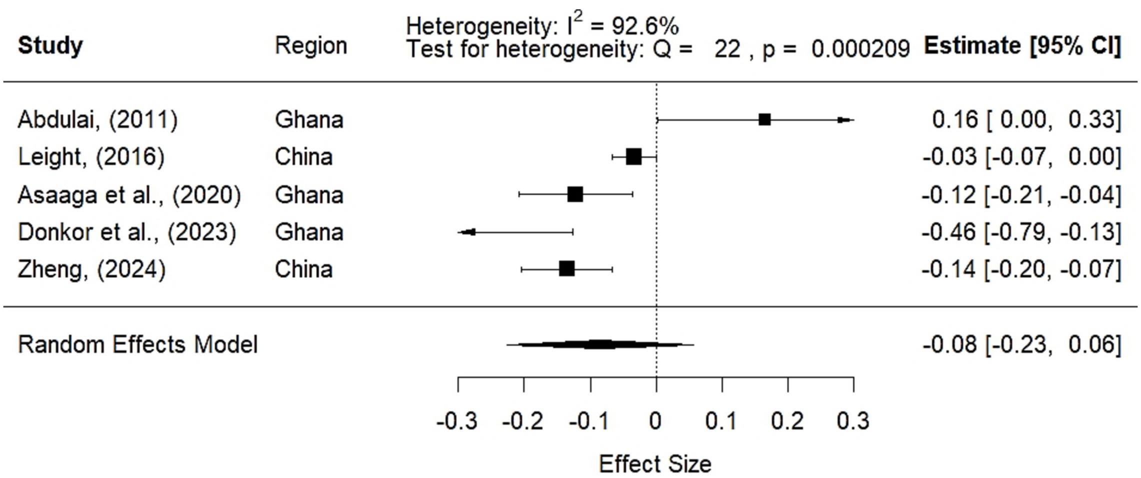

FIGURE 4
The association between land tenure security (LTS) and fertilizer expenditure indicates statistically heterogeneous and context-dependent effects.

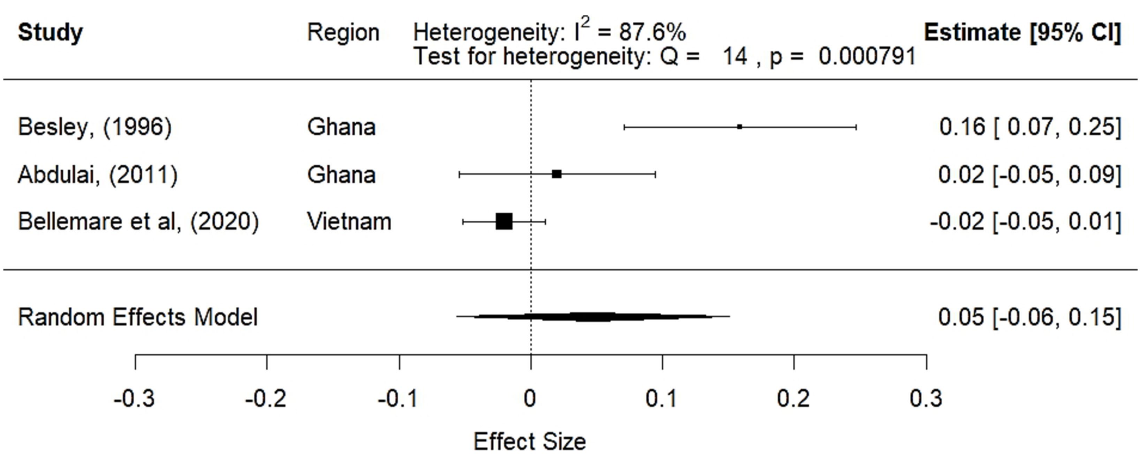

FIGURE 5
The pooled association between land tenure security (LTS) and irrigation investments highlights substantial cross-study heterogeneity.

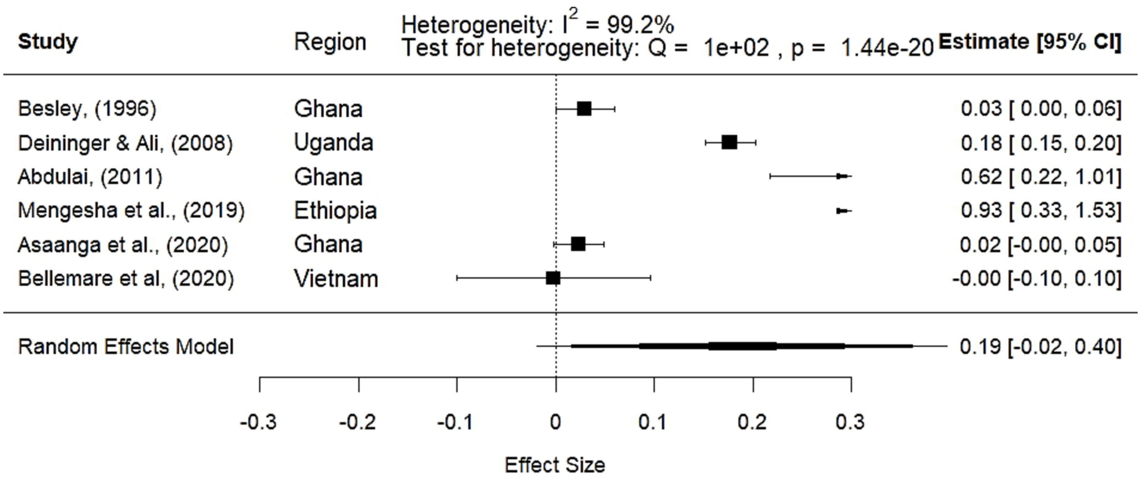

FIGURE 6
The association between land tenure security (LTS) and planting investments has non-significant pooled effects and high contextual variation.

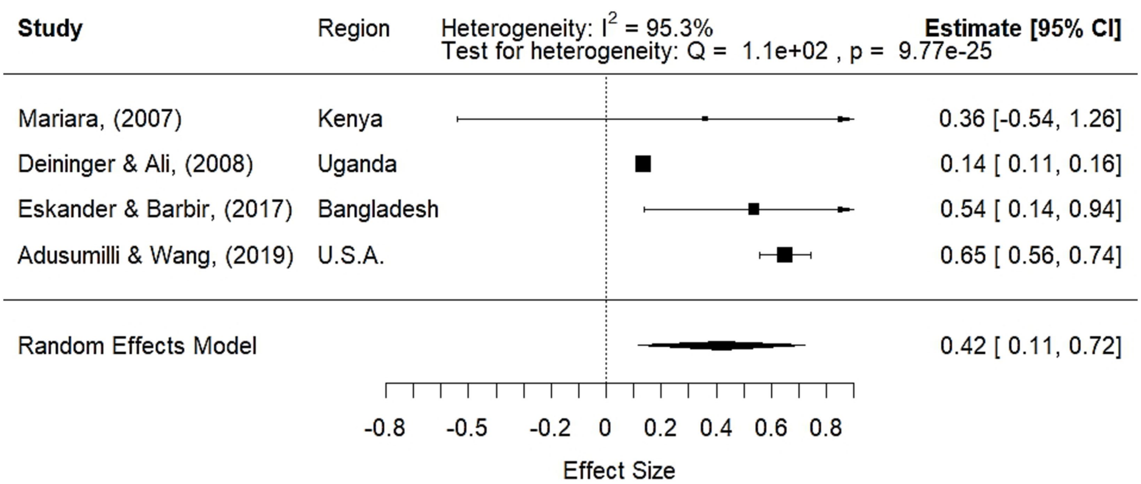

FIGURE 7
The pooled association between land tenure security (LTS) and the adoption of soil–water conservation practices across diverse institutional settings.

consistently positive direction of effect sizes across the studies and the significant pooled estimate.

As shown in Figure 3, the random-effects pooled effect sizes yielded a value of 0.14 (95%, *CI:* 0.06, 0.23), showing a relatively small but statistically significant positive relationship between LTS and agricultural investments. The confidence interval that does not include zero backs up this inference. The study identified substantial heterogeneity ($I^2 = 76.1\%$, $Q = 30$, $p = 1.56e\text{-}05$), suggesting potential significant contextual variations in the relationship between agricultural investments and LTS. The consistently positive effect sizes in the most recent studies, along with the large pooled estimate, suggest that improving LTS was associated with more resources being invested in agriculture, but its strength depends on various empirical settings of their geographic regions. The impact of LTS on farmers' expenditure on fertilizers was presented in Figure 4 by pooling the results from various regions. The overall effect size was insignificantly negative (−0.08; 95% CI: −0.23 to 0.06), indicating that, in general, more secure tenure tends to correspond with a marginally slightly lower fertilizer spending. However, this relationship was not statistically significant since the confidence interval that includes zero indicated that no consistent global association between land tenure security and fertilizer use can be established. Considerable variation exists across studies ($I^2 = 92.6\%$; $Q = 22$, $p = 0.0002$), implying that the differences were largely due to real contextual factors rather than random noise. In practice, this finding suggests that the influence oftenure security on fertilizer investment depends heavily on local conditions, such as crop type, market access, and credit availability, rather than following a uniform global pattern.

Figure 5 illustrates the pooled estimates for the relationship between land tenure security and irrigation investments. The results indicated that the combined effect size was modestly positive (0.05; 95% CI: −0.06 to 0.15), implying that secured land rights may encourage slightly higher spending on irrigation. However, this effect was not statistically significant, as the confidence interval crosses zero, suggesting that land tenure security alone does not systematically influence irrigation investments across contexts. Significant variation was observed across the studies ($I^2 = 87.6\%$; $Q = 14$, $p = 0.0008$), indicating that the influence of regional and study contexts varies considerably. This heterogeneity suggests that the influence of LTS on irrigation investments was not uniform but influenced by local institutional conditions, access to irrigation infrastructure, and regional water availability. The pooled outcomes of the assessment of how LTS relates to farmers' investments in planting activities are presented in Figure 6. The results indicated that the pooled effect size was positive (0.19; 95% CI: −0.02 to 0.40), suggesting that the secured land tenure encourages higher levels of investment in planting activities, but the relationship was not statistically significant as the confidence interval includes zero, indicating that the association between land tenure security and planting decisions remains context-dependent and cannot be generalized across regions. The analysis also revealed very high heterogeneity ($I^2 = 99.2\%$; $Q = 100$; $p = 1.44 \times 10^{-20}$), indicating that the results vary greatly across the regions and the study settings. These variations imply that the strength of the association between land tenure security and planting investments depends strongly on contextual influences such as local cropping systems, market access, institutional arrangements, and environmental conditions. This study suggests that a variety of factors, such as local farming practices, market accessibility, and environmental conditions, may have affected the extent to which LTS impacted planting decisions.

Figure 7 shows the meta-analytical investigation demonstrating that the LTS had a significant positive impact on the adoption of soil–water conservation methods by the farmers. The random-effects model shows a positive association between the investments in LTS and soil–water conservation, with a pooled effect size value of 0.42 (95% *CI*: 0.11, 0.72). The reliability of this estimate, which was shown by the relatively narrow confidence interval that does not include zero, provides strong evidence that tenure security had a consistently positive effect on conservation practices. The study shows that there were considerable amounts of heterogeneity ($I^2 = 95.3\%$, $Q = 1.1e+02$, $p = 9.77e\text{-}25$), which means that the relationship between the LTS and investments in soil–water conservation changes a significant degree depending on the context. The positive association was statistically significant and differed considerably across the regions, and this general trend indicates that increasing land tenure security may be responsible for boosting soil–water conservation investments. This finding suggests that factors that include local conservation practices, environmental conditions, and institutional support for sustainable agriculture may mitigate the effect of LTS on conservation investments. In all outcome domains investigated by quantitative synthesis, heterogeneity levels were persistently high (I^2 values often above 70% and in cases above 90%), signifying considerable genuine variation in effect sizes beyond mere sampling error. Although additional statistical decomposition via meta-regression or structured subgroup analysis by tenure type or institutional characteristics would be advantageous, such analyses were not statistically viable due to the limited number of studies within specific outcome categories and the uneven distribution of land tenure security measures across contexts. Thus, heterogeneity was presented as an empirical attribute of the findings, and pooled effect values were understood as average associations rather than consistent global effects.

The funnel plot illustrated in the Supplementary Figures 1–6 reveals no significant publication bias in the land tenure security's impact on the investments in agriculture (Egger test $p = 0.224$) and a notable publication bias in agricultural productivity (Egger test $p = 0.001$). This bias was most clear in three studies where the analysis showed big standard errors and effect sizes. This trend of bigger effects in less precise studies was in line with what other meta-analyses had found (Lawry et al., 2017; Higgins et al., 2008), which suggests that researchers tend to publish positive results. Similar publication bias was also found in planting investments depicted in Supplementary Figures 5 and no significant publication biases in fertilizer expenditures, irrigation investments, and soil–water conservation measures were illustrated in Supplementary Figures 3, 4, and 6 respectively.

Discussion

The fundamental economic principles pertaining to property rights and investment behavior can be reflected through the positive relationship between agricultural productivity and LTS (Njoroge et al., 2024). This positive relationship should be understood as an association rather than a causative effect, indicating the patterns identified primarily identified in observational studies. The identified association between agricultural productivity and LTS was often attributed in academic discussions to farmers' increased confidence in making long-term investment decisions rather than to a directly established causal link (Akber et al., 2024). Farmers possessing more secure land rights tend to be more inclined to undertake adjustments in production processes associated with enhanced productivity and efficiency outcomes (Besley et al., 2016). Significant heterogeneity across local contexts indicated disparities in tenure arrangements, institutional capability, and governance quality, emphasizing that these relationships were highly context-dependent rather than homogeneous (Deininger et al., 2011; Tesfaye et al., 2023): Ghana (Besley, 1995; Bugri, 2008; Abdulai et al., 2011; Donkor et al., 2023), Kenya (Mariara, 2007; Njoroge et al., 2024), Zimbabwe (Moor and Nieuwoudt, 1998), Southeast Asia (Michler and Shively, 2015), India (Banerjee and Ghatak, 2004; Paltasingh et al., 2022; Akber et al., 2024), China (Leight, 2016; Zhang and Chen, 2022), and Vietnam (Do and Iyer, 2008; Bellemare et al., 2020). Tenure security's productivity benefits are not independent, rather, they are significantly impacted by complementary elements such as technical support networks and credit availability (Carter and Olinto, 2003; Rashid, 2021), thereby underscoring the need for comprehensive institutional frameworks to optimize these benefits (Bromley, 2009). Significant variation across local contexts by the heterogeneity effect of various tenure arrangements (Deininger and Juan, 2004; Place, 2009; Lawry et al., 2017; Singirankabo and Ertsen, 2020; Zhang and Chen, 2022). Well-established customary tenure systems can offer adequate security to motivate farmers to invest in their land, contrary to the conventional view that formal land titling is absolutely essential, as argued by Place and Otsuka (2002). As Sjaastad and Bromley (1997) noted, tenure assurance can arise from multiple institutional settings, emphasizing the importance of locally grounded approaches to land governance.

The varying impacts of land tenure security across different forms of agricultural investment highlight important behavioral patterns among farmers. The association between LTS and agricultural investment differs by the form of investment rather than demonstrating a uniform causal effect (Donkor et al., 2023) as it tends to discourage spending on fertilizers (Leight, 2016; Asaaga et al., 2020; Donkor et al., 2023; Zheng, 2024), promotes investments in irrigation (Besley, 1995; Abdulai et al., 2011), land improvement (Besley, 1995; Donkor et al., 2023), and investments on planting activities (Besley, 1995; Deininger and Ali, 2008; Abdulai et al., 2011; Mengesha et al., 2019; Asaaga et al., 2020; Bellemare et al., 2020). These effects were not uniform across the world, as a wide range of contextual factors, such as cultural norms, political and institutional structures, market accessibility, economic conditions, historical legacies, population pressures, and the degree of local governance determine how tenure security influence the different types of investment (Besley, 1995; Place and Otsuka, 2002; Deininger and Jin, 2006; Jacoby and Minten, 2007; Goldstein and Udry, 2008; Holden et al., 2009; Fenske, 2015; Grimm and Klasen, 2015). These findings emphasize that policy relevance was rooted in acknowledging heterogeneity rather than supposing uniform investment responses to tenure security. Evidence consistently shows that long-term investments, particularly in land development and soil or water conservation, respond more strongly to secure land rights (Place and Hazell, 1993; Deininger and Jin, 2006; Mariara, 2007; Deininger et al., 2011; Eskander and Barbier, 2017; Adusumilli and Wang, 2019; Tesfaye et al., 2023). This pattern indicated an association between tenure assurance and investment horizons rather than strong causation evidence. When farmers feel confident about their tenure, they are more inclined to invest in practices that not only raise productivity but also preserve natural resources over the long term. These investments usually need long gestation periods, which indicates that having secure land rights was very important (Besley, 1995; Jacoby et al., 2002; Goldstein and Udry, 2008). Historical data from Costa Rica's tree crop sector supports this trend, showing that when property rights are secure, long-term agricultural investments grow significantly (Bandiera, 2007). Research conducted in different regions yielded comparable findings, indicating that formalized land rights resulted in increased long-term investments in perennial crops and soil conservation, as in Ethiopia (Holden et al., 2009; Mengesha et al., 2019) and Vietnam (Do and Iyer, 2008; Bellemare et al., 2020). Farmers' seasonal investment decisions were shaped by the risk perceptions and short-term financial constraints (Dercon and Christiaensen, 2011; Barrett and Carter, 2013; Karlan et al., 2014). The interaction between farmers' confidence in land ownership and their capacity to cope with liquidity limitations and production risks was reflected by the distinction that indicated tenure security exerts a stronger influence on long-term commitments, such as land improvement or conservation, than on short-term or seasonal investments.

This study employs the narrative synthesis instead of the quantitative meta-analysis as the limited number of qualifying studies and the variability of outcome measures prevented formal statistical aggregation. The relationship between LTS and food security was characterized as indicative and highly context-specific, with empirical proof indicating that improved land tenure security frequently corresponds with sustainable agricultural development, poverty reduction, and enhanced food accessibility rather than demonstrating a statistically pooled effect (Holden and Ghebru, 2016; Ekpodessi and Nakamura, 2022; Dagdeviren et al., 2023). Narrative evidence collected from multiple regions indicated that households with more secure land rights frequently experience enhanced nutrition and food accessibility, although these results significantly differ across institutional and socioeconomic settings (Santos et al., 2014; Ghebru and Holden, 2013). This connection highlights how tenure security strengthens both the economic and social foundations of food systems by promoting stability, encouraging investment, and supporting long-term livelihood resilience. It is not always evident how food security and LTS are related. Research indicates that farmers often devise alternative strategies to ensure food security when confronted with uncertainties over their land tenure (Keovilignavong and Suhardiman, 2020). This adaptive response varies greatly across different socioeconomic circumstances, with some communities exhibiting remarkable resilience through community management systems (Santos et al., 2014; Sibhatu and Qaim, 2017). The gender-specific impacts of tenure security on food security outcomes further emphasize the need for incorporating intersectional issues in land governance reforms (Doss et al., 2014; Dzanku, 2019). Doss et al. (2014) point out that women's legitimacy over land and productive assets was associated more significantly with household food intake and dietary diversity than mere household ownership, emphasizing intra-household disparities in allocation of resources. Dzanku (2019) demonstrated that the benefits of food security derived from land access differ systematically by gender, with female-managed plots often converting land rights into consumption stability more efficiently than male-managed plots. These findings suggest that tenure security most effectively improved food security when women's land rights were expressly acknowledged rather than implicitly presumed within household tenure structures. Secure land rights were often highlighted in the literature as an essential resource for attaining specific Sustainable Development Goals (SDGs); however, the intensity and mechanisms of these relationships vary across different policies and institutional contexts (Rashid, 2021; Childress et al., 2022; Fletschner et al., 2022). Consequently, SDG-related linkages should be understood as facilitating relationships rather than the direct outcomes of tenure security measures. Initiatives for land titling emerged as a calculated measure to achieve sustainable development objectives. In the Ethiopian context, enhanced tenure security had been specifically associated with advancements in certain Sustainable Development Goals (SDGs), particularly those concerning poverty alleviation (SDG 1), zero hunger (SDG 2), gender equality (SDG 5), and protecting life on land (SDG 15) (Mengesha et al., 2023). Environmentally sustainable farming practices and resource management behaviors were also strongly influenced by the secured land rights (Bugri, 2008; Mengesha et al., 2019). A growing body of narrative evidence indicated that secure land tenure was associated with greater adoption of sustainable land management practices, such as soil conservation, agroforestry, and organic farming, though the extent of these effects differs across agro-ecological and institutional contexts (Mariara, 2007; Teklewold et al., 2013). Evidence from Ethiopia and other regions shows that stable land tenure promotes greater environmental stewardship and encourages long-term investments in land enhancement (Kassie et al., 2015; Adere et al., 2022; Olumba et al., 2024). These studies collectively suggest that, when farmers perceive enhanced tenure security, they are more likely to adopt conservation-oriented strategies, yet such responses are context-dependent and influenced by institutional factors.

The interaction between the adaptation to climate change and the LTS was more complex and equally important. Narrative evidence indicated that agricultural systems with secure land rights may have enhanced resilience to climatic stress, as evidenced by particular investigations and reviews (Murken and Gornott, 2022). Furthermore, under unfavorable weather conditions, farmers possessing more secure land rights tend to sustain relatively robust farming systems, as indicated by vegetation-based indicators, but these conclusions were not based on aggregated statistical estimations (Rampa and Levo, 2023) and also suggest that tenure security not only supports improved vegetation growth but also enhances the adaptive capacity of farming systems. Narrative evidence indicated that LTS is associated with climate adaptation and conservation activities, although these associations vary significantly between agro-ecological zones and were not based on aggregated statistical analysis. The ownership status of the tenant farmers often depends on traditional coping mechanisms, whereas landowners were better positioned to access institutional credit and formal financial tools to manage climate-related risks, leading to marked differences in risk management strategies (Adusumilli and Wang, 2019; Ullah et al., 2019; Adere et al., 2022). Complementary factors that were essential to fully realize the environmental benefits of tenure stability include the adoption of sustainable technologies, access to climate information services, and active participation in agricultural extension programs, which were emphasized by the recent studies (Abab et al., 2023; Olumba et al., 2024). The study also found that the farmers with secure land rights were more likely to invest in sustainable water management and soil fertility enhancement (Abab et al., 2023; Olumba et al., 2024). Collectively, these narrative findings indicated that land tenure security can serve as a facilitating factor for sustainable and resilient agricultural systems, especially when paired with supplementary institutional support rather than functioning as an isolated determinant of climate resilience. By encouraging youth participation in agriculture, secured land rights play an important role in broader rural economic development. Narrative evidence from nation-specific research indicated that secure land rights may be associated with motivating young participation in agriculture; however, these impacts were significantly influenced by labor market conditions and regulatory frameworks (Msangi et al., 2024). Merely ensuring secure tenure was inadequate for retaining youth in agriculture when structural barriers remain. Youth-related outcomes should be regarded as suggestive and necessitate incorporation into comprehensive rural employment initiatives. The study conducted in China was on the rural land contracting reforms, which led to a significant increase in rural employment by 4.6% for men and 6.6% for women, as well as sharp increases in off-farm employment, which was up by 39.4% for women and 29.4% for men (Chang et al., 2018). Recent land certification initiatives among households receiving certification for the first time have produced comparable benefits by increasing off-farm employment by approximately 8%, with even greater gains (Tian et al., 2024). Additional case-based evidence indicated that formal land documentation may enhance agricultural entrepreneurship and long-term livelihood security; nevertheless, these results were context-dependent rather than universally applicable (Akowedaho et al., 2022).

Based on the findings of the study, we further developed a conceptual framework, as shown in Figure 8, that depicted several ways that land tenure security influences agricultural performance. Our meta-analysis results led to the development of this paradigm, which encompasses both the immediate relationships and the contextual factors that regulate them. Our approach identifies four major intermediary mechanisms, such as land markets, investment incentives, risk perception, and credit availability, through which LTS influences agricultural outcomes. The fact that these parts often work together instead of separately led to the development of interactions between these processes, which were shown by the lines that connect them in our framework. For instance, people who believed that they had less risk were more likely to invest when they had better access to money. One important finding that our method captures was that LTS had different effects on different types of agricultural investments. Our meta-analysis showed that LTS was positively related to most types of investment, such as planting, irrigation, and soil–water conservation practices. However, it was also strongly negatively related to fertilizer spending. This variation in investment responses refers to a pattern that has yet to be adequately addressed by recent studies: farmers with secure land tenure may place a higher priority on long-term investments than on short-term inputs. Additionally, the framework highlights the importance of local and regional settings, which were represented at the highest level. Our study found substantial discrepancies in LTS impacts across different studies, which we ascribe to diverse market, political, socioeconomic, and contextual factors. For example, the strength of the association between LTS and agricultural investments changed a lot depending on the rules and the state of the local credit market. The bottom layer of our framework shows how these different investments come together to make farming more efficient and productive, which in turn leads to agricultural growth. Our results, on the other hand, show that this path was not always the same and was affected by things that were specific to each region. The study enhances our understanding of how local contexts shape the success of such initiatives, emphasizing that institutional strength, social dynamics, and environmental conditions collectively determine their effectiveness in influencing agricultural investments, which helps us to clarify why similar land tenure security programs yield different results across regions. This analysis highlights the importance of designing policies that are responsive to regional circumstances rather than relying on a standardized one-size-fits-all framework by providing a comprehensive evaluation of the association between tenure security and agricultural development.

Conclusion and policy implications

The variations in the influence of LTS on various agricultural development outcomes across regions and contexts were revealed by this meta-analysis encompassing 35 empirical studies. The high degree of statistical heterogeneity confirmed that these effects differ and are shaped by differences in institutional quality (such as land administration and legal enforcement), socioeconomic structures (credit access and market integration), environmental conditions (agro-ecological systems and climate variability), and cultural factors (customary practices and gender norms). The positive effects of LTS on agricultural productivity were primarily pronounced in regions with well-developed institutional support, effective governance, and accessible market conditions that together create an enabling environment for farmers to invest confidently in long-term agricultural improvements, highlighting that these results were contextual rather than universally applicable. Moreover, farmers with secure land rights consistently demonstrate a greater willingness to invest in their farms, underscoring the critical role of tenure security in fostering long-term agricultural growth and sustainability. The

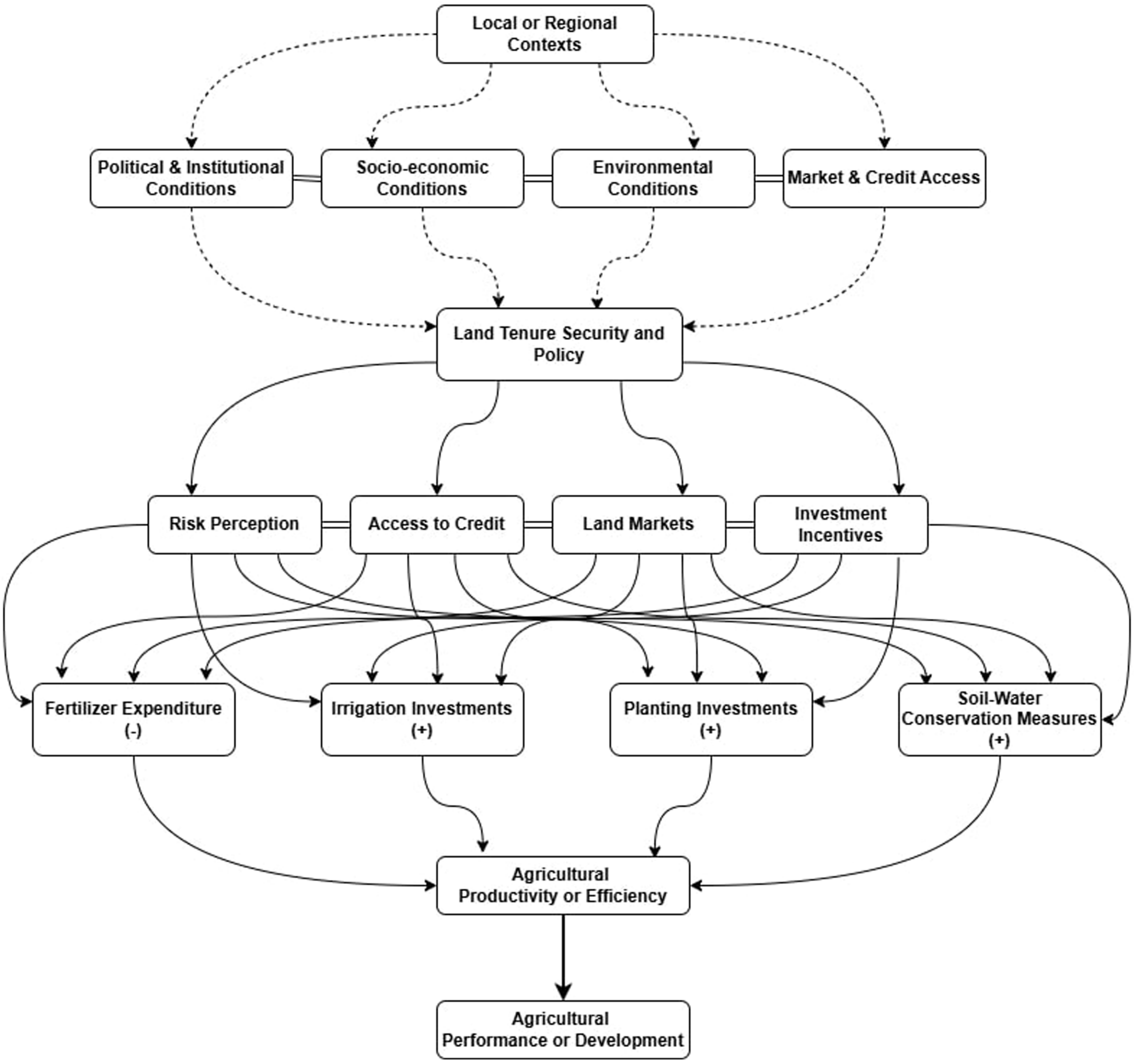

FIGURE 8
Conceptual framework of the relationship between the LTS and agricultural performance.

extent and orientation of these relationships were significantly influenced by supported institutional and financial conditions. The discussion on food security and poverty alleviation outcomes was based on a narrative synthesis rather than a quantitative meta-analysis. Existing evidence indicated generally positive relationships between LTS and household welfare; however, they were highly context-specific and sensitive to market integration and social support systems. In particular, LTS tends to work much better in places where agricultural markets were strong and social support systems were stronger. Narrative evidence indicated that LTS is associated with climate change adaptation and soil conservation measures; however, the intensity and direction of these associations differ significantly between agro-ecological zones and were not based on aggregated statistical estimations. The determinants of the impact of tenure security on the sustainable farming practices were the local environmental conditions, and the presence of conservation incentives plays a crucial role. The association between land tenure security and young participation in agriculture was derived from a limited number of context-specific studies revealing significant variability influenced by local economic prospects, social ambitions, and cultural conventions rather than a consistent global pattern.

The principal findings of this study that yielded significant policy implications for practice were that reforms to land tenure must be carefully designed to fit the needs of each area, taking into account the current institutional frameworks and systems that help farmers. To maximize the benefits of tenure security, it was important to make additional investments in agricultural infrastructure and support services. Strategies for implementation should be different in different places, especially in places where the institutional framework is weaker. These are programs that protect people's homes, taking into account local ecological conditions and traditional ways of doing things, while combining with environmental conservation efforts. Policy recommendations ought to avoid one-size-fits-all approaches and instead consider differences in governance capacity, institutional maturity, and market integration. Due to the inconsistent evidence underpinning across outcome domains, policy suggestions concerning food security, climate resilience, and youth participation should be considered suggestive and contingent rather than as universal directives. The limitations of our investigation, such as the comparatively limited number of studies that met all inclusion requirements and sensitivity analyses, indicated strong overall results. To understand further how the effects of LTS change over time and interact with other agricultural development interventions, future research should concentrate on long-term longitudinal studies.

Author contributions

BM: Visualization, Software, Writing – original draft, Conceptualization, Methodology, Formal analysis, Writing – review & editing. EK: Data curation, Writing – review & editing, Visualization, Validation. SR: Validation, Writing – review & editing, Investigation. PS: Validation, Writing – review & editing, Data curation. SK: Writing – review & editing, Supervision, Methodology, Conceptualization. VK: Project administration, Conceptualization, Writing – review & editing, Supervision. PP: Writing – review & editing, Project administration, Supervision.

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Conflict of interest

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2026.1752236/full#supplementary-material

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