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Agroecological transition assessment frameworks: a critical scoping review

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As the limitations of conventional agriculture become increasingly evident—ranging from environmental degradation to social inequity—the agroecological transition (AET) has emerged as an alternative and transformative pathway toward sustainable food systems. However, evaluating whether the AET achieves this objective remains methodologically challenging due to its complex, multi-dimensional nature. This scoping review analyzes 28 assessment frameworks—comprising both agroecology-specific frameworks and broader agricultural sustainability frameworks that incorporate agroecological principles—identified through a systematic PRISMA-ScR-guided search. Our analysis identified four key analytical dimensions for evaluating the frameworks, emerging inductively from the literature and empirical practice: (1) interactions between sustainability components and indicators, (2) stakeholder interactions, (3) learning produced by interactions, and (4) the participation and adaptability in the evaluation process. While many frameworks position themselves on one or more of the four analytical dimensions, only six (*Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, TAPE*, and *Tata-Box*) fully integrate the four of them. The majority of frameworks remain rooted in top-down, expert-led approaches, with limited capacity for participatory adaptation or facilitation of transformative learning. The findings underscore the need for more integrated, inclusive, and iterative frameworks that not only assess agroecological systems but also accompany and support the co-construction of transition pathways. Such frameworks are essential to address the systemic, contextual, and political dimensions of agroecological change. For the future, hybrid and modular designs are suggested to benefit from complementary strengths of existing frameworks and non-negotiable four design principles are defined for next generation of AET assessments.

KEYWORDS

adaptability, agroecological transition, assessment framework, indicator interactions, learning, scoping review, stakeholder interactions

1 Introduction

The intensification of agriculture in recent decades has largely been driven by the increasing global demand for food and agricultural commodities (Alexander et al., 2015; Tilman et al., 2011). This intensification now manifests more clearly, with farming becoming increasingly reliant on synthetic inputs. Although it has contributed significantly to food security, this model also generates negative impacts, including soil degradation (Oldeman, 1992; Sumberg and Giller, 2022), public health concerns (Leighton, 2021), environmental pollution (Horrigan et al., 2002), as well as issues of justice, access, and choice (Busscher et al., 2020; Hendrickson and James, 2005). Consequently, changes in food production system are urgently needed to enhance sustainability and support a global shift toward healthier, more sustainable diets.

In addressing these challenges, agroecology has long been promoted as a promising—though still marginal—pathway. As a holistic approach, agroecology seeks to balance multiple agronomic, ecological, and social functions simultaneously, rather than solely maximizing productivity while minimizing environmental harm (Trabelsi et al., 2016; Wezel et al., 2009). The agroecological transition (AET) has garnered widespread recognition and is a focus of the endeavors of numerous organizations, including governmental bodies, non-governmental organizations (NGOs), and research institutions. Landmark publications, such as the FAO (2018) report and policy instruments like the Policy Guidelines on Agroecology Transitions in ASEAN (CIRAD, ESCAP, FAO, DALaM, 2024), aim to facilitate this transition through knowledge sharing, technical support, and financial incentives.

Given AET's central role in reshaping agricultural sustainability (Altieri, 2009; Kerr et al., 2021), developing appropriate assessment frameworks is essential. These frameworks are needed not only to evaluate agroecological performance, but also to support transition processes through reflection, dialog, and strategic learning, and to challenge dominant metrics that reinforce conventional, reductionist views of agricultural performance. Existing tools—such as the FAO's Sustainability Assessment of Food and Agriculture Systems (SAFA), the Indicateurs de Durabilité des Exploitations Agricoles (IDEA) (Zahm et al., 2008), the Tool for Agroecology Performance Evaluation (TAPE) (FAO, 2019), the Método de Avaliação Econômico-Ecológica de Agroecossistemas (Lume) (Petersen et al., 2020) and the Original Agroecological Survey Indicator System (OASIS) (Peeters et al., 2018)— embody a range of methodologies and conceptual approaches, offering diverse responses to the need for AET-supportive assessments. Nevertheless, evaluating AET remains methodologically demanding and calls for multidisciplinary approaches and engagement with a wide range of stakeholders across food systems (Wezel and David, 2012), as recent reviews show that existing tools are highly heterogeneous and often fail to capture agroecology's systemic and transitional nature (Geck et al., 2023).

Transitions are dynamic processes shaped by interacting technical innovations, social practices, and institutional arrangements (Wezel and David, 2012). Building on this view, transition studies emphasize that AET unfold within broader socio-technical systems, where established norms, power relations, and learning processes influence the direction and pace of change. Approaches such as the Multi-Level Perspective (MLP) (Geels, 2019) and theory of transformative social learning (Mezirow, 2000) together show how socio-technical structures and asymmetries in knowledge and power shape interactions among actors, institutions, and knowledge systems, influencing whether these interactions reproduce existing arrangements or enable more systemic transformation. These interactions from the MLP perspective are also inherently multi-scalar, spanning plots, farm systems, communities, territories, and broader food-system regimes, indicating that transitions are shaped not only by the level at which they are examined but also by the territorial settings in which they unfold (Duru et al., 2015; Levidow et al., 2014). This implies that assessment frameworks must position themselves within these interacting levels—whether explicitly or implicitly. Recognizing the multi-scalar and territorial nature of AET provides conceptual grounding for interpreting how frameworks define their operational scale, from plot- and farm-based diagnostics to broader territorial and governance-oriented assessments.

In this review, these concepts do not serve to predefine analytical categories; rather, they provide a conceptual backdrop for interpreting how the inductively derived dimensions relate to transition dynamics. The analysis follows an inductive approach that draws on both the conceptual literature on AET and a close examination of the selected frameworks. Through this process, we identified a set of transition-relevant dynamics that were consolidated into the analytical dimensions used to assess the frameworks. By examining how current frameworks operationalize these dimensions, this review aims to illuminate both strengths and gaps in current AET assessment practices. In doing so, it contributes to the design and refinement of frameworks that are more participatory, adaptive, and context-sensitive—thereby enhancing their capacity to support AET.

2 Methodology

2.1 Literature search

This scoping review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes extension for Scoping Reviews (PRISMA-ScR) guidelines, see in Figure 1 and Tricco et al. (2018). Its objective was to identify and analyze existing assessment frameworks relevant for evaluating AET.

Evaluating AET requires assessing both the pathway—the process of applying agroecology principles—and the goal, which is the achievement of broad sustainability goals (Leach et al., 2010; Duru et al., 2015; Gliessman, 2016; HLPE, 2019). To capture these two dimensions, our review analyzes two complementary types of frameworks. First, we examine agroecology-specific frameworks to evaluate alignment with the transition pathways. Second, we include broader agricultural sustainability assessment frameworks, as they often incorporate key agroecology elements. Drawing on FAO's elements of agroecology (2018) and the HLPE's agroecological principles (2019), we refer to shared themes — enhancing diversity and biodiversity, building synergies, ensuring resource use efficiency, promoting recycling, prioritizing soil health, strengthening resilience and economic diversification, co-creating and sharing knowledge, upholding human values, fairness, and cultural traditions, ensuring responsible and participatory governance, and developing a circular and solidarity economy—as the agroecology components (AE components) used in this review. This inclusive scope enables us to assess both the pathway (transition process) and the destination

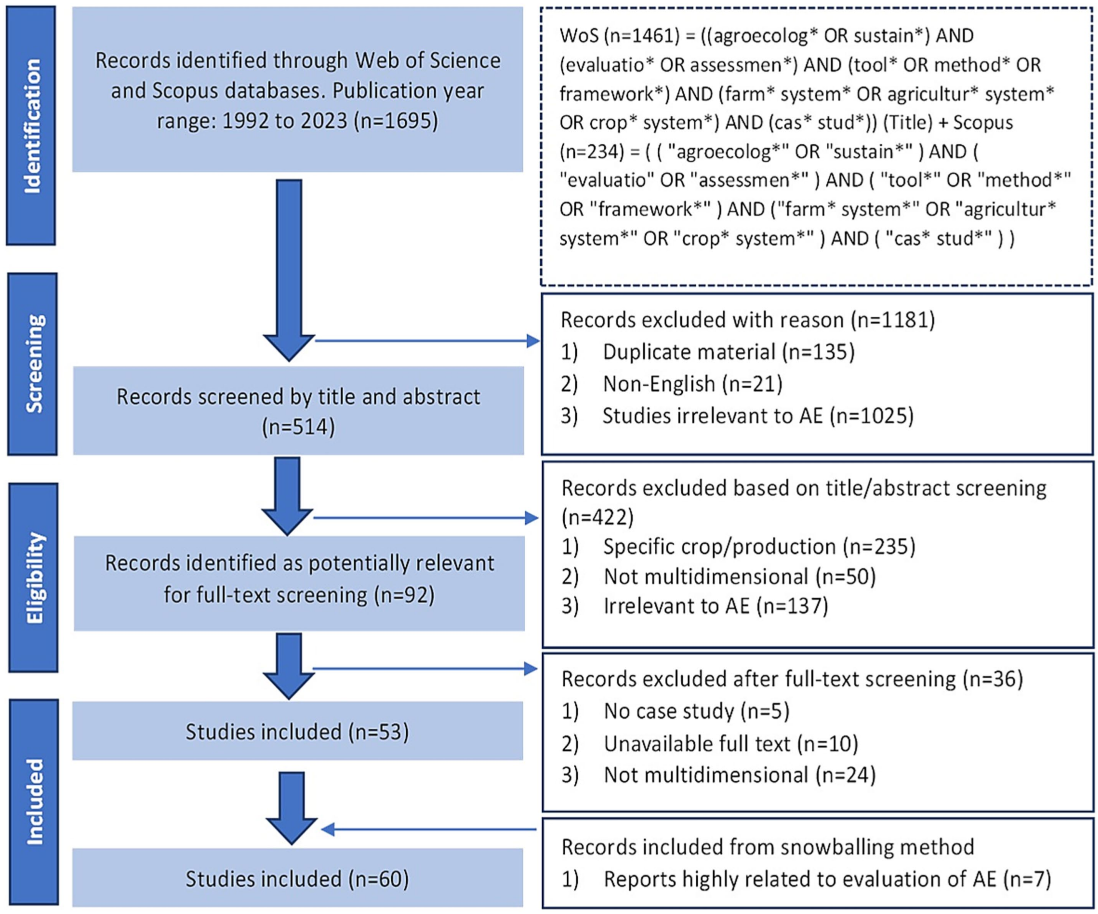

FIGURE 1
PRISMA-ScR flowchart showing the systematic screening process and selection criteria applied to identify 60 articles and 28 relevant assessment frameworks for AET.

(sustainability outcomes), and to identify where sustainability tools fail to capture AET-specific dynamics (Magrini et al., 2019; Darmaun et al., 2023).

A systematic literature search was performed using two major scientific databases: Web of Science and Scopus. Searches were conducted on 31 January, 2024. The search string was designed to capture both sustainability and agroecological assessment frameworks and was formulated as follows:

> ("agroecolog*" OR "sustain*") AND ("assessmen*" OR "evaluatio*") AND ("tool*" OR "method*" OR "framework*") AND ("farm* system*" OR "agricultur* system*" OR "crop* system*") AND ("cas* stud*").

This query was applied to the title, abstract, and keyword fields in each database. It yielded 1,461 records from Web of Science and 234 records from Scopus, totalling 1,695 records. Articles were initially screened based on title and abstract. Inclusion criteria were: (1) the article presents or applies an assessment framework relevant to agricultural sustainability or agroecology and (2) the article includes empirical data or case study application. Exclusion criteria included non-English articles, those not available in full text, or those focused exclusively on single production systems without reference to broader systemic evaluation. During screening, frameworks were considered relevant if they explicitly addressed agroecology or incorporated the principles detailed above. When relevance was unclear, the decision was based on a careful review of the article's aims and methodologies. In addition to database searches, complementary sources were identified through snowball sampling of references and citations in key articles. This process yielded seven additional relevant articles, bringing the final total to 60 articles included in the full review.

2.2 Data analysis

Among the 60 articles included in the review, 28 assessment frameworks were identified and analyzed. For each framework, a structured data extraction template was used to document key characteristics, including the framework's name and origin, geographic application, operational scale and territorial orientation, sustainability dimensions considered (environmental, economic, social, political), its features, and whether the framework explicitly focused on agroecology, and agroecological principles that the frameworks addressed.

The analytical framework for this review was developed inductively, based on a review comprising both (1) a close reading of the frameworks themselves and (2) a targeted review of conceptual and empirical literature on AET. The literature component focused on works that discuss the nature and challenges of AET—particularly how transitions unfold as systemic, non-linear, and multi-actor processes. Several relevant literatures such as Duru et al. (2015), Wezel and David (2012), Magrini et al. (2019), Tittonell (2023a), Wiget et al. (2020), and Darmaun et al. (2023) were central in shaping the conceptual orientation of this study.

The process was iterative. First, the literature provided a foundational understanding of the theoretical and practical dimensions involved in assessing AET. Second, as the frameworks were reviewed and coded recurring conceptual features began to emerge, reinforcing and sharpening insights gained from the literature. These principles are not externally imposed, but instead reflect a grounded synthesis of both the literature and the empirical diversity present in existing frameworks. As such, they serve both as analytical lenses and as conceptual contributions, bridging the gap between theoretical insights on agroecological transitions and the practical design of assessment frameworks. Each framework was assessed against the principles thus used as analytical dimensions. Thematic coding and synthesis techniques were used to identify strengths, gaps, and recurring patterns in how the principles were integrated. This comparative analysis forms the basis for the findings and discussion presented in the following sections.

3 Results

3.1 Overview of the selected assessment frameworks

Based on the review of 60 studies, 28 assessment frameworks were identified as relevant for AET and subjected to in-depth analysis (Table 1). The analysis focused on the sustainability dimensions they cover, the geographical contexts in which they have been applied, their defining characteristics, operational scales and territory orientations, methodological approaches, and agroecological principles that each framework covers.

Figure 2 presents an overview of the sustainability dimensions and operational scales and territoriality addressed by the 28 assessment frameworks. All frameworks incorporate the three core dimensions of sustainability: environmental, social, and economic. Nine frameworks focused exclusively on these three same pillars (with minor terminological variations such as referring to the environmental pillar as "agro-environmental" or "ecological"): *ESSIMAGE, FAI, Lume, Memento GTAE, MOTIFS, PROMETHEE, RISE, and SAEMETH and Soulé*. The remaining 19 frameworks incorporate additional sustainability dimensions beyond the core dimensions of environmental, social, and economic. Political and/or governance aspects appear in eight frameworks (*SAFA, PSDCIFASA, SAFE, SMART-Farm Tool, PG Tool, Tata-Box, TAPE, Autodiag*), while institutional considerations are present in three (*PSDCIFASA, SAFE, Tata-Box*). Resilience is included in two frameworks (*FoPIA-SURE-Farm, OASIS*), and ecosystem or ecosystem service dimensions in two others (*Dendoncker, SEPLS*). Additional unique dimensions include viability and acceptability (*FESLM*), adaptability (*MMF*), socio-territorial integration (*IDEA*), education and population (*ESEEP*), and self-empowerment/equity (*MESMIS*).

Across the 28 frameworks, three main configurations emerge regarding operational scale and territoriality. Most frameworks (18)—including *IDEA, RISE, MOTIFS, ESSIMAGE, FAI, Autodiag, APOIA-NovoRural, SAEMETH, PG Tool, PSDCIFASA, SMART, SAFA, OASIS, Memento GTAE, Soule, ESEEP, LUME*, and *PROMETHEE*—operate primarily at the farm scale. In this group, territoriality is either absent or treated implicitly, with the territory effectively reduced to the managed production unit and spatial processes captured only statistically rather than analytically. A second group (5)—*SAFE, MESMIS, MMF, FoPIA-SURE-Farm,* and *FESLM*—explicitly define nested spatial levels (parcel–farm–community–landscape/region) and distribute indicators across them, enabling analysis of cross-scale interactions and territorial processes. A third cluster (5)—*TAPE, SEPLS, SES(T), Tata-Box,* and *Dendoncker*—conceptualizes territory as a social-ecological system, although operational assessments still rely mainly on farm- or household-level data complemented by community- or territory-level contextual information.

Figure 3 presents an overview of the methodological architectures and agroecological orientation of the 28 assessment frameworks reviewed. In terms of methodological structure, all frameworks included in this review are assessment tools that offer a systematic, step-by-step procedure to guide their implementation.

- Focused assessment frameworks (13) primarily rely on a dominant methodological approach. For example, *APOIA-NovoRural* integrates biophysical sampling and remote sensing data through utility functions, while *RISE* organizes sustainability indicators using a driving force–state–response model.
- Integrated multi-method frameworks (15) combine several complementary methods within a coherent implementation process. *MESMIS*, for instance, applies a whole-system evaluation linked to management decision-making, and *TAPE* follows a sequential methodology to generate evidence on agroecological performance. Frameworks such as *Dendoncker* and *Tata-Box* further incorporate cyclical, participatory processes designed to facilitate continuous system learning and support transition pathways.

Among the 28 frameworks reviewed, eight were specifically developed to assess agroecological systems: *Autodiag*, *Dendoncker*, *ESSIMAGE*, *Lume*, *Memento GTAE*, *OASIS*, *TAPE*, and *Tata-Box*. They explicitly align with agroecological principles and aim to capture the complexity, dynamics, and socio-ecological specificity inherent to agroecological transitions. They are specifically designed to assess not only environmental and economic performance but also social, political, and knowledge-based dimensions essential to agroecology, such as biodiversity conservation, resource recycling, resilience, equity, and participatory governance. All remaining 20 frameworks were originally created to evaluate broader concepts of agricultural sustainability rather than agroecology specifically. Nevertheless, many of them incorporate agroecological principles such as ecological integrity, social well-being, resilience, and multifunctionality—even if they do not position themselves explicitly within the agroecological paradigm.

In terms of coverage of the agroecological components (Figure 4), *OASIS, TAPE, Memento GTAE*, and several others, such as *Autodiag, FAI, IDEA, Lume, MESMIS, MMF, PG Tool, PSDCIFASA, SAEMETH, SAFA, SEPLS, SMART-Farm Tool,* and *Tata-Box*, each cover all ten

TABLE 1 Overview of the 28 assessment frameworks relevant to AET, including their sustainability dimensions, geographical application, methodological features, operational scale and territoriality, and agroecological components that they cover.

No	Frameworks	Sustainability dimensions	Case study/ empirical application locations	Key features	Operational scale and territoriality	AE focus	AE components addressed	Sources
1	"System for weighted environmental impact assessment of rural activities (APOIA-NovoRural)"	Ecological, socio-cultural, economic, mgt and admin	Brazil	Environmental impact assessment; sustainability index	Farm-centric (Implicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance	Rodrigues et al. (2010, 2014)
2	"Self-diagnosis of agroecological practices in a family farming context (Autodiag)"	Environmental, Socio-economic, Political and organizational	Burkina Faso, Senegal, Peru	Community-based self-diagnosis of AE practices	Farm-centric (implicit)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Arango et al. (2019)
3	"Integrated valuation of ecosystem services to understand and steer agroecological transitions (Dendoncker)"	Biophysical, economic, sociocultural, ecosystem service	Belgium	Cyclical framework guiding AE transitions via ecosystem services assessment	Territorial (SES)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance	Dendoncker et al. (2018)
4	"Evaluation system for sustainable, regional agricultural development (ESEEP)"	Economy, society, environment, education, and population	China	Sustainable regional agriculture assessment using entropy theory	Farm-centric/ regional (implicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience	Li et al. (2019)
5	"Evaluation and Simulation of Agroecological Systems (ESSIMAGE)"	Agro-environmental, social, and economic	France	Indicators and GIS simulation for farm assessment	Farm-centric (none)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Human Values	Trabelsi et al. (2019)
6	"Farm assessment index (FAI)"	Socio-economic, ecology	India	Composite indices using stock and flow framework	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Muthuprakash and Om Damani (2019)
7	"Framework for evaluating sustainable land management (FESLM)"	Productivity, security, protection, viability, and acceptability	Vietnam, Indonesia, Thailand	Sustainability thresholds integrated into a DSS	Multi-scale (explicit)	No	Biodiversity; Synergies; Efficiency; Soil Health; Resilience; Knowledge Co-creation; Human Values; Governance	Lefroy and Hans-Dieter Bechstedt (2000), Rais and Sharma (2008), and Smyth and Dumanski (1995)
8	"Framework of Participatory Impact Assessment for Sustainable and Resilient Farming systems (FoPIA-SURE-Farm)"	Food prod, Economic, Natural resources, and Resilience	The Netherlands, Belgium, Italy	Stakeholder-based resilience evaluation	Multi-scale (explicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values; Governance	Meuwissen et al. (2022), Paas et al. (2020), and Paas et al. (2021)

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TABLE 1 (Continued)

No	Frameworks	Sustainability dimensions	Case study/ empirical application locations	Key features	Operational scale and territoriality	AE focus	AE components addressed	Sources
9	"Farm Sustainability Indicators method (IDEA)"	Agroecological, socio-territorial, economic	France, Morocco, Tunesia	Self-assessment tool using sustainability indicators	Farm-centric (implicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Baccar et al. (2019), Gara et al. (2021), Hakimi and Hamdoun (2023), and Zahm et al. (2006, 2008)
10	"Assessment method for the economic-ecological analysis of agroecosystems (Lume)"	Environmental, social, and economic	Brazil	Family farms as economic-ecological units	Farm-centric (implicit)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	De Mey et al. (2011) and Petersen et al. (2020)
11	"A system for monitoring of monitoring and evaluation agroecology (Memento GTAE)"	Agro-enviroment, Socio-economic	Madagascar, Burkina Faso, and Haiti	Monitoring agroecology practices and enabling factors	Farm-centric (implicit)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Levard et al. (2019)
12	"Framework for the Evaluation of Management Systems using Indicators (MESMIS)"	Productivity, Stability, Reliability, Resilience, Adaptability Equity, Self-empowerment	Guatemala	Cyclical sustainability evaluation of agroecosystems	Multi-scale (explicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Astier et al. (2012), González-Esquivel et al. (2020), and López-Ridaura et al. (2002)
13	"Method to assess sustainability of agricultural systems (Soulé)"	Environmental, social, and economic	France	Assessment of environmental and ecosystem service impacts	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health	Soulé et al. (2023)
14	"Multiscale Methodological Framework (MMF)"	Productivity, stability, reliability, resilience, adaptability	Mali	Systems analysis for sustainability and scenario development	Multi-scale (explicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	López-Ridaura et al. (2005)
15	"Monitoring Tool for Integrated Farm Sustainability (MOTIFS)"	Ecological, economic, social	Belgium	Integrated farm sustainability indicators	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Human Values	De Mey et al. (2011), Meul et al. (2008), and Van Passel and Meul (2012)

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TABLE 1 (Continued)

No	Frameworks	Sustainability dimensions	Case study/ empirical application locations	Key features	Operational scale and territoriality	AE focus	AE components addressed	Sources
16	"Original Agroecological Survey Indicator System (OASIS)"	Agroecological farm practices, Economic, Socio-political, Environment, Resilience	Kyrgyzstan	Indicators aligned with SDGs and AE components	Farm-centric (implicit)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Peeters et al. (2018)
17	"Public Goods tool (PG tool)"	Environmental, economic, social and governance	EU countries	Multi-criteria agroforestry sustainability assessment	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	den Herder et al. (2022), Gerrard et al. (2012), and Smith et al. (2022)
18	"Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)"	Social, economic, and environmental	Bangladesh	Multi-criteria decision analysis for farm systems	Farm-centric (none)	No	Synergies; Soil Health; Resilience; Human Values; Circular Economy	Talukder and Hipel (2018) and Uzun et al. (2021)
19	"Problem-oriented Status-Driver Composite Indicator-base Framework of Agricultural Sustainability Assessment (PSDCIFASA)"	Demographic and natural, Socio-economic, and Political and institutional	Iran	Composite indicators for sustainability evaluation	Farm-centric/ regional (implicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Fallah-Alipour et al. (2018)
20	"Response-inducing sustainability evaluation (RISE)"	Social, economic, and ecological	Ecuador	Assessing sustainability directly at the farm level	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Human Values	De Olde et al. (2016), Häni et al. (2003), and Heredia-R et al. (2020)
21	"Sustainable Agri-Food Evaluation Methodology (SAEMETH)"	Socio-cultural, agro-environmental, economic	EU	Sustainability of small-scale supply chains	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Peano et al. (2014, 2015)
22	"Sustainability Assessment of Food and Agriculture Systems (SAFA)"	Political, environmental, economic, and social	Indonesia, Switzerland, Paraguay, France, UK, Italy	FAO framework for evaluating sustainability in food and agriculture systems	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Gayatri et al. (2016), Iocola et al. (2020), Landert et al. (2017), and Soldi et al. (2019)

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TABLE 1 (Continued)

No	Frameworks	Sustainability dimensions	Case study/ empirical application locations	Key features	Operational scale and territoriality	AE focus	AE components addressed	Sources
23	"Sustainability Assessment of Farming and the Environment (SAFE)"	Social, governance, Environmental, Economic	Europe	Sustainability framework for production systems	Multi-scale (explicit)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Human Values	Sauvenier et al. (2005) and Van Cauwenbergh et al. (2007)
24	"Assessment of the resilience of socio-ecological production landscapes and seascapes (SEPLS)"	Ecosystem, social, agricultural system	Cyprus, China	Resilience of socio-ecological production landscapes	Territorial/SES (SES)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Ciftcioglu (2017), Dunbar et al. (2020), and Yang et al. (2020)
25	"SMART-Farm Tool"	Environment, economic, social well-being, good governance	Ghana, Kenya, Sweden	SAFA-based farm sustainability assessment	Farm-centric (none)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Blockeel et al. (2023); Resare Sahlin et al. (2022); Schader et al. (2016, 2019)
26	"Social-Ecological Systems Framework for Food Systems "SES (T)"	Social, Ecological, Externalities to other SES	Cambodia	Diagnosing sustainability issues in food systems	Territorial/SES (SES)	No	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values; Governance	Marshall (2015)
27	"Tool for Agroecology Performance Evaluation (TAPE)"	Env and CC, health and nutrition, society and culture, econ, and gov	Colombia, Nicaragua	Assessing AE-aligned practices, policy influence	Territorial/SES (SES)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Barrios Latorre et al. (2023), Bicksler et al. (2021), El Mujtar et al. (2023), and Mottet et al. (2020)
28	"Participatory design assessment methodology of territorial biodiversity-based agriculture (Tata-Box)"	Natural resources, Farming systems, Supply Chain, Gov & Institutional	France	Visioning and steering local agricultural system transitions	Territorial/SES (SES)	Yes	Biodiversity; Synergies; Efficiency; Recycling; Soil Health; Resilience; Knowledge Co-creation; Human Values & Fairness; Governance; Circular Economy	Bergez and Audouin (2023) and Duru et al. (2015)

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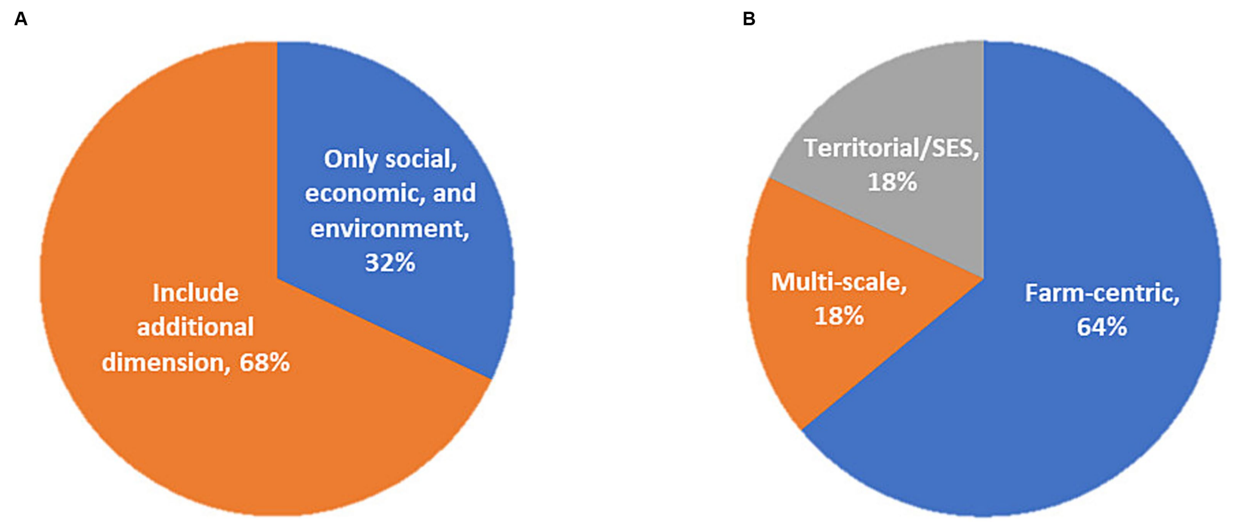

FIGURE 2
General characteristics of **(A)** Sustainability dimensions and **(B)** Operational scale and territoriality of frameworks.

components of the synthesized FAO-HLPE framework. These highly comprehensive frameworks span the full range of agroecology components — including diversity, synergies, resilience, recycling, efficiency, equity, responsible governance, co-creation of knowledge, as well as cultural values and traditions, and circular and solidarity economy considerations. In contrast, a few frameworks, such as *Soulé* and *PROMETHEE*, cover only five components, while tools like *ESEEP* and *FESLM* fall in the mid-range with 6 and 8 components. Two components were addressed in all 28 frameworks: Synergies and Soil Health. And 6 were covered in 27 frameworks: Diversity and Biodiversity, Resource Efficiency, Resilience and Economic Diversification, and Human Values, Fairness, and Cultural Traditions. Recycling appears in 26 frameworks, while Co-create and Share Knowledge and Responsible and Participatory Governance are addressed by 21 frameworks each. The Circular and Solidarity Economy is the least integrated, appearing in only 17 frameworks.

Last but not least, there is a clear geographical concentration in the origin and application of the frameworks: 13 out of 28 (46%) have been applied in Europe, and 8 frameworks (29%) in Latin America. In contrast, regions such as South Asia and sub-Saharan Africa are notably underrepresented, with only a few frameworks developed or tested in these contexts. This geographical imbalance may limit the contextual validity and adaptive relevance of many frameworks, as they may not fully capture the agroecological, socio-political, and institutional dynamics specific to these underrepresented regions.

3.2 Analysis of AET-relevant assessment frameworks

The analysis of the 28 assessment frameworks revealed four recurring analytical dimensions that are central to evaluating AET. These were not predefined but emerged inductively through repeated comparison between patterns observed in the frameworks and themes noted in the AET literature mentioned in the methodology. In practice, this meant that as we examined each framework's objectives, structure, and indicator sets, we noted common ways in which they conceptualized and organized assessment. These recurring patterns were then refined through iterative review until four overarching dimensions could be articulated.

These dimensions first cover a triple focus of evaluation on:

1 Interactions between sustainability components and indicators: Refers to how frameworks assess the relationships—both synergies and trade-offs—between sustainability dimensions (environmental, economic, social, and political) and their associated indicators. In our review, some frameworks explicitly linked indicators across dimensions (e.g., soil health with farm income or community well-being), while others treated them in isolation without examining interdependencies.
2 Stakeholder interactions: Examines how frameworks account for the roles, relationships, and influence of different actors, including mapping networks, exploring power dynamics, and assessing collaboration or conflict.
3 Learning produced by interactions: Evaluates whether frameworks generate or capture learning through participatory processes, reflection cycles, adaptive management, or feedback mechanisms.

In addition to this triple focus, a fourth dimension was identified in the mode of evaluation:

4 Participation and adaptability: Consider both the extent of stakeholder participation and the framework's flexibility to adapt to local contexts, knowledge systems, and diverse scales or production systems.

As illustrated in Figure 5, nearly all frameworks (27) position themselves in at least one of the four identified dimensions (only the *ESEEP* does not address any). Six frameworks—*Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, TAPE,* and *Tata-Box*—integrate all four

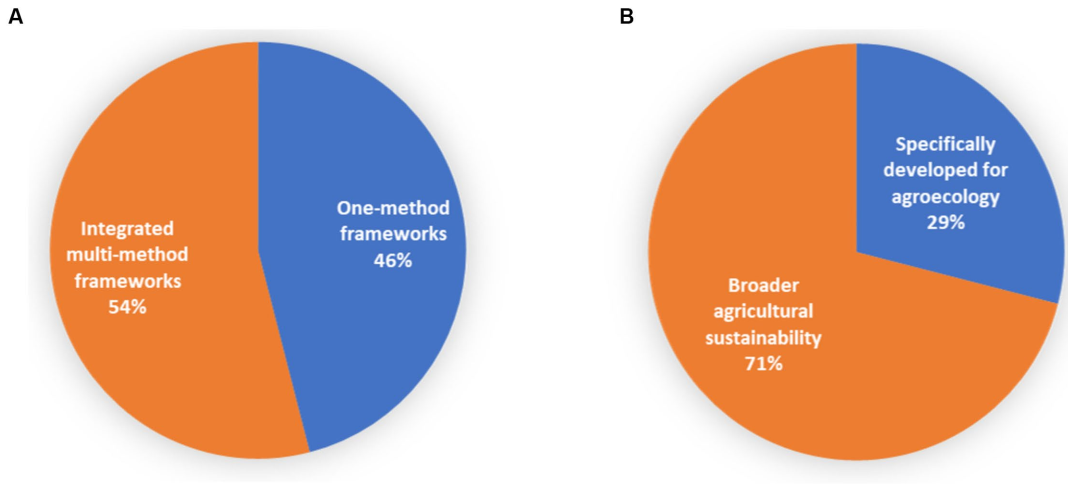

FIGURE 3
Overview of **(A)** the methodological architectures and **(B)** agroecological orientation of the 28 assessment frameworks.

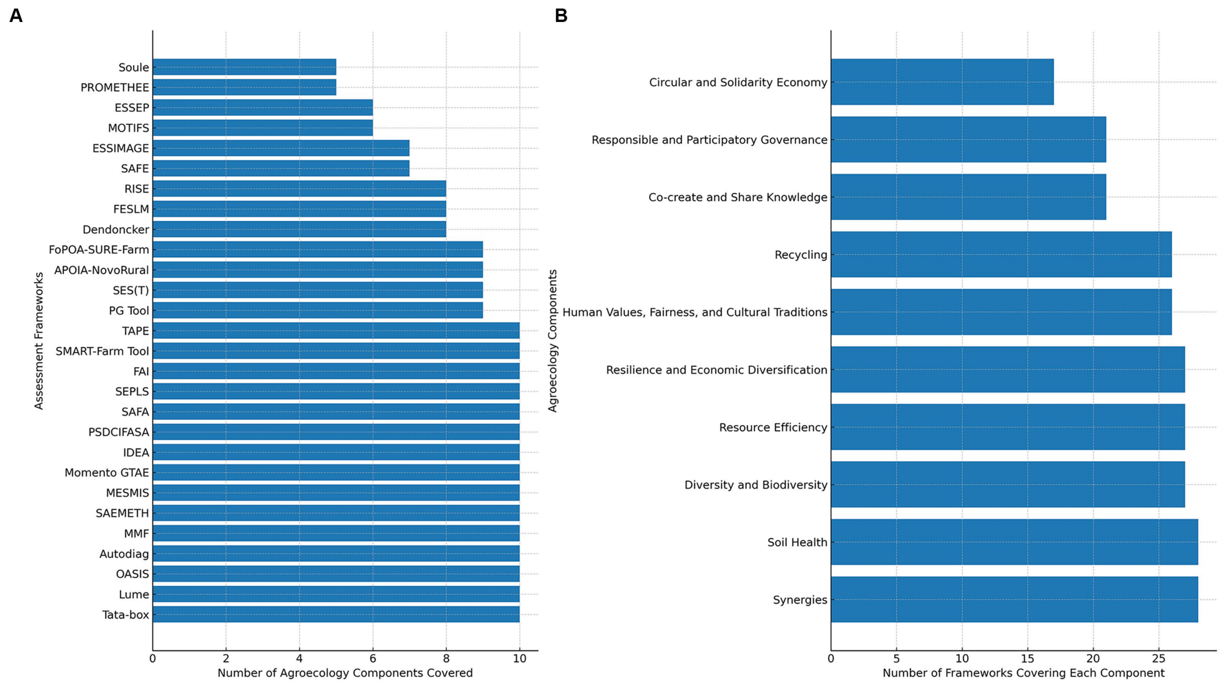

FIGURE 4
(A) Coverage of AE components by each framework and **(B)** frequency of each AE component across all frameworks.

dimensions, though they apply a variety of methodologies, each adapted to meet specific objectives within these.

3.2.1 Interaction between sustainability components and indicators

Among the 28 frameworks analyzed, 18 explicitly address such interactions: *APOIA-NovoRural, Autodiag, Dendoncker, ESSIMAGE, FAI, FoPIA-SURE-Farm, MESMIS, MMF, PROMETHEE, PSDCIFASA, RISE, SAFA, SAFE, SES(T), Soulé, SMART-Farm Tool, TAPE*, and *Tata-Box*. Based on their methodological orientation, these frameworks can be grouped into three categories.

3.2.1.1 Expert-driven frameworks (11)

These are frameworks primarily designed and analyzed by technical experts, relying on modeling, indicator hierarchies, or statistical approaches to identify synergies, trade-offs, and redundancies. Frameworks in this category include *APOIA-NovoRural, ESSIMAGE, FAI, PROMETHEE, PSDCIFASA, RISE, SAFA, SAFE, SES(T), Soulé*, and *SMART-Farm Tool*. Many adopt integrated indicator frameworks—for example, *SAFE* and *SAFA* apply hierarchical structures that link environmental, social, economic, and governance criteria, while the *SMART-Farm Tool* operationalizes SAFA guidelines for systematic evaluation of impact convergence and divergence. Modeling-based approaches such as *ESSIMAGE* use dynamic simulations to forecast management impacts, *PROMETHEE* employs multi-criteria decision analysis to balance conflicting objectives, and RISE combines assessments of state and driving forces to reveal interdependencies. Others focus on systemic relationship mapping, such as *APOIA-NovoRural*'s synthesis graphs or Soulé's correlation matrices, to detect complementarities and conflicts. *FAI* and *PSDCIFASA* integrate multidimensional indicators with explicit analysis of interrelations, and *SES(T)* embeds learning and reflexivity within a socio-ecological transformation framework to evaluate interactions over time.

3.2.1.2 Hybrid frameworks (3)

These frameworks combine participatory processes with expert-led analysis. *Dendoncker, MMF,* and *FoPIA-SURE-Farm* integrate stakeholder engagement with technically supported analytical tools. *Dendoncker* combines participatory diagnostics involving farmers, researchers, local authorities, NGOs, and market actors with expert modeling of ecosystem services and trade-offs. *MMF* engages actors across levels—from farm households to state institutions—in co-defining sustainability criteria, which are then modeled using simulations and linear programming. *FoPIA-SURE-Farm* facilitates stakeholder workshops to co-construct causal loop diagrams, followed by expert-supported system dynamics analysis.

3.2.1.3 Participatory-driven frameworks (4)

Autodiag, *MESMIS, TAPE,* and *Tata-Box* place stakeholders at the centre of the assessment process from selecting indicators to analyzing synergies and trade-offs. These approaches foster co-creation of knowledge, resulting in context-sensitive, socially grounded assessments. *MESMIS* applies iterative participatory evaluations to balance multiple sustainability objectives. *TAPE* guides participatory agroecological performance assessments focusing on interaction effects. *Tata-Box* facilitates territorial scenario-building processes, while *Autodiag* supports farmer-led self-assessments of agroecological practices and their systemic interdependencies.

3.2.2 Stakeholder interactions involved in the AET

Stakeholder interactions constitute a core analytical dimension in evaluating AET. In the context of assessment frameworks, this dimension examines how frameworks account for the roles, relationships, and influence of different actors (e.g., farmers, consumers, NGOs, institutions, policymakers). This is important because social interaction, coordination, and engagement are widely recognized as essential both for the co-production of situated knowledge and for driving the institutional and systemic changes required for AET. Among the 28 frameworks reviewed, 23 explicitly address interactions among actors involved in AET. We identified two main methodological approaches in which these frameworks address social interactions: mixed-method social analysis and participatory stakeholder analysis.

The mixed-method social analysis was used in 22 frameworks. It primarily combines quantitative indicators (e.g., participation rates) with qualitative assessments (e.g., levels of trust) to provide a snapshot of social structures and outcomes. This method focuses on evaluation through predefined metrics rather than active co-analysis with stakeholders. The indicators used cover four main thematic areas:

- Diversity and strength of relationships: Eleven frameworks (*Autodiag, IDEA, Lume, MESMIS, MMF, SAEMETH, SAFA, SAFE, SMART-Farm Tool, TAPE,* and *Tata-Box*) evaluate how frequently and effectively different actors interact, focusing on trust, collaboration, and mutual learning. For example, *MESMIS* and *SMART-Farm* assess levels of trust between farmers and institutions, while *SAFA* and *Lume* examine the range and diversity of actors involved in knowledge-sharing and support networks.
- Organizational involvement: Twelve frameworks (*ESSIMAGE, FESLM, Lume, MOTIFS, OASIS, PG Tool, PSDCIFASA, SAEMETH, SAFA, SMART-Farm Tool, TAPE,* and *Tata-Box*) assess participation in cooperatives, producer associations, local events, or collective decision-making. These indicators reflect how actors are engaged in formal and informal institutional structures. For instance, the *PG Tool* and *TAPE* consider

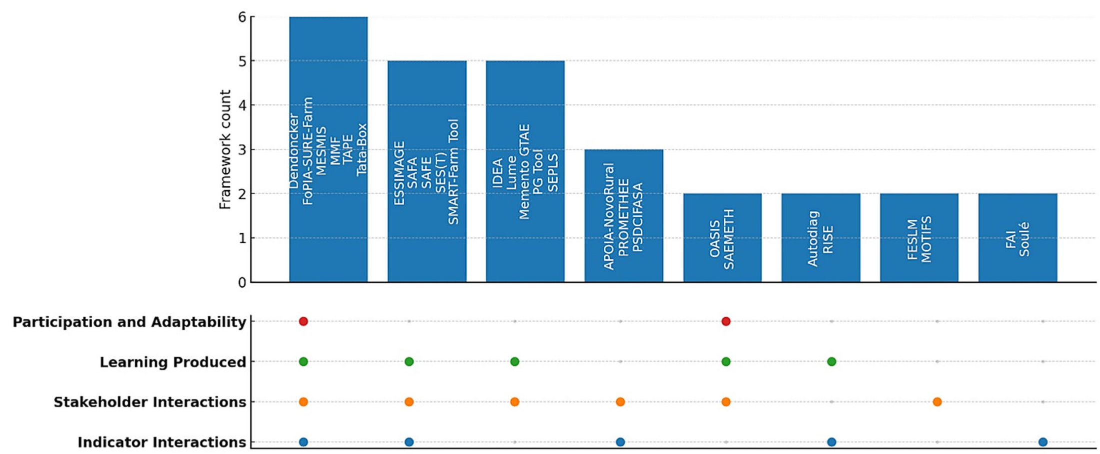

FIGURE 5
Synthesis of the 28 assessment frameworks based on the extent to which they integrate the four analytical dimensions for evaluating AET: (1) Interaction between sustainability indicators, (2) stakeholder interactions, (3) learning produced by interactions, and (4) participation and adaptability.

participation in multi-stakeholder platforms and planning forums, while frameworks like *OASIS* and *SMART-Farm* assess membership in cooperatives and producer groups.
- Connection to local contexts: Five frameworks (*Dendoncker, SAEMETH, SAFA, SEPLS*, and *SMART-Farm Tool*) consider how actors are embedded in specific territorial, cultural, and governance settings. SAFA and Dendoncker assess alignment with local institutions; SEPLS and SMART include indicators on traditional ecological knowledge and local responsiveness.
- Equity and inclusion: Nine frameworks (*Lume, Memento GTAE, PROMETHEE, SAEMETH, SAFA, SEPLS, SMART-Farm Tool, TAPE*, and *Tata-Box*) evaluate the participation of women, youth, and marginalized groups. These indicators go beyond representation in leadership roles (as in *Lume* and *SAFA*) to include broader inclusion in planning and implementation, as emphasized in *TAPE* and *Tata-Box*.

Participatory stakeholder analysis was used in only three frameworks (*FoPIA-SURE-Farm, SES(T),* and *Tata-Box*). It adopts more in-depth participatory approaches aimed at analyzing actor roles, power dynamics, and governance structures. *FoPIA-SURE-Farm* uses participatory system modeling and multi-stakeholder workshops to identify and assess the roles, influence, and interrelations of various actors (e.g., farmers, NGOs, state agencies), often using causal loop diagrams and scenario-building techniques. *SES(T)* integrates "actors" as a core sub-system of analysis, focusing on institutional configurations, co-management arrangements, and the negotiation of sustainability goals among diverse stakeholder groups, including public agencies and farmers organizations. *Tata-Box* incorporates a structured process for stakeholder identification, mapping, and iterative engagement. It emphasizes co-design and visioning exercises as tools for facilitating shared governance and territorial coordination in support of AET.

3.2.3 Learning produced by interactions between stakeholders

In this review, "learning" refers to processes through which actors—whether individuals, collective stakeholder groups, or institutions—acquire, share, or adapt knowledge, skills, and practices relevant to AET. We distinguish between learning as a measured property of the socio-ecological system and learning generated by the assessment process itself. The latter can occur deliberately, when built intentionally into the assessment design, or incidentally, when it emerges as a by-product of using the framework.

First, learning as a measured property of the socio-ecological system was addressed in three frameworks: *SEPLS, SAFE,* and *SES(T)*. These frameworks explicitly or indirectly address learning as part of the system's capacity for transformation. In *SEPLS*, learning is assessed through indicators on ecological knowledge and adaptive behavior within its resilience framework, examining whether landscapes and communities possess the cognitive and behavioral tools to respond to change. *SAFE* does not measure learning directly but incorporates governance, coordination, and innovation indicators that can indirectly capture aspects of institutional learning. *SES(T)* embeds learning and reflexivity into its socio-ecological transformation theory, explicitly evaluating whether systems engage in iterative knowledge production, adaptive management, and critical reflection—key elements for sustaining long-term change.

Second, the learning generated by the assessment process itself covers cases where the assessment process creates opportunities for knowledge acquisition, exchange, or adaptation during its implementation.

- Deliberate learning: Eight frameworks—*Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, OASIS, SAEMETH, TAPE,* and *Tata-Box*—intentionally foster learning by involving stakeholders across all stages of the assessment. *MESMIS, MMF*, and *SAEMETH* emphasize cyclical assessment processes, using repeated feedback loops to enable both institutional and individual learning. *Dendoncker, FoPIA-SURE-Farm*, and *Tata-Box* employ participatory scenario-building, causal loop diagrams, and co-design workshops to strengthen shared understanding of trade-offs, ecosystem dynamics, and resilience. *TAPE* and *OASIS* embed experiential and deliberative learning, encouraging farmers and other actors to critically engage with results, reflect on practices, and adapt accordingly.
- Incidental learning: Nine frameworks—*Autodiag, ESSIMAGE, Lume, Memento GTAE, SMART-Farm Tool, IDEA, PG Tool, SAFA,* and *RISE*—do not explicitly aim to measure or foster learning, but their outputs and processes can indirectly stimulate reflection and adaptation. *Autodiag* promotes peer-to-peer learning through farmer-led self-assessment. *Lume* uses visual participatory tools (e.g., productivity–efficiency graphs) to help stakeholders understand system dynamics. *Memento GTAE* incorporates collective field visits and debriefing meetings that facilitate comparison and exchange of experiences. *ESSIMAGE, SMART-Farm Tool, IDEA, PG Tool, SAFA*, and *RISE*—while more expert-led—produce outputs that, when interpreted locally, can lead to operational or strategic adjustments in line with AET goals.

Third, eight frameworks showed minimal or no link to learning: *APOIA-NovoRural, ESEEP, FAI, FESLM, MOTIFS, PROMETHEE, PSDCIFASA,* and *Soulé*. In most cases, these frameworks are predominantly expert-driven and rely on predefined quantitative or indicator-based assessments, such as threshold scoring systems or multi-criteria decision algorithms. Five frameworks (*APOIA-NovoRural, ESEEP, FAI, FESLM, and PSDCIFASA*) show no explicit link to learning, as they neither include participatory design nor provide mechanisms for iterative feedback, co-creation of knowledge, or capacity building. The remaining three (*MOTIFS, PROMETHEE,* and *Soulé*) exhibit a minimal or indirect link to learning, in which results may be shared with stakeholders but without a structured process for reflection, dialog, or adaptation. In both cases, the absence of participatory or reflexive components limits their ability to embed learning as a deliberate outcome of the assessment process.

3.2.4 Participation and adaptability of assessment frameworks

The degree of stakeholder involvement and the adaptability of assessment frameworks to specific contexts are key dimensions influencing their relevance, legitimacy, and transformative potential. Based on our analysis of 28 assessment frameworks, we distinguish three main categories: (1) top-down, (2) consultative/semi-participatory, and (3) participatory and adaptive frameworks.

3.2.4.1 Top-down assessment model (12)

APOIA-NovoRural, ESEEP, FAI, FESLM, IDEA, MOTIFS, PG Tool, RISE, SAFE, SAFA, SEPLS, and *SMART-Farm Tool* were developed by expert institutions to produce standardized and comparable assessments across diverse agricultural systems and regions. Their methodologies rely on fixed sets of indicators and pre-established procedures, offering little to no opportunity for users to adapt the framework to local contexts or modify the evaluation process. Stakeholder involvement, when present, is often limited to the provision of data or validation of results after the assessment has been conducted. As such, these frameworks prioritize methodological rigour and cross-case comparability over participatory engagement or contextual responsiveness. While effective for benchmarking and policy-oriented evaluation, their rigid structures constrain local ownership, iterative learning, and the capacity to reflect the complex, dynamic realities of AET.

3.2.4.2 Consultative or semi-participatory model (8)

These frameworks incorporate stakeholder involvement at selective stages such as implementation, interpretation, or validation, while retaining an expert-led structure with fixed indicators and methodologies. Frameworks, like *Autodiag* and *Lume*, allow stakeholders—primarily farmers—to reflect on assessment results through group discussions or interpretive workshops, supporting context-based interpretation without influencing the framework's design. *Memento GTAE* and *Soulé* involve stakeholders during result validation or data collection phases through interviews and surveys, though the assessment criteria remain centrally defined and analyzed by experts. Some frameworks permit stakeholder input in scoring or diagnostics. Specifically, *ESSIMAGE* and *PROMETHEE* incorporate local assessments of pre-set indicators, while *PSDCIFASA* blends participatory scoring with institutional evaluation. Finally, *SES(T)* integrates stakeholders more deeply during the framing phase, such as scenario development and system mapping, yet relies on a fixed socio-ecological framework shaped by researchers.

3.2.4.3 Participatory and adaptive model (8)

Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, OASIS, SAEMETH, TAPE, and Tata-Box were intentionally designed to be flexible, iterative, and co-constructed with local stakeholders. They support stakeholder engagement throughout the process—from framing sustainability challenges to developing indicators, analysing results, and defining future actions. Frameworks—such as *MESMIS, MMF,* and *SAEMETH*—adopt fully iterative participatory approaches that involve stakeholders in co-defining criteria and re-evaluating indicators over time, thereby enabling learning, reflection, and adaptive management. *FoPIA-SURE-Farm* and *Tata-Box* use participatory scenario-building and system mapping, respectively, to facilitate dialog and uncover trade-offs, power dynamics, and resilience strategies. *TAPE* and *OASIS* rely on participatory self-assessment and regional customisation; *TAPE* supports farmers in evaluating their own practices, fostering peer learning, while *OASIS* guides co-design and place-based planning for AET. Finally, the *Dendoncker* integrates stakeholders in both valuation and governance processes by combining participatory diagnostics and trade-off analysis, often through deliberative forums.

4 Discussion

4.1 Analytical dimensions for assessing AET

The four analytical dimensions identified in this review—(1) interactions between sustainability components and indicators, (2) stakeholder interactions, (3) learning generated through interactions, and (4) participation and adaptability—emerged inductively through a grounded process that combined transition theory, agroecology literature, and analysis of 28 frameworks (Duru et al., 2015; Geels, 2019; Magrini et al., 2019; Tittonell, 2023a). Because AET unfold across multiple interacting scales, the spatial positioning of frameworks directly shapes how these dimensions are conceptualized and operationalized. Across all four dimensions, power also emerges as a transversal axis, influencing whose knowledge is legitimized, who defines indicators, and whether frameworks reinforce or challenge existing socio-technical hierarchies (Leach et al., 2020; Pimbert, 2015; Giraldo and Rosset, 2018). Making this explicit shifts the analysis from a methodological comparison to a political–epistemological reading of how assessment tools participate in—or resist—dominant agricultural development trajectories (Anderson et al., 2019; Wezel et al., 2020).

The first dimension (interactions between sustainability components and indicators) captures the challenge of managing the synergies and trade-offs inherent to complex, multifunctional agroecosystems, a central theme in the work of authors like Gliessman (2016) and Tittonell (2023a, 2023b). Drawing from sustainability pathways research, the second dimension (stakeholder interactions) acknowledges the politics of transitions, recognizing that change is socially embedded and shaped by institutional arrangements, actor networks, and unequal power relations (Leach et al., 2020; Darmaun et al., 2023). The third dimension (learning produced by interactions) highlights the shift from top-down knowledge delivery to social learning, emphasizing reflexive and adaptive processes where knowledge is co-created, allowing actors to revise goals and navigate emerging challenges, including through evaluation itself (Pretty, 2008; Duru et al., 2015; Oteros-Rozas et al., 2019). Finally, the last dimension (participation and adaptability) underscores the context-specific nature of AET and the need for evaluation frameworks to fit into these specificities. It calls for governance approaches that embrace diversity and uncertainty, reinforcing the need for inclusive and flexible frameworks that are meaningful in diverse local settings and avoid being the mere translation of pre-established operational schemes (Stirling, 2014; Wezel et al., 2009).

When assessed against the AE components, most frameworks show partial alignment with significant gaps. Some frameworks—such as *Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, TAPE*, and *Tata-Box*—achieve more balanced integration by combining ecological, social, economic, and cultural dimensions with participatory governance and co-learning processes. In contrast, many frameworks emphasize biophysical indicators such as efficiency, resilience, or diversity while giving limited attention to socio-cultural dimensions, and the narrowest tools (e.g., *FAI, Soulé, FESLM, MOTIFS*) remain largely technical and ecological. This divergence reflects not only conceptual differences but also the scalar choices embedded in the frameworks: farm-centric designs tend to privilege biophysical metrics, whereas multi-scale and territorial approaches are better equipped to integrate governance, culture, and social learning. This reflects a broader trend in agroecological assessments where cultural values, governance, and participatory processes are marginalized in favor of measurable biophysical metrics (Anderson et al., 2019; Wezel et al., 2020). This bias represents a missed opportunity, holding back the meaningful participation and deliberate learning that are crucial entry points to enable transformative, context-specific transitions (Pimbert, 2015; Giraldo and Rosset, 2018).

4.2 Synergies, trade-offs, and systemic complexity

Agroecosystems are inherently complex and multifunctional, with changes in one domain—such as productivity—often cascading into others, including biodiversity, labor, or social equity (Perfecto et al., 2019; Tittonell, 2023a). Frameworks that reduce sustainability dimensions to isolated metrics risk generating siloed insights that, while technically sound, overlook the relational dynamics of farming systems (Liu et al., 2022; Wiget et al., 2020). Even when interactions are acknowledged, they are frequently approached through technocratic modeling or statistical aggregation, rather than participatory exploration of trade-offs and synergies. This tendency reflects the persistence of reductionist traditions in agricultural assessment, which struggle to capture the systemic interdependencies that are central to AET. These reductionist tendencies can also reproduce existing power dynamics, as standardized, expert-driven metrics often privilege institutional priorities over farmers' situated knowledge and locally defined sustainability concerns.

Addressing this gap requires evaluative approaches that are reflexive, integrative, and capable of illuminating tensions between competing goals such as productivity, equity, and ecological regeneration (Tittonell, 2023a). The appropriate level of complexity should be guided by the framework's purpose—whether for learning, monitoring, planning, or policy evaluation—as well as the material, temporal, and institutional resources available to support implementation (Patton, 2008; Tittonell, 2023a). While participatory and systems-oriented frameworks can provide transformative insights, they may be less feasible in settings with limited facilitation capacity or stakeholder access (Pereira et al., 2020). A more deliberate alignment between assessment objectives, methodological complexity, and resource constraints is therefore essential to ensure that tools not only reflect systemic realities but are also operationally viable and contextually appropriate.

4.3 Stakeholder interactions in AET

Stakeholder engagement is widely recognized as a cornerstone of AET, both for co-producing situated knowledge and as a lever for institutional change (Pimbert, 2015; Wezel et al., 2009). While most frameworks include some form of interaction—through surveys, workshops, or collaboration indicators—the depth of engagement often remains limited. In many cases, participation is reduced to consultation that records perspectives without shaping framework design, indicator choice, or decision-making. This corresponds to what Arnstein's "Ladder of Citizen Participation" (1969) describes as tokenistic forms of involvement, where stakeholders are heard but lack real influence over decisions. Such approaches risk treating engagement as a procedural requirement rather than a substantive process, thereby missing opportunities to mobilize local expertise, build ownership, and co-create transition strategies (Schneider and Niederle, 2010). These patterns reflect deeper political–epistemological dynamics, where expert-defined agendas and institutional authority often determine what counts as legitimate knowledge, limiting the ability of frameworks to challenge dominant regimes or accommodate alternative agroecological visions.

Only a few frameworks explicitly address the power asymmetries that determine whose voices are prioritized, whose knowledge is legitimized, and who influences pathways of change (Darmaun et al., 2023; Pretty, 2008). Without this lens, participation risks becoming tokenistic, reinforcing dominant narratives and sidelining women, youth, and indigenous groups. Notable exceptions—such as *Tata-Box, FoPIA-SURE-Farm,* and *SES(T)*—demonstrate how participatory mapping, scenario-building, and institutional analysis can transform engagement into a process that surfaces hidden dynamics and challenges entrenched hierarchies. For stakeholder interaction to drive equitable, context-sensitive agroecological transition, frameworks must interrogate not only who participates, but also how influence is distributed and decisions are negotiated (Elzen et al., 2012; Sutherland et al., 2014).

4.4 Learning produced by interactions as a driver of transition

Learning is widely recognized as a central driver of AET (Oteros-Rozas et al., 2019; Soini Coe and Coe, 2023), yet many assessment frameworks remain unclear on whether it is conceived as a system-level outcome and/or an actively facilitated process. This distinction parallels the difference between learning as a *destination*—a measurable outcome—and learning as a *pathway*—an iterative, socially mediated process. Most frameworks capture "single-loop" learning, which improves practices within existing assumptions, but transformative AET requires "double-loop" learning that questions underlying norms and institutional logics (Pahl-Wostl, 2009; Argyris, 1977). This ambiguity reflects a broader methodological gap: diagnostic approaches often reduce learning to static indicators—such as ecological knowledge, reflexivity, or innovation capacity—while participatory approaches frequently treat it as an incidental byproduct of engagement rather than a deliberate design feature (Schneider and Buser, 2018). As a result, few frameworks examine how learning actually unfolds, who benefits from it, or how it reshapes governance relations and transition trajectories (Elzen et al., 2012; Klerkx et al., 2012). Addressing this limitation requires moving from procedural participation toward intentional co-design, where learning is both an explicit objective and a mechanism for building collective agency (Engeström, 2001; Sterling et al., 2017). Recent work further underscores that AET depend on deliberate, collaborative processes of knowledge creation that integrate scientific, experiential, and local understandings (Munoz-Araya et al., 2024).

Embedding such intentionality demands mechanisms that capture not only what is learned but also by whom, under what conditions, and with what implications for equity and institutional change (Schut et al., 2016). While no single framework currently integrates these dimensions fully, promising elements exist. *SES(T)* provides diagnostic rigor in tracking learning outcomes and their systemic effects, while Tata-Box incorporates iterative, multi-actor processes that facilitate joint reflection, inclusivity, and adaptation. *FoPIA-SURE-Farm* adds participatory system mapping and scenario-building to explore alternative pathways and institutional constraints. Strategic integration of these approaches could yield assessment frameworks capable of both evaluating learning and actively cultivating the transformative capacities needed to sustain agroecological change across scales.

4.5 Participation and adaptability as design principles

Participation and adaptability are foundational to AET, as they ensure that assessment frameworks remain responsive and meaningful across a wide range of socio-cultural, ecological, and institutional contexts (Pimbert, 2015; Wezel et al., 2009). This is especially crucial in the Global South, where agricultural systems are embedded within diverse land tenure arrangements, gendered divisions of labor, agro-climatic risks, and varying degrees of market access (Morton, 2007; Meinzen-Dick et al., 2011). Inflexible, top-down frameworks risk obscuring these contextual nuances, potentially sidelining local knowledge systems and reinforcing existing institutional inequalities (Wiget et al., 2020). Therefore, assessment frameworks must strike a balance between ensuring a globally coherent understanding of agroecological principles and offering sufficient flexibility to adapt to local realities. This dual approach promotes both comparability across cases and contextual sensitivity, enabling frameworks to serve as useful tools for both global benchmarking and local transformation (Wiget et al., 2020). Such rigidity also reflects underlying power dynamics, as externally defined indicators and evaluation criteria often privilege institutional agendas over locally grounded priorities. This, in turn, limits the capacity of communities to articulate and pursue their own transition pathways.

In practical terms, the implementation of different types of frameworks also presents notable challenges. More top-down or expert-driven designs, while offering comparability, may generate data collection fatigue, local resistance, or outputs perceived as irrelevant by farmers and local institutions. Conversely, participatory frameworks—despite their conceptual strengths—are not immune to constraints such as elite capture, high facilitation and time demands, and difficulties in being scaled or institutionalized within policy processes (Arnstein, 1969). These practical tensions highlight the need for frameworks that are not only conceptually coherent but also operationally feasible across diverse governance settings.

While no single framework fully achieves a balance between global coherence and local adaptability, several participatory and adaptive models—such as *Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, OASIS, SAEMETH, TAPE,* and *Tata-Box*—offer promising approaches. These frameworks engage stakeholders throughout the assessment process, support iterative learning, and allow tailoring to regional priorities and governance contexts, thereby enhancing legitimacy and contextual relevance (Pretty, 2008; Duru et al., 2015). However, their diverse functions—ranging from diagnostic learning to policy evaluation—reveal the limits of relying on any one tool. Rather than pursuing a universal framework, future efforts should focus on aligning frameworks with specific objectives and strategically integrating complementary designs. Hybrid and modular approaches that combine diagnostic rigor with participatory, iterative processes can produce assessment tools that are both methodologically robust and catalytic for transformation (Patton, 2008; Pereira et al., 2020). For example, diagnostic designs like *SES(T)* could pair with participatory models like *Tata-Box* to merge systemic analysis with co-produced learning; principle-based frameworks such as *SAFE* could integrate with adaptive, feedback-driven processes like *MESMIS*; *FoPIA-SURE-Farm*'s scenario analysis could combine with *TAPE*'s field-level participatory application; and *OASIS*'s experiential, territorial focus could align with *Dendoncker*'s culturally embedded approach. Testing such integrated designs in real-world contexts will be essential for understanding how co-production, adaptability, and learning can be effectively operationalized to strengthen AET.

4.6 Limitations of the study

This scoping review was guided by a systematic protocol, yet some methodological limitations must be acknowledged. First, the selection of frameworks was restricted to those published in English and mainly supported by publicly accessible documentation. This likely excluded emerging or regionally grounded tools developed by farmer organizations, NGOs, or indigenous networks that operate outside formal publication channels. Second, the inductive coding strategy—while methodologically rigorous—inevitably involved interpretive judgment (Thomas, 2006). Themes were constructed through researcher-led analysis, shaped by particular theoretical lenses, which may have introduced subjectivity and constrained the range of identified dimensions of analysis (Nowell et al., 2017). Lastly, although the reviewed frameworks were grounded in case studies, the analysis focused on their conceptual design rather than the contextual realities of implementation. As a result, it offers limited insight into how various framework elements—such as participation, adaptability, and learning—are enacted, negotiated, or constrained across different agroecological settings. Future work should therefore explicitly assess the practical implementation of these frameworks, examining how they are applied (or not) at various scales, and how they handle the contextual and territorial aspects of AET.

5 Conclusion

This review analyzed 28 assessment frameworks to see how well they handle the systemic, multi-actor, and adaptive nature of AET. The study identified four key dimensions to characterize AET assessment: indicator interactions, stakeholder interactions, learning produced through interaction, and participation with adaptability. While most frameworks position themselves on at least one of these dimensions, few integrate their underlying principles in an explicit, fully comprehensive or reflexive way, which limits their ability to capture the full complexity of transition processes. The findings reveal several persistent gaps: many frameworks treat indicators as separate metrics instead of interconnected parts of a complex system, and less than half explicitly address how indicators interact. Furthermore, stakeholder engagement is often a procedural step rather than a substantive process for challenging power dynamics. Learning, while frequently mentioned, is rarely an intentional design feature and is often just a byproduct of the assessment. Additionally, many frameworks have rigid structures that hinder their adaptability to diverse contexts.

Despite these limitations, frameworks such as *Dendoncker, FoPIA-SURE-Farm, MESMIS, MMF, TAPE,* and *Tata-Box*, demonstrate more integrated, participatory, and context-responsive approaches. These examples highlight that effective assessment requires not only technical rigour but also tools capable of engaging with systemic complexity, fostering co-produced learning, and navigating power dynamics. No single framework is universally applicable; the future lies in hybrid and modular designs that combine complementary strengths. Potential integrations include: *SES(T)* with *Tata-Box* to merge diagnostic depth with participatory, iterative processes; *SAFE* with *MESMIS* to unite structured, principle-based assessment with adaptive, feedback-driven design; *FoPIA-SURE-Farm* with *TAPE* to link scenario analysis with participatory field application; and *OASIS* with *Dendoncker* to combine experiential learning with strong territorial and cultural grounding.

Taken together, the analysis suggests that future frameworks must not only improve their integrative and adaptive capacities but also confront how power influences whose knowledge is recognized, who defines evaluation criteria, and whose priorities shape transition pathways. Addressing these underlying dynamics is essential for developing tools that can genuinely support transformative agroecological change. Building on this evidence, we propose a programmatic manifesto for the next generation of AET evaluation. This manifesto establishes four non-negotiable design principles. First, evaluation must possess a Systemic Character, capable of mapping both synergies and trade-offs across components and scales. Second, frameworks must embody Power Awareness, with explicit mechanisms that make power asymmetries visible and ensure that marginalized knowledge actively shapes evaluation processes. Third, assessment must prioritize a Learning Orientation, designed as a deliberate and continuous learning process that embeds reflexive, adaptive feedback loops at its core. Finally, frameworks must incorporate Contextual Adaptability, enabling local adjustment of tools and methods while upholding fundamental principles of equity and validity. Implementing new integrated models under these principles can generate deeper insights into how co-production, learning, and adaptability are achieved, positioning assessment not only as a measurement tool but also as a driver of transformative change.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

CS: Writing – original draft, Conceptualization, Data curation, Formal analysis, Investigation, Methodology. AP: Methodology, Validation, Writing – review & editing. GB-C: Methodology, Validation, Writing – review & editing. NA-M: Methodology, Supervision, Validation, Writing – review & editing. LL: Validation, Writing – review & editing, Methodology, Supervision.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was used in the creation of this manuscript. In particular, ChatGPT (OpenAI, GPT-5, 2025) assisted with grammar refinement, rephrasing for clarity, and the preparation of Figures. All AI-assisted outputs were carefully reviewed by the authors to ensure accuracy and that the figures correctly represent the underlying data. Responsibility for the content, interpretations, and conclusions presented in this work rests entirely with the authors.

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