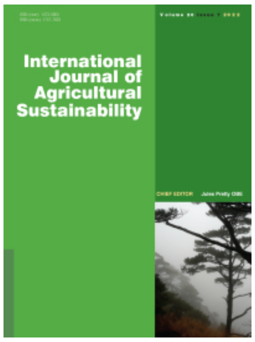

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Identifying critical incentives for scaling out the adoption of agroecological practices–a systematic review of Peruvian cacao value chains

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ABSTRACT

The growing global importance of agroecology highlights the pivotal role public and private sectors play in providing incentives and investments to catalyze behavioural changes and transform food systems. However, limited research exists on incentives for scaling agroecological practices in cacao value chains. This study employed a systematic review approach, focusing on Peruvian cacao sector, to explore incentives promoting agroecological practices and their sustainability outcomes. Findings reveal that within Peru's cacao value chains, non-market incentives constitute the majority (36%), followed by regulatory measures (25%), market-based incentives (22%), and cross-compliance incentives (17%). Main providers of incentives include certification bodies, community-based organizations, and international funding organizations. Effective incentives include sustainability standards, market support subsidies, in-kind rewards, and agroecological schemes that support the adoption of practices such as intercropping, nature conservation for carbon sequestration, and the use of green and animal manure. These incentives have significantly improved sustainability outcomes: economic (39%), environmental (33%), and social (28%). However, limited use of cross-compliance incentives and modest emphasis on social outcomes highlight the need for policy instruments targeting the adoption of agroecological practices within cacao sector. This study provides insights for policymakers, development agencies, and private-sector to design effective incentivesfor advancing agroecological transitions in Peru and beyond.

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Agroecology; cacao value chain; incentives; transitions; sustainability; private sector; systematic review; Peru; cocoa

1. Introduction

Agrifood systems currently face multiple challenges, including environmental, economic, social, and political changes. Recent studies have identified vital environmental challenges, such as climate change, biodiversity loss, water pollution, and deforestation, affecting agri-food systems (Mockshell & Villarino, 2019; Piñeiro et al., 2020). These challenges coincide with pressing social problems, such as farmer marginalization, malnutrition, child labour, and adverse working conditions (Meemken et al., 2021; Mockshell & Villarino, 2019). Such crises constrain agri-food systems progress towards key Sustainable Development Goals (SDGs), such as eradicating hunger

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(SDG2), reducing inequalities (SDGs 5 and 10), mitigating the effects of climate change (SDG 13), and conserving natural resources (SDGs 12 and 13). Current research emphasises that addressing these multifaceted challenges necessitates a fundamental shift from unsustainable practices to more sustainable food systems with minimal environmental impacts and reduced social risks (Altieri & Nicholls, 2012; Bezner Kerr et al., 2021).

Agroecological approaches offer a promising solution to these challenges by optimizing natural resource utilization and minimizing the use of external inputs to enhance sustainability (Gliessman, 2014; Jones et al., 2022). The adoption of agroecological principles and the scale-up of this transition, whether at the farm, community, or national level, require incentives and investments to encourage and compel actions associated with adopting agroecological practices and commercializing agroecological production systems (Bunn et al., 2017; Piñeiro et al., 2020). Incentives and investment mechanisms play a significant role in influencing the decisions and actions of stakeholders in food systems, leading to transitions toward agroecological practices. Incentives catalyze changes in food systems, in terms of stakeholders' decisions and actions, while investments furnish the required resources to achieve desired outcomes (Bunn et al., 2017). Scholars have developed typologies to analyze different incentive mechanisms, including market-based, non-market, regulatory, and cross-compliance instruments (Bulman et al., 2021; Piñeiro et al., 2020).

In this review, the terms 'agroecological practices' and 'sustainable agricultural practices' have been used interchangeably. However, while agroecological practices incorporate ecological principles into the holistic design and management of agricultural systems, sustainable agricultural practices focus more on adopting farming methods and technologies to minimize environmental impacts while maintaining productivity and profitability (Ewert et al., 2023). Furthermore, we discuss 'agroecological production' and 'organic production', recognizing that while they are not identical, they share many common principles and practices. Both approaches emphasize sustainable farming methods, environmental conservation, and the reduction of synthetic inputs (see Mockshell & Kamanda, 2018). Agroecological production focuses on the ecological relationships within agricultural systems, promoting biodiversity, soil health, and ecosystem services (FAO, 2019), and organic production, on the other hand, adheres to specific certification standards that prohibit the use of synthetic pesticides and fertilizers (Escobar et al., 2019).

The impacts of public-sector incentives, such as payments for ecosystem services, subsidies, credit access, and tariffs, on food systems have been well-documented in the literature (Giraldo & McCune, 2019; Montoya-Zumaeta et al., 2021; Nicholls & Altieri, 2018). For instance, the provision of public goods has been employed as a cross-compliance instrument within the agricultural policy frameworks of the European Union (EU) and the United States (US). In these contexts, cross-compliance links agricultural subsidies to farmers' adherence to specific environmental conditions (Meyer et al., 2014). Additionally, Giraldo and McCune (2019) have observed that public policies have played a pivotal role in the scaling up of agroecological practices in Latin America. These government incentives towards agroecology initiatives can produce both positive and negative outcomes. Positive outcomes include environmental conservation (Montoya-Zumaeta et al., 2021), building resilience to shocks and increased average incomes for family farms practicing agroecology through public procurement programmes (Nicholls & Altieri, 2018). However, as noted by Nicholls and Altieri (2018), some public policies can create dependencies that may weaken farmers' intrinsic motivation to adopt agroecological practices. For instance, while access to credit as an incentive to farmers could promote the adoption of agroecological practices, it is frequently correlated with a rise in the use of agrochemicals (Nicholls & Altieri, 2018). In contrast, the role of private-sector incentives and investments in driving agroecological transitions remains poorly understood (Jones et al., 2022; Piñeiro et al., 2020; Tristán et al., 2022), pointing to the need to comprehensively examine the effect of incentives on the adoption and sustainability of agroecological practices.

This study aims to address this gap by investigating the intricate relationships between incentives, the adoption of agroecological practices, and sustainability outcomes within Peru's cacao value chain. Peru is a major player in the global cocoa market, having experienced remarkable growth in the cacao industry in recent years, which has strengthened its position in the global cocoa market (Rojas-Briceño et al., 2022). Peru's strong commitment to sustainable, high-quality production practices, including the cultivation of organic fine-flavored cacao, has positioned the country as the world's second-largest organic cocoa producer (Scott et al., 2015; Tristán et al., 2022). These factors make Peru's cacao value chain a focal point for substantial agroecological investments and incentives, aimed at boosting cacao productivity and quality, enhancing farmers' socioeconomic well-being, and generating positive environmental outcomes. Understanding the interplay of public- and private-sector incentives in this context can provide insights to guide strategies for agroecological transitions in other commodity sectors.

This review employs the incentive classification framework proposed by Piñeiro et al. (2020) to analyze Peru's cacao value-chain incentives. Incentives are measures or mechanisms used by governments or private partners to influence investors (such as smallholder farmers) toward different actions, potentially leading to new or expanded practices, for example, to support the adoption of agroecological practices (Bulman et al., 2021). According to Piñeiro et al. (2020), incentives are classified into four main categories: market-based, non-market, regulatory, and cross-compliance.

Market-based incentives encompass a wide range of approaches, including financial support, price signals, input subsidies, grants, loans, compensation, income transfers, or other incentives designed for farmers. Non-market incentives encompass technical assistance, technology transfer, business support, and measures such as energy pricing, taxes, research and development, and extension services. Regulatory measures involve specific policies and standards enforced by either governments or private entities to enforce better practices that may be favourable to smallholder producers. Cross-compliance incentives, on the other hand, encourage farmers to adopt a specific environmental practice in exchange for government support. Cross-compliance mechanisms have been employed as incentive structures within the EU, facilitating the provision of public goods and consequently broadening environmental protection initiatives (Meyer et al., 2014). These incentive typologies provide a foundation for analyzing how different mechanisms shape stakeholder decisions and actions towards agroecological transitions. This review employs the above-mentioned incentive classification framework (Piñeiro et al., 2020) to analyze the incentive structures critical for shaping strategies that promote the adoption of agroecological and sustainable agricultural practices within the Peruvian cacao value chain.

This systematic review envisions incentives that catalyze the adoption of agroecological practices in Peru's cacao value chain, fostering positive economic (e.g. increased yields/quality, profitability, and market access), environmental (e.g. reducing deforestation, improving soil carbon, and reducing soil degradation), and social (e.g. improved livelihoods, youth engagement,

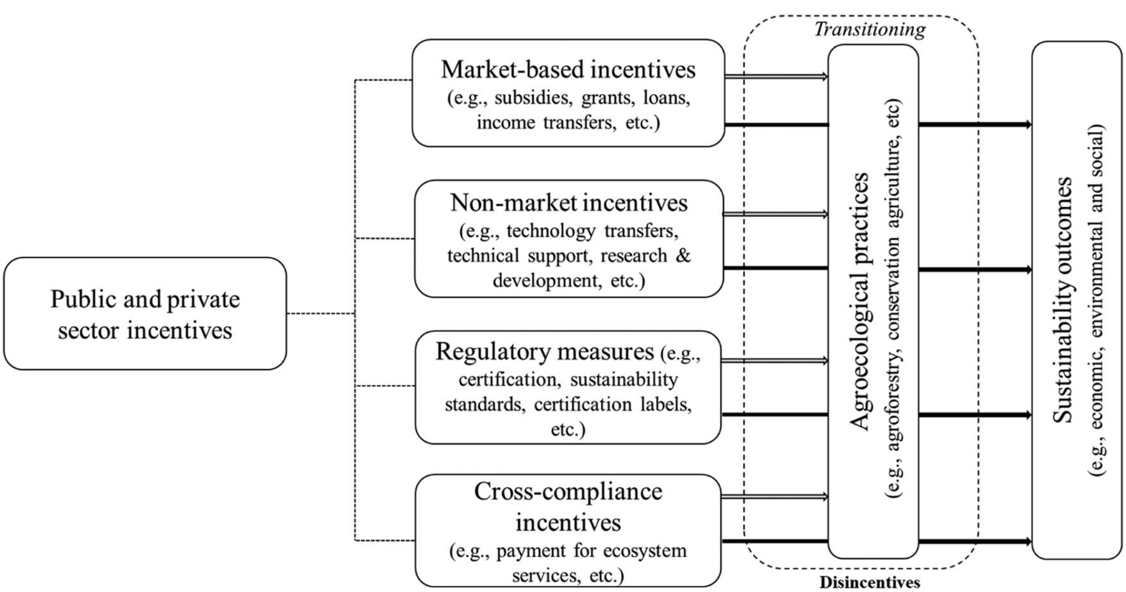

Figure 1. Incentive types, agroecological practices, and outcomes typology. Source: Adopted from Mockshell et al. (2023).

gender inclusion, poverty reduction, and food security) outcomes as illustrated in Figure 1. The agroecological transition is a shift from conventional and input-intensive practices to holistic sustainable and ecology-driven practices (FAO, 2019). Agroecological transition aims to enhance the resilience, biodiversity, and environmental stewardship of agricultural landscapes, while maintaining or improving agricultural productivity and providing ecosystem services (Escobar et al., 2019). The review also explores potential disincentives that may hinder public- and private-sector collaboration in promoting agroecological and sustainable agricultural practices (see Figure 1).

2. Methodology

This section details the methodology applied in the literature review, which includes a systematic process for identifying, selecting, evaluating, and extracting data from relevant primary research on incentives and investments within the Peruvian cacao value chain. The approach employed is designed to ensure a comprehensive and rigorous analysis of the available literature.

2.1. Evidence synthesis methodology and protocol pre-registration

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, which offer a comprehensive framework for reporting systematic reviews (Page et al., 2021). The PRISMA 2020 statement encompasses a 27-item checklist designed to suit mixed-methods systematic reviews that incorporate both quantitative and qualitative studies (Page et al., 2021). In this study, PRISMA 2020 guidelines were employed for manuscript selection and to establish eligibility and screening criteria. The primary focus of this systematic review was to investigate incentives facilitating the transition of Peruvian cacao value-chain farmers from conventional practices to agroecological food systems.

2.2. Information sources, searches, and citation management

The study implemented a comprehensive search strategy to emphasize pertinent research pertaining to public- and private-sector incentives and investments that support the transition to agroecological food systems within the cacao value chain in Peru. To extract text from the reviewed manuscripts, we utilized text summarization techniques. This process involved identifying and selecting key sentences or phrases from the papers, and then creating concise summaries through interpretation and rewriting of relevant content. The search strategy comprised specific search terms and query strings, encompassing the core concepts aligned with our research inquiry. These concepts included agroecology, sustainable agriculture, biodiversity conservation, climate change, incentives, investments, subsidies, transitions, cacao, cocoa, and Peru. For further insight, Table 1 provides details of the search strategy. The study employed a comprehensive approach to data collection, drawing from three main databases: Google Scholar, SCOPUS, and CAB Abstracts. Additionally, researchers included relevant grey literature from institutions' websites and search engines to complement the empirical data sources.

2.3. Study selection and eligibility criteria

The study selection process was meticulously conducted using an Excel spreadsheet to systematically organize the chosen manuscripts derived from the various databases. After the removal of initially ineligible and duplicate papers, the titles and abstracts of the remaining papers were scrutinized to confirm

Table 1. Summary of databases, search terms, and results.

Database	Search term
Google Scholar	Transitions OR Agroecology OR sustainable agriculture OR conservation agriculture OR biodiversity conservation OR climate change OR climate-smart agriculture OR subsidies OR incentives and investments 'private sector incentives' OR 'public sector incentives' OR 'agroecology' Cocoa OR Cacao
SCOPUS	(ALL ('transition*' OR 'agroecology' OR 'agroecological' OR 'sustainable agriculture' OR 'conservation agriculture' OR 'biodiversity conservation' OR 'climate change' OR 'climate-smart agriculture' OR 'incentive*' OR 'investment*' OR 'subsid*') AND ALL ('Cocoa' OR 'cacao') AND ALL('Peru'))
CAB Abstracts	(('agroecology' OR 'agroecological' OR 'sustainable agriculture' OR 'conservation agriculture' OR 'biodiversity conservation' OR 'climate change' OR 'climate-smart agriculture' OR 'incentives' OR 'investments' OR 'subsidies' OR 'transitions') AND ('Peru') AND ('cocoa' OR 'cacao') AND yr: [2012 TO 2022])
Publication year	2012–2022

their eligibility. Subsequently, two researchers independently assessed the full texts of the remaining manuscripts to determine whether they met the criteria for inclusion or exclusion. In cases of conflicting assessments, the researchers engaged in further discussion to reach a consensus regarding the inclusion or exclusion of the paper from the review.

The inclusion criteria were comprehensive and finely tuned to ensure a coherent connection between incentives, agroecological practices, and sustainability outcomes. These linkages relied on human judgment, as they could not be entirely captured through the search strategy alone. Following the strategy by Piñeiro et al. (2020), the authors conducted an evidence-based assessment to understand and evaluate the evidence used to support the incentive, adoption, and outcome logic. A team of authors carried out a subjective assessment to score each study according to the strength of evidence presented. Each paper was scored based on specific incentives, agroecological practices adopted, and outcomes, including economic, environmental, and social factors. It is important to note that some papers were included in more than one category, as they encompassed multiple incentives, practices, and/or outcomes.

The eligibility criteria encompassed the following:

(i) Studies published between 2012 and 2022.
(ii) Studies explicitly centred on incentives and investments related to agroecological practices or sustainable agricultural practices.
(iii) Studies with a distinct focus on the adoption of agroecological or sustainable agricultural practices.
(iv) Studies that explicitly established a connection or linkage between the adoption of agricultural practices and sustainability outcomes.
(v) Studies that specifically analyzed the impact of incentives and investments on aspects such as income, production, productivity, profitability, and environmental sustainability.
(vi) Original research, including qualitative and quantitative reports, as well as reviews of existing research, encompassing grey literature associated with the aforementioned criteria.
(vii) Availability of the full text in either English or Spanish.[1]
(viii) Peer-reviewed papers, dissertations/theses, academic books, or grey literature from reputable institutions with a track record of producing reliable research.

Adherence to these specific selections and eligibility criteria enabled the researchers to retrieve information exclusively from manuscripts that were relevant to the research.

2.4. Data extraction and data items

Upon finalizing the selection process, pertinent data related to the subject matter of the study, publication year, publishers, incentive categories, investment mechanisms, agroecological practices, and private-sector collaborators were systematically extracted. The names of the authors and the titles of the publications were meticulously recorded to prevent any potential duplication or redundancy. The incentives, including investment incentives, were categorized into market-based, non-market-based, regulatory, and cross-compliance incentives. The outcomes were evaluated in terms of their impact on various sustainability objectives, encompassing environmental conservation, economic equilibrium (e.g. enhanced yields and profitability), and social well-being (e.g. better livelihoods, poverty reduction, and greater food security).

3. Results

In this section, we present the findings derived from the analysis of the stakeholder landscape, incentives, and their interrelation with the adoption of agroecological practices, culminating in transition outcomes within Peru's cacao sector.

3.1. Overview of the reviewed literature

Our search across academic databases yielded a total of 1,741 papers, with contributions from Google Scholar (857 papers), Scopus (825 papers), CAB Abstracts (46 papers), and grey literature sources (12 papers). Thirteen papers were identified as duplicates, and 1,642 papers were either inaccessible or excluded from the review based on the initial title screening (Figure 2). Subsequently, a comprehensive evaluation of abstracts and full texts was conducted for 134 papers, resulting in the exclusion of 49 papers that were either unrelated to the fields of agroecology in Peru or were inaccessible. The remaining 88 papers underwent an additional assessment for quality,

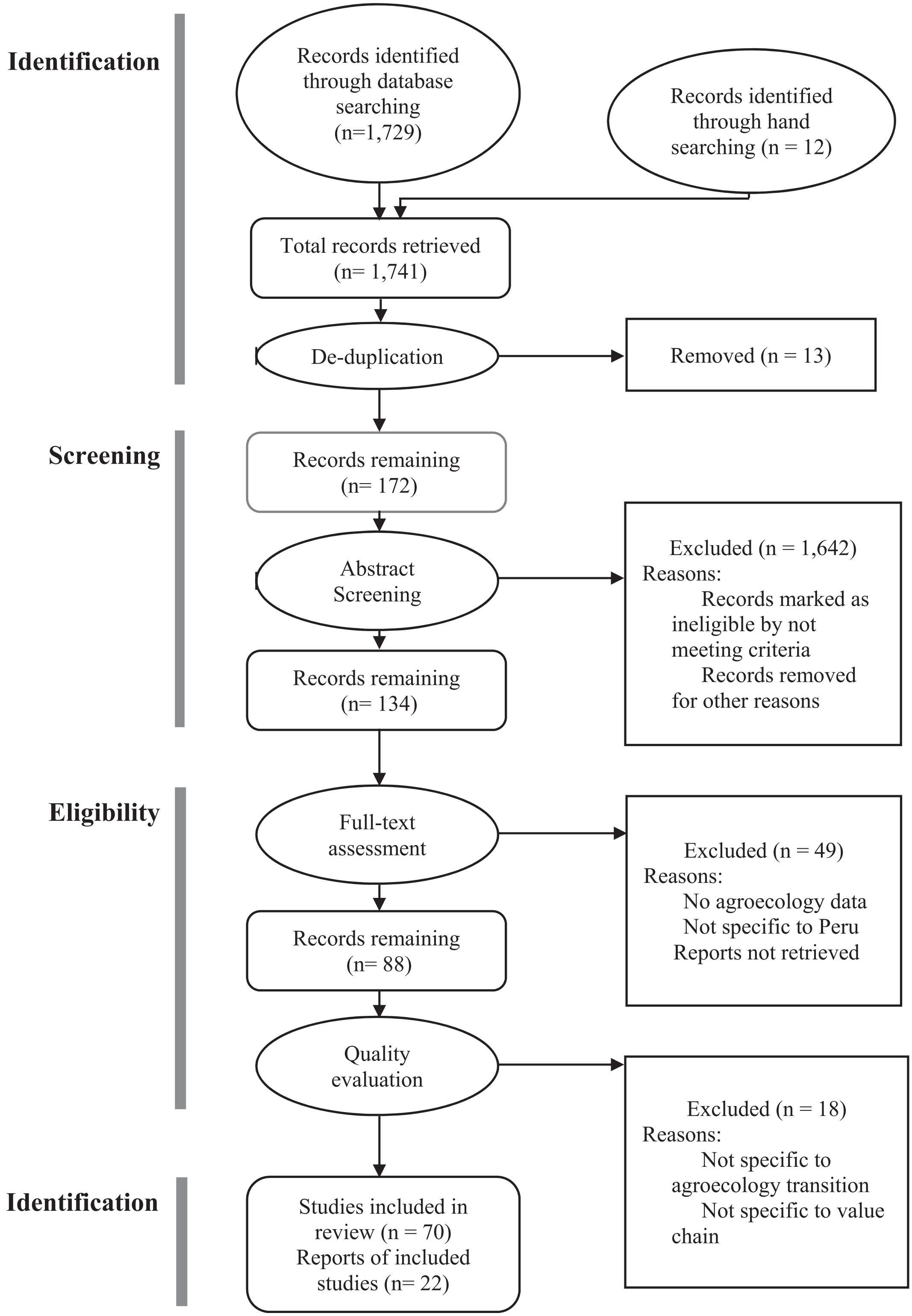

Figure 2. PRISMA flow diagram highlighting systematic approach for data collection and analysis.

leading to the exclusion of 18 papers that did not specifically pertain to agroecology or the cacao value chains. Thus, a total of 70 papers focusing on the intersection of agroecology and cacao value chains remained (see Appendix 1). From this subset, a final selection of 22 papers, which specifically address Peru's cacao value chain and agroecology were included in the review (Table 2).

The subset of 22 papers (Table 2) facilitated a detailed investigation of the relationships between agroecological practices, incentive mechanisms, and sustainability outcomes. Of the 22 papers analyzed, 18 (81.8%) were peer-reviewed publications, two (9.1%) were research Info Notes from CGIAR, one (4.5%) was a conference paper, and one (4.5%) was a working paper (Table 2). Each manuscript contained empirical evidence linking either (1) incentives and agroecological practices, and/or (2) agroecological practices and sustainability outcomes. For each paper, the researchers systematically identified the types of incentives employed, documented the farmers' adoption of various agroecological approaches as described in the literature, and recorded the corresponding sustainability outcomes as a function of the implemented incentives.

The bibliometric analysis of the publications on agroecology-related topics pertaining to Peru's cacao value chain revealed a progressive increase from one in 2014 to seven publications in 2022, with the years 2017, 2021, and 2022 exhibiting the highest annual publications rates (Table 2). The thematic analysis of the title and abstract screening within agroecological subject areas identified recurrent themes, including cacao agroforestry systems, cacao cooperatives, cacao incentive initiatives, agroecological movements, and cacao genetic diversity (Table 2). Additionally, other subject areas were identified during the initial screening stages, such as climate-change impacts, environmental and social sustainability, carbon sequestration and greenhouse gas (GHG) emissions, agroecology scaling up and deforestation-free value chains (Table 2).

The systematic review analyzed 22 papers exploring the connections between incentives, agroecological practices, and associated outcomes in Peru's cacao sector. The papers were distributed across several focus areas: 39% examined the linkages between incentives, agroecological practices, and the associated outcomes, 39% concentrated on incentives and their related outcomes, and the remaining 22% focused on agroecological practices and their resultant outcomes (Figure 3). Regarding the stakeholder landscape, a diverse array of private- and public-sector entities were involved in promoting agroecological practices or providing support for incentives and investment initiatives (Figure 4). Key contributors included local cooperatives (17%), certification organizations (15%), international funding organizations (12%), community organizations (10%), and government and national research bodies (10%). The remaining 36% comprised various actors, such as public and private development organizations, medium and large enterprises, NGOs, the public and government sector, the National Service of Meteorology and Hydrology of Peru, and the National University of Ucayali. Finally, the review identified five prominent obstacles that hinder incentives for agroecological transition within Peru's cacao value chain: (1) government-imposed sanctions and penalties; (2) limited engagement from both government and private-sector organizations in the implementation and monitoring of agroecological practices; (3) minimal involvement of local academic and research organizations; (4) inadequate investments by public and private sectors in public social amenities and infrastructure; and (5) land tenure insecurity.

3.2. Incentives and agroecological practices linkages

Here, we elucidate the linkages between the various incentives and the adoption of agroecological practices in the Peruvian cacao sector. Through a review of nine relevant papers, the researchers identified and analyzed the connections between the identified incentives and their subsequent influence on the adoption of agroecological practices (Figure 3). The analysis revealed that non-market incentives played a predominant role (48%), followed by regulatory measures (19%), cross-compliance incentives (19%), and market incentives (14%) in facilitating the adoption of agroecological practices in Peru's cacao value chain (Figure 5). Generally, public and private-sector actors favoured non-market incentives over other incentive types. The adoption of 11 agroecological practices directly correlated with nine distinct incentives commonly applied in Peru's cacao value chain (Figure 5). These agroecological practices encompassed intercropping (19%), applying green and animal manure (19%), irrigation with recycled materials (14%), soil conservation (10%), and using

Table 2. Summary details of the papers included in the review.

No.	Paper title	Key words	Article type	Subject area	Author
1	Carbon Sequestration in Fine Aroma Cocoa Agroforestry Systems in Amazonas, Peru	CO2; Cordiasp; Theobroma cacao; climate change; fruit species	Research article	Agroforestry and climate change mitigation	Goñas et al. (2022)
2	Fertigation in the culture of cocoa as alternative mitigation for climate change in the Ucayali region.	–	Conference paper	Climate change mitigation	Camacho et al. (2018)
3	Neuroeconomic decisions in cocoa producers: Impact of cooperative innovation methodology on prospecting for fair trade organic niche as an incentive for agricultural sustainability	Agricultural sustainability; Cocoa producers; Fair trade; Neuroeconomic; Organic; Prospecting	Research article	Cooperative Innovation	Zúniga Aguilar (2021)
4	Development impact bonds: learning from the Asháninka cocoa and coffee case in Peru	Impact bonds; Public-private partnership; Result-based; Social investing	Research article	Development impact bonds	Belt et al. (2017)
5	Social capital and soil conservation: Is there a connection? Evidence from Peruvian cocoa farms	–	Research article	Environmental and social sustainability	Cancino et al. (2022)
6	Climate-change impact on cultivated and wild cocoa in Peru and the search of climate change-tolerant genotypes	Breeding for climate-change adaptation; Cacao genotypes; Ensemble modelling; Habitat suitability modelling	Research article	Impact of climate change	Ceccarelli et al. (2021)
7	The potential of agroforestry concessions to stabilize Amazonian forest frontiers: a case study on the economic and environmental robustness of informally settled small-scale cocoa farmers in Peru	Agroforestry concessions; Cocoa; Deforestation; Livelihoods; Peruvian Amazon; Small-scale farming	Research article	Agroforestry concessions	Pokorny et al. (2021)
8	Farmer satisfaction and cocoa cooperative performance: Evidence from Tocache, Peru	Cluster analysis; Cocoa; Cooperative; Exploratory factor analysis; Peru	Research article	Cacao cooperatives	Higuchi et al. (2020)
9	Costs, quality, and competition in the cocoa value chain in Peru: An exploratory assessment	Markets; Processing; Trade	Research article	Cocoa exports	Scott et al. (2015)
10	High genetic diversity in arbuscular mycorrhizal fungi influences cadmium uptake and growth of cocoa plants.	Biodiversity; Mycorrhizae; Phytoremediation; Theobroma	Research article	Genetic diversity	Vallejos-Torres et al. (2022)
11	Tree diversity in cocoa agroforests in San Alejandro, Peruvian Amazon	Primary forest; Secondary forest; Species richness; Theobroma cacao; Vegetation structure	Research article	Agroforestry systems	Vebrova et al. (2014)
12	Stuck in a rut: emerging cocoa cooperatives in Peru and the factors that influence their performance	Cooperatives; NGOs; business performance; cocoa; rural development	Research article	Cacao cooperatives	Donovan et al. (2017)
13	Peru Cocoa Alliance: Carbon sequestration as a co-benefit of Cocoa expansion	–	Info Note	Carbon sequestration and GHG emission	Nash et al. (2016)
14	Unpacking 'sustainable' cocoa: do sustainability standards, development projects and policies address producer concerns in Indonesia, Cameroon and Peru?	Cocoa; development; global value chain; issue-attention cycle; policy; sustainability standards; swing potential	Research article	Sustainability standards	Mithöfer et al. (2017)
15	Conservation and use of genetic resources of cacao (Theobroma cacao L.) by gene banks and nurseries in six Latin American countries	Cacao propagation material; Certification and traceability systems; Clonal gardens; Criollo cacaos; Fine or flavour cacao; Native cacaos	Research article	Genetic diversity	Ceccarelli et al. (2022)
16	Beyond institutional bricolage: An intertwining approach to understanding the transition towards agroecology in Peru	Agriculture transition; Agroecology; Critical institutionalism; Intertwined relations; Power relations	Research article	Agroecological movements	De La Cruz and Dessein (2021)

(*Continued*)

Table 2. Continued.

No.	Paper title	Key words	Article type	Subject area	Author
17	Peru: agroecological movement history 1980–2015	Agroecological movement; Peru; agroecology; small farmers	Research article	Agroecological movements	Alvarado et al. (2017)
18	Incentive-based conservation in Peru: Assessing the state of six ongoing PES and REDD + initiatives	Climate services; Deforestation; Environmental policy; Hydrological services; Payment for environmental services	Research article	Incentive-based conservation initiatives	Montoya-Zumeta et al. (2021)
19	The importance of traditional ecological knowledge in agroecological systems in Peru	Agroecology; Ecosystem services; Environmental management; Ethno-ecology; Indigenous knowledge; Social ecology; Sustainability; Traditional ecological knowledge	Research article	Traditional ecological knowledge	Saylor et al. (2017)
20	Roadmap for the scaling up of Agroecology in Peru: An analysis of existing policies, programmes and limiting factors	–	Info Note	Agroecology Scaling up	Valdivia-Díaz and Le-Coq (2022)
21	Incentives for deforestation-free value chains in the Peruvian Amazon	–	Working Paper	Deforestation-free value chains	Tristán et al. (2022)
22	An evidence-based relationship between technical assistance and productivity in cocoa from Tocache, Peru	Cocoa; Cooperative; Peru; Production function; Technical efficiency	Research article	Technological assistance	Higuchi et al. (2023)

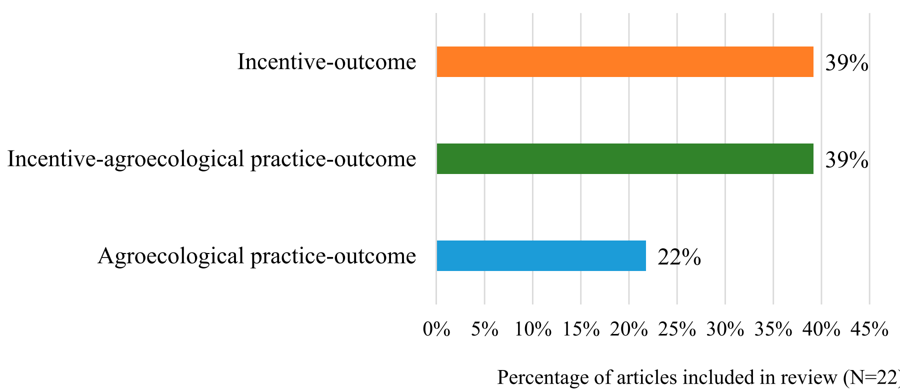

Figure 3. Thematic distribution of the reviewed literature.

arbuscular mycorrhizal fungi (10%). Others (5% each) included cacao agroforestry, organic cacao, nature conservation for carbon sequestration, cacao genetic resources' conservation, cacao fertigation, and the adoption of climate-resilient genotypes.

Non-market incentives, particularly investments in drip irrigation, played a pivotal role in promoting the adoption of cacao fertigation (applying fertilizer solutions with irrigation water) and the use of mulches. Furthermore, in-kind rewards, such as training, workshops, equipment, and agricultural inputs, influenced the adoption of practices like irrigation with recycled materials, cacao intercropping, using green and animal manures, and applying arbuscular mycorrhizal fungi in Peruvian cacao cultivation. Social capital incentives contributed to the increased use of soil conservation measures, while cooperative participation empowered farmers to adopt climate-resilient cacao genotypes. Regulatory measures, such as sustainability standards and agroforestry

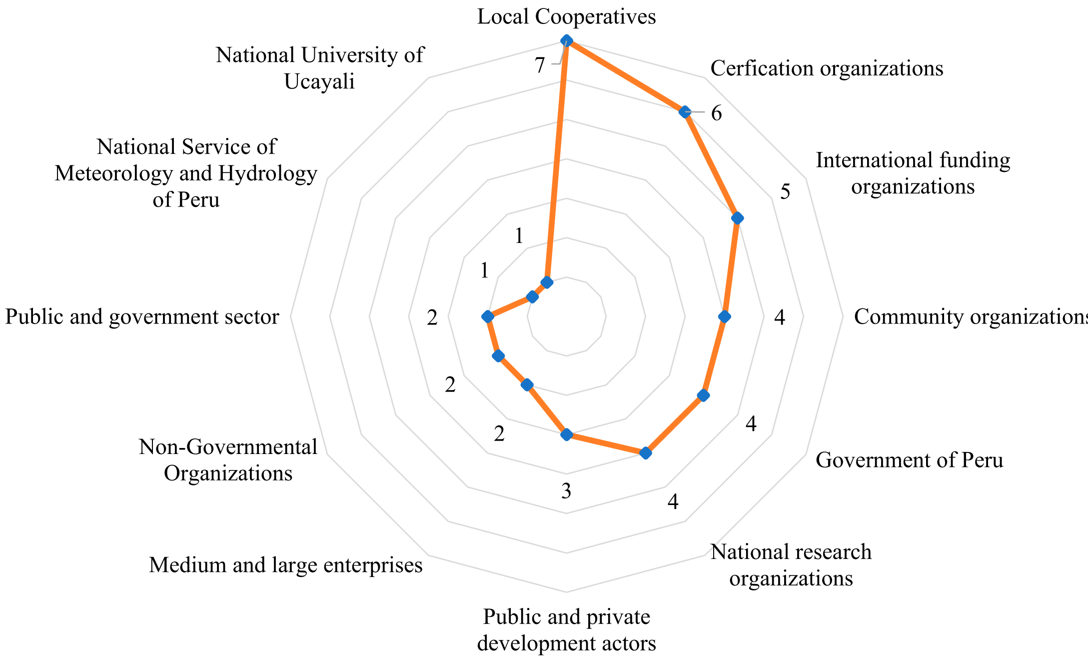

Figure 4. Radar diagram of public and private organizations in Peru.

Note: The data presented represent the frequency of organizational support for agroecological practices and incentives within Peru's cacao sector.

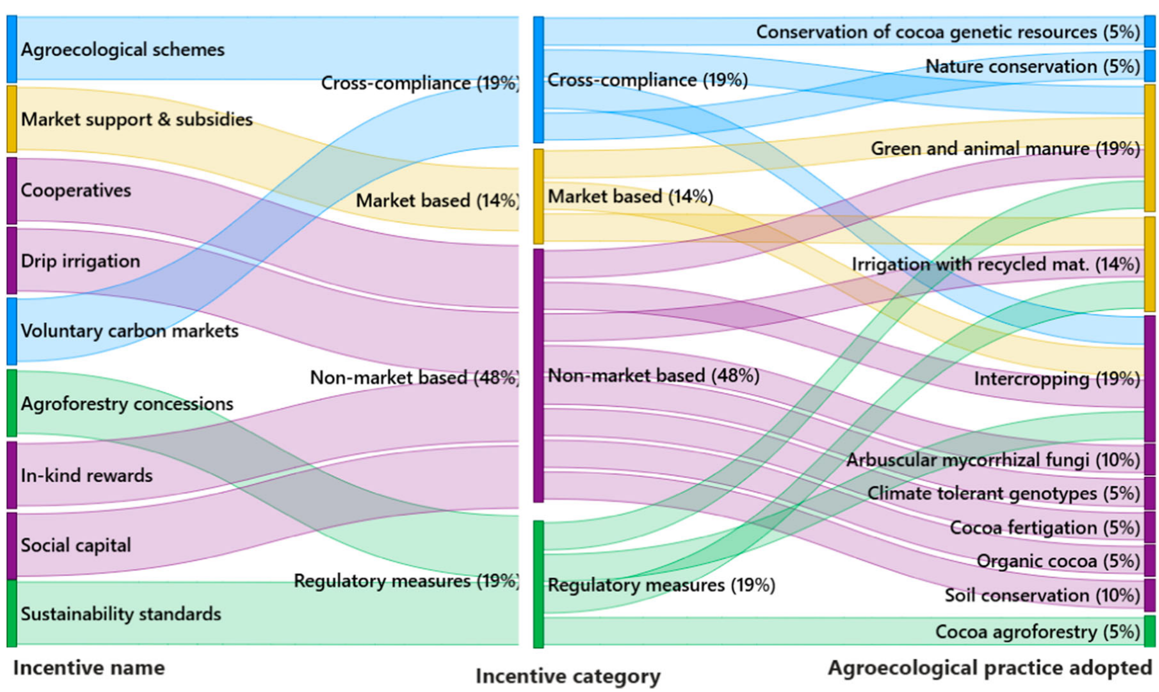

Figure 5. Incentives and agroecological practices adoption linkages in Peru's cacao sector.

Note: The links are from a subset of 12 papers, colour-coded by the incentive category.

concessions, greatly facilitated the adoption of diverse agroecological practices among Peruvian cacao farmers. Agroforestry concessions influenced the adoption of cacao agroforestry systems, while sustainability standards led to the adoption of practices involving green and animal manures (organic fertilizer application), intercropping, and irrigation with recycled materials.

Cross-compliance incentives, such as voluntary carbon markets and regional agroecological schemes, played a fundamental role in enabling the adoption of cacao intercropping, applying green and animal manure, nature conservation practices aimed at carbon sequestration, and conserving cacao genetic resources. In contrast, market-based incentives were less frequently used in Peru's cacao sector. Specifically, market support and subsidies facilitated the adoption of practices related to cacao intercropping, organic cocoa production, and the application of green and animal manure. This review underscores the pivotal role of non-market incentives in driving the adoption of agroecological practices in the Peruvian cacao value chain, compared to regulatory measures, cross-compliance, and market-based incentives. Using these incentives to promote the transition to agroecological practices yielded a range of sustainability outcomes, as outlined in Section 4.2.

3.3. Incentives and sustainability outcomes linkages

The systematic review synthesized insights from a subset of nine relevant papers to uncover the complex interconnections between various incentives and the resulting sustainability outcomes within Peru's cacao sector. The analysis unveiled a comprehensive framework of 20 pivotal incentives that contributed to sustainability outcomes in this context, as depicted in Figure 6. Notably, only nine of the reviewed incentives exhibited a direct, explicit link to the adoption or transition of agroecological practices and their associated outcomes, as outlined in Section 4.2. The most widely employed incentives to drive sustainability outcomes in Peru's cacao sector were non-market

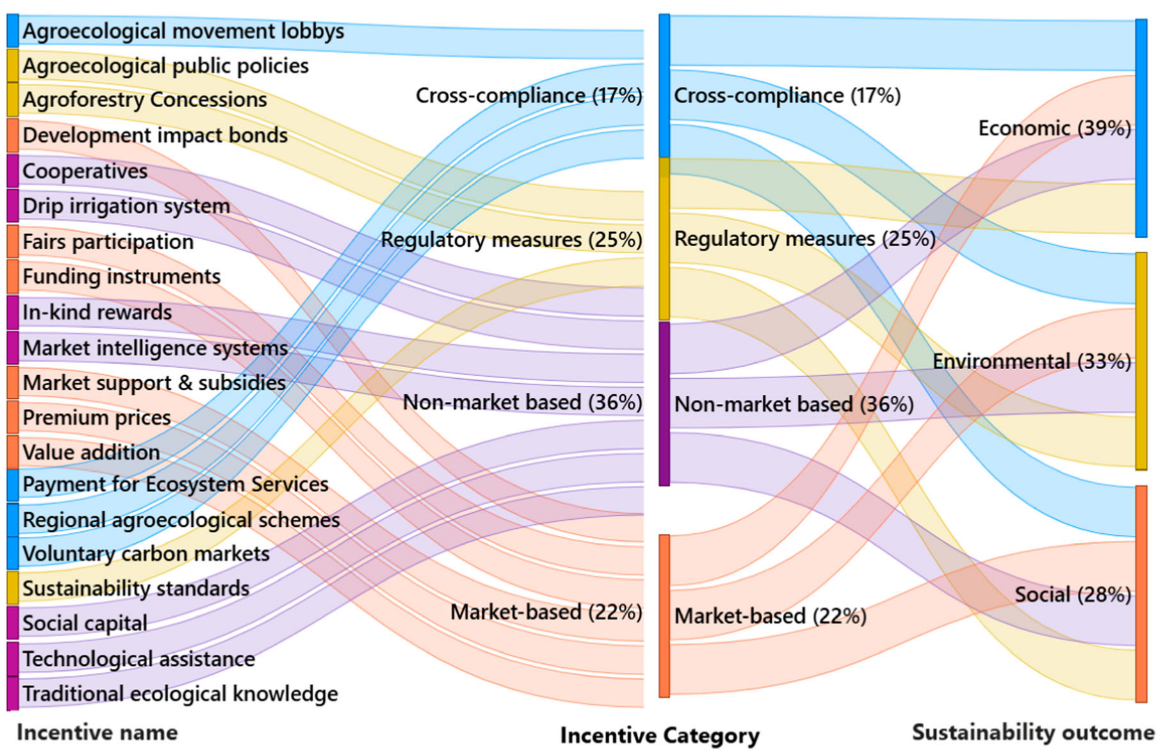

Figure 6. Recorded links between incentives, incentive type, and outcomes.

Note: The links are from the 22 reviewed papers, colour-coded by incentive category.

incentives, encompassing social capital, in-kind rewards, cooperatives, technological assistance, and market intelligence systems that prioritize and favour environmentally beneficial business models for small-scale cacao producers. In contrast, cross-compliance incentives were less prominent in supporting sustainability outcomes among Peruvian cacao stakeholders. These incentives included sustainability standards, regional agroecological schemes, payment for ecosystem services, and agroecological movement lobbies.

Considering the total of 22 papers, the incentives for promoting sustainable cacao production systems in Peru were approximately 36% non-market incentives, 25% regulatory measures, 22% market-based incentives, and 17% cross-compliance incentives (Figure 6). Generally, most incentives were connected with economic (39%) and environmental sustainability (33%) outcomes, with the remaining incentives related to social (28%) outcomes (Figure 6). However, the incentives specifically related to the transition or adoption of the 12 agroecological practices detailed in Figure 5 contributed to 43%, 33%, and 24% of measurable economic, environmental, and social outcomes, respectively. This review illuminates the tendency of various incentives, particularly non-market incentives, to predominantly target cacao farmers' and other value-chain actors' economic well-being and environmental concerns, with less emphasis on social dimensions. The prevalence of incentives focusing on economic and environmental outcomes implies a primary objective of achieving economic prosperity and ecological sustainability within the context of agroecological cacao production.

4. Discussion

4.1. Impacts of incentives on the adoption of agroecological practices in Peru

This section presents a comprehensive synthesis of the effect of various incentives on the transition towards agroecological practices in Peru's cacao sector.

4.1.1. Non-market incentives

Non-market incentives were instrumental in motivating agroecological shifts within Peru's cacao value chain in multiple ways:

Drip irrigation incentives: These incentives have played a pivotal role in facilitating Peru's transition to cacao fertigation techniques and other sustainable practices like mulching. However, these technologies are still in the experimental phase, primarily implemented in local research institutions. The primary purpose of cacao fertigation technology and mulching is to supply cacao with essential nutrients through irrigation systems, thereby minimizing water loss due to challenging climatic conditions. Studies have demonstrated the agronomic feasibility of cacao fertigation technology, making it a suitable approach for reducing the impact of climate change and conserving water resources, particularly in the Peruvian Ucayali region (Camacho et al., 2018).

Social capital incentives: The study by Cancino et al. (2022) investigated the use of social capital incentives by government-led institutions and their impact on both Indigenous and non-Indigenous cacao farmers in Peru. These researchers found that the participation of these farmers in Amazonian Indigenous producers' associations has demonstrably enhanced their social capital to adopt sustainable soil practices. However, the findings suggest that the effects of these social capital structures on the adoption of sustainable soil practices by cacao farmers have been mixed. While the benefits of these social networks and structures can lead to increased ability to gain benefits, the implications on the adoption of sustainable soil practices have been both positive and negative. These included using organic fertilizers, introducing agroforestry, restricting the use of chemical fertilizers, and adopting appropriate organic waste and pest management practices (Cancino et al., 2022). This indicates that relying on these social capital entities for implementing agroecological practices may be insufficient. Hence, there is a need for a more comprehensive approach that considers the complex interplay between social capital, institutional support, and the adoption of agroecological practices by Peruvian cacao farmers.

Cooperatives incentives: Cooperatives are treated as an incentive for cacao farmers to implement sustainable and climate-resilient practices. This is because cooperatives facilitate knowledge sharing about the long-term economic, social, and environmental benefits of adopting sustainable practices. Snapp et al. (2021) highlighted

> the significant influence of climate change on cacao production in Peru and the key role incentives play in enabling the transition to sustainable practices. Researchers recognize that the threats from climate change have necessitated the adoption of more climate-resilient cacao genotypes, including material derived from wild cacao. Cooperative incentives have been instrumental in promoting the adoption of these resilient cacao genotypes, which are more resistant to the effects of climate change compared to commonly grown traditional varieties. This is particularly essential given the expected substantial changes in global cacao production dynamics due to climate change, as indicated by Ceccarelli et al. (2021, 2022). Cooperative incentives that facilitate the adaptation and improvement of current cacao production systems to mitigate the adverse impacts of climate change are important and necessary to ensure sustainable and resilient cacao production in Peru.

In-kind rewards, such as training and workshops, have contributed to the adoption of sustainable agricultural practices in cacao farming systems. According to De La Cruz and Dessein (2021), providing farmers with workshops, training, support to reach larger markets, and subsidies all promoted: (i) the use of intercropping; (ii) replacing chemical pesticides with organic ones; (iii) using green and animal manure to improve soil quality; and (iv) implementing drip irrigation systems using recycled materials. Similarly, inoculating arbuscular mycorrhizal fungi has proven effective in enhancing nutrient absorption and vegetative growth within Peru's cacao system. This approach also reduces the absorption of cadmium by cacao, contributing to improved cacao plant growth, both in terms of plant height and leaf area, under nursery conditions in the Amazonian regions of Peru (Vallejos-Torres et al., 2022). By preventing cadmium immobilization in the soil, this method yields economic and environmental benefits, aligning with the stringent maximum limits established for cadmium levels in cacao and chocolates imported into the EU (European Parliament and Council, 2023).

4.1.2. Regulatory measures

The implementation of regulatory measures was also cited to encourage agroecological shifts within Peru's cacao sector. One such measure is the establishment of *cacao agroforestry concessions*. Cacao agroforestry concessions in Peru have been instrumental in facilitating the cultivation of additional crops alongside cacao trees and promoting forest conservation. These incentives aim to harness the potential of agroforestry and land ownership for economically and environmentally sustainable livelihoods (Vebrova et al., 2014). However, the economic benefits of these concessions have been limited, with less than 20% of Peru's cacao farmers achieving economic stability. Furthermore, persistent challenges such as land degradation have hindered the desired environmental outcomes (Nash et al., 2016; Pokorny et al., 2021). The current regulatory measures, such as agroforestry concessions, may not be sufficient on their own to address the complex challenges faced by Peru's cacao sector. To ensure the sustainable use of public forest land, a more comprehensive approach is necessary, one that extends beyond regulatory measures to achieve the desired economic and environmental goals (Nash et al., 2016; Pokorny et al., 2021).

4.1.3. Cross-compliance incentives

The use of cross-compliance incentives has played a key role in promoting agroecological practices within Peru's cacao sector. These incentives, such as regional agroecological schemes, have facilitated conserving cacao genetic resources, maintaining cacao intercrop systems, and using green and animal manures (De La Cruz & Dessein, 2021). In addition to the regional agroecological schemes, the voluntary carbon markets have been instrumental in promoting nature conservation initiatives for carbon sequestration among Peruvian cacao farmers (Montoya-Zumaeta et al., 2021). However, earlier research has indicated that ensuring compliance requires the enforcement of measures to mitigate the risks of fraudulent activities, which can result in increased expenses due to the extensive distribution of smallholder farmers across various locations (Meemken et al., 2021).

4.1.4. Market-based incentives

Finally, using green and animal manures, as well as recycled materials, for irrigation purposes in Peru's cacao production systems has been greatly influenced by market support and subsidies (Camacho et al., 2018). This contrasts with the findings of Pokorny et al. (2012), who examined the effects of integrated forest-based development initiatives in Peru and other nations. They found that market-based incentives rarely support community-based forestry because they often do not align with local conditions, lack financial viability, and place local communities at a competitive disadvantage compared to better-capitalized entities.

This study has demonstrated that the decision to adopt different agroecological practices depends on many factors, including incentives, programme conditions, farmers' cultural characteristics, economic status, environmental beliefs, and consumer demands. Existing literature further underscores that the long-term adoption of agroecological practices relies heavily on incentive structures at national and local levels and the establishment of enabling environments (Bulman et al., 2021; Piñeiro et al., 2020). Therefore, designing suitable incentives for the private sector, coupled with investment models in the public sector, represents a key strategy for aiding cacao farmers and value-chain actors in transitioning from conventional practices to agroecological practices.

4.2. Relationship between incentives and sustainability outcomes in Peru's cacao sector

4.2.1. Non-market incentives

Non-market incentives, such as carbon pricing, technology support, research and development, and extension services, have played a pivotal role in driving agroecological transitions globally (Bakali et al., 2023; Bulman et al., 2021). These incentives have been instrumental in mitigating information asymmetries, particularly those related to market access, for small-scale producers (Piñeiro et al., 2020). Cooperatives serve as an incentive by providing market access for small-scale producers. Cooperatives can be useful in commercializing various agricultural products by operating and marketing them under a single brand, which provides recognizability for consumers (Jacobi et al., 2017). In the case of cacao production in Peru, the use of marketing cooperatives has led to marked socioeconomic benefits and farmer satisfaction (Higuchi et al., 2020). Private-sector partners have leveraged cooperative innovation incentives to promote sustainable farming practices, enhancing the well-being of cacao farmers, particularly those involved in fair-trade organic cacao markets (De La Cruz & Dessein, 2021). However, a study assessing the impact of fair-trade certification among coffee farmers in Peru found a non-significant effect on household income for both organic and conventional farmers, as the benefits derived from the fair-trade premium were very limited and unevenly distributed (Ruben, 2017). Nevertheless, fair-trade farmers possessed higher levels of animal stocks, better access to credit, and more investments in agricultural assets compared to their counterparts, and they were more satisfied with cooperative services, and they had higher risk acceptance (Ruben, 2017).

Cancino et al. (2022) reported that social capital from local communities and agricultural associations in Peru motivated cacao farmers to adopt agroecological practices, leading to positive economic, environmental, and social outcomes. However, the adoption of agroecological practices in Peru was influenced by adherence to principles, market intelligence systems, and community support (Tristán et al., 2022). Further, technological assistance and in-kind rewards, such as training in sustainable drip irrigation systems, were also critical in addressing environmental challenges and climate-change impacts in Peru (Ceccarelli et al., 2021; Mendoza et al., 2020). When properly implemented with support from research institutions and public- and private-sector partners, drip irrigation systems improved cacao performance and environmental sustainability by reducing water usage (Camacho et al., 2018). Furthermore, utilizing local traditional ecological knowledge to inform farmers' environmental decisions was a vital incentive for agroecological transition in Peru. Local traditional ecological knowledge helped farmers respond to climate variability, predict seasonal changes, manage water resources, plan their agricultural activities, and adapt to new agricultural technologies (Saylor et al., 2017).

4.2.2. Regulatory measures

Regulatory measures, including adopting sustainability standards, agroforestry concessions, and agroecological public policies, have been employed to promote agroecological transitions and sustainability outcomes (Bulman et al., 2021; Piñeiro et al., 2020). Sustainability standards are used to evaluate and certify cacao production practices, resulting in social, economic, and environmental benefits. However, the lack of harmonization among these standards has created competition and interdependencies (Mithöfer et al., 2017). Public agroecological policies, championed by governments and grassroots organizations, play a key role in promoting agroecological transitions in Peru. In the context of Peru, agroecological public policies refer to government-implemented policy instruments and programmatic interventions that support and promote the adoption and scaling up of agroecological practices in cacao production systems among farmers and farming communities (Valdivia-Díaz & Le-Coq, 2022). Collaboration among farmers, agroecological movements, universities, public officials, businesses, consumers, and non-governmental organizations is essential to achieve desired outcomes (Valdivia-Díaz & Le-Coq, 2022).

Agroecological public policies have contributed to social and environmental sustainability outcomes among Peruvian cacao farmers. These policies encompass regulatory measures for organic products and ecological production and are vital in promoting agroecological transitions and sustainability outcomes. Cacao agroforestry, an integral part of these policies, has led to environmental and economic advantages in terms of increased yield, profitability, and mitigating the effects of climate change (Pocomucha et al., 2016). Similarly, agroforestry concessions have resulted in positive economic and environmental outcomes. The adoption of cacao agroforestry has increased cacao yield, quality, and profitability, coupled with climate-change mitigation benefits in the Amazonian region of Peru (Jacobi et al., 2017; Nash et al., 2016; Pocomucha et al., 2016). The agroforestry approach has also led to reduced fertilizer and pesticide use, thus reducing nitrogen loss, enhancing plant nutrient availability, and organic matter accumulation, and reducing external pesticide inputs (Nash et al., 2016).

4.2.3. Market-based incentives

Market-based incentives play a key role in promoting the adoption of agroecological practices and fostering sustainable outcomes. Research has demonstrated that these incentives can take various forms, including adjustments to input and output prices, subsidies, grants, loans, credit options, compensatory measures, income transfers, and even in-kind rewards (Bakali et al., 2023; Bulman et al., 2021; Jacobi et al., 2017; Piñeiro et al., 2020). This review focuses on the effectiveness of premium pricing as an incentive mechanism to empower cacao farmers in Ucayali, Peru, to overcome the challenges associated with deforestation-free and low-GHG emission initiatives. Premium pricing, facilitated by multi-stakeholder involvement from the public and private sectors, provides farmers with access to alternative cacao markets, thereby increasing prices and economic gains. The presence of premium prices not only led to an increase in productivity and improved profitability but also benefited small-scale farmers (Tristán et al., 2022). The successful implementation of premium-price incentives within Peru's cacao sector depends on strict adherence to deforestation-free criteria across all levels of the value chain. Farmers have demonstrated a steadfast commitment to producing deforestation-free cacao, while fostering a conducive environment for business expansion, benefiting various stakeholders within the value chain.

However, Peru's premium prices are devalued on international markets, notably within the EU, as these markets progressively adopt stringent legal and environmental standards (European Parliament and Council, 2023). Recent research highlights the unintended consequences of these developments, which disproportionately affect cacao farmers in resource-constrained developing nations (Meyer et al., 2014; Mockshell, 2023).

Using development impact bonds in Peru to replace upfront financing of charitable activities with pay-for-success contracts has had a positive influence on the economic prosperity of cacao growers in the Amazonian region of Peru (Belt et al., 2017). Value-addition incentives provided by value-chain actors, such as cacao processors and exporters, have produced mixed social and economic outcomes (Donovan et al., 2017). Value-chain actors' participation greatly influences the present and future performance of the cacao sector, affecting factors such as quality, costs, and competitiveness (Donovan et al., 2017; Scott et al., 2015).

Fair participation by cacao value-chain actors is essential to understanding how incentives influence cacao farmers' decisions to adopt agroecological practices and the outcomes that result. Public- and private-sector funding mechanisms, such as deforestation-free cacao value-chain strategies, have contributed to environmental and economic outcomes. These mechanisms extend beyond carbon sequestration and GHG emissions reduction to support smallholder cacao producers. Their success depends on non-market-based and cross-compliance incentives as well, such as market intelligence systems and payment for ecosystem services, respectively (Tristán et al., 2022).

4.2.4. Cross-compliance incentives

Cross-compliance incentives, such as direct payments linked to compliance with environmental standards and voluntary arrangements for maintaining good agricultural and environmental conditions, have played a crucial role in promoting sustainability in the Peruvian cacao sector. For instance, government subsidies have been tied to maintaining specific environmental practices such as payment for ecosystem services (Montoya-Zumaeta et al., 2021). These findings contradict the observations by DeFries et al. (2017), who reported that the voluntary certification of tropical agricultural commodities, including cocoa, did not yield substantial environmental, economic, and social benefits for smallholder farmers. Various actors in Peru have implemented conditional conservation incentives, such as rewards for hydrological ecosystem service mechanisms, participation in voluntary carbon market initiatives (local REDD + programmes), and engagement in a national forest protection plan in alignment with environmental responsibilities (Montoya-Zumaeta et al., 2021). These incentives are primarily provided by local governments, local and international organizations, and local non-governmental organizations. However, the effectiveness of cross-compliance incentives hinges on issues of equity, transparency, differentiation, and conditionality (Piñeiro et al., 2020).

4.3. Disincentives to agroecological transition for the cacao sector in Peru

Despite the incentives offered by both public and private-sector partners to encourage agroecological transition and outcomes for the cacao sector in Peru, various disincentives hinder these efforts. First, significant government penalties and sanctions aimed at creating negative consequences for breaching regulations and policies impede the adoption of sustainable practices, leading to land degradation and using unsustainable methods such as deforestation. Such sanctions include non-compliance fines or removal of certifications or sustainability labels among others (Montoya-Zumaeta et al., 2021). Additionally, the lack of active engagement by government agencies and non-governmental organizations during the development and monitoring stages of agroecological systems discourages the transition to sustainable approaches (Donovan et al., 2017). Therefore, coordination between public- and private-sector partners is pivotal for generating alternative interventions and risk-sharing opportunities.

The absence of participatory research in local academic institutions hinders the development of new agroecological methods that incorporate local or traditional knowledge (Alvarado et al., 2017), further complicating the study of small farmers' diversity, decision-making processes, and power dynamics. Furthermore, the lack of organizational capacity building for smallholder farmers by private-sector partners poses a challenge to the long-term promotion of agroecological principles (De La Cruz & Dessein, 2021; Pokorny et al., 2021). Insufficient investments in the public sector can also greatly impede the efforts of private-sector partners to promote agroecological transformation. These include public sector areas such as education, healthcare, infrastructure, financial access, logistics, and markets (Pokorny et al., 2012). Finally, land tenure insecurity has also been identified as a major obstacle to adopting and implementing sustainable agroecological practices in cacao agroforestry systems (Loch et al., 2021). Addressing these disincentives is fundamental to promoting effective agroecological transition in Peru.

5. Conclusions and policy implications

Incentives from both the public and private sectors play a crucial role in advancing food and nutrition security, poverty reduction, adaptation to climate-change impacts, and the generation of knowledge within agrifood systems (Jones et al., 2022). This review examines the incentives, agroecological practices, and sustainability outcomes in Peru's cacao value chain, serving as a pioneering endeavour to emphasize the importance of incentives in driving agroecological transitions.

In this study, we have focused specifically on the cacao production value chain. Cacao is a crop that has received significant attention from both the public and private sectors regarding the need to transition from conventional approaches to more agroecological production systems. Our research has identified the types of incentives and investments currently being applied within the cocoa value chain and assessed some of their effects.

The primary agroecological practices championed within Peru's cacao sector include cacao agroforestry, soil conservation, intercropping, application of green and animal manure, irrigation employing recycled materials, and the use of arbuscular mycorrhizal fungi. The implementation of these agroecological practices in Peru's cacao sector has likely contributed to significant sustainability outcomes, distributed across the economic (45%), environmental (32%), and social (23%) dimensions. While acknowledging the important role of social attributes in agroecological transformation, it is essential to highlight the limited number of incentives directed towards fostering related social outcomes within Peru.

The analysis highlights that non-market incentives and regulatory measures are the primary drivers of agroecological practice adoption in Peru's cacao sector, compared to market-based and cross-compliance incentives. Cocoa marketing cooperatives, agroecological public policies, and investments in social capital have played crucial roles in facilitating private sector engagement, ultimately leading to increased resilience and sustainability. This review emphasises the importance of creating private-sector incentive models coupled with the reduction of public-sector disincentives, such as penalties, sanctions, lack of participatory research, lack of organizational capacity building, and insufficient investment in the public sector. This can facilitate the transition from conventional practices to agroecological food systems in Peru's cacao sector.

Several key actors, including certification bodies, local cooperatives, community-based organizations, and international funding agencies, have been identified as primary contributors to incentives and investments influencing the transition toward agroecological systems in Peru. Policy innovations and incentive mechanisms must align with the diverse stakeholder landscape, spanning from cacao breeding, farms, and consumers, while accommodating trade-offs between economic, social, and environmental factors. Gaining a nuanced understanding of the barriers that impede public and private sector involvement in agroecological transition is necessary for formulating strategies to overcome these obstacles and foster sustainable agricultural practices. However, the core of private-sector engagement lies in eliminating disincentives, by particularly creating an enabling environment via the public sector. Addressing the limited involvement of local stakeholders and constraints related to technical proficiency are imperative to overcome bottlenecks in private-sector incentives and investments. The insights generated can guide policies and practices to accelerate the adoption of agroecological principles to transition to sustainable production systems and promote sustainable development within the cacao value chain in Peru, as well as in other settings.

5.1. Limitations and future research

The results of this systemic analysis are based on associational evidence, lacking the underpinnings of rigorous causal analysis. This highlights the compelling need for more stringent evaluations and qualitative research endeavours to gain a nuanced understanding of the barriers that impede public and private sector involvement in the agroecological transition. Such research is significant for formulating strategies to overcome these obstacles and foster a transition to sustainable agricultural practices. Additionally, more rigorous evaluations and qualitative research endeavours are needed to build the evidence base and guide the design of more effective policy interventions to support the transition towards agroecological practices.

Gender, youth, and Indigenous or other ethnic groups' considerations are pivotal factors in the context of agroecological transitions for various value chains. However, this review highlights a lack of clear emphasis on gender, youth, and Indigenous-related aspects with both public and private sector incentives and investments in Peru's cacao value chain. This is of paramount importance, considering that a key agroecology principle emphasises the need for incentives and investments for agroecological transition to promote gender equality and empower women, thereby alleviating gender-related challenges in the agrifood systems (Bulman et al., 2021). There remains a notable gap in understanding gender-tailored incentives and associated specific gender measures, risks, and inequalities in the context of Peruvian cacao farmers.

Note

1. The review omitted papers that could not be accessed, as well as articles that were requested from authors who did not respond.

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