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Collecting holistic evidence on agroecology performance to accelerate sustainable food system transitions

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ABSTRACT

A growing body of research shows the potential of agroecology for enabling a shift to planet-friendly and socially just agrifood systems through context-specific transition pathways. We conduct a scoping review to identify and evaluate the potential of 42 existing agroecology adherence and/or agricultural performance assessment tools to generate credible, legitimate, salient and transferable evidence to inform these transitions. Results show that while multiple relevant tools exist, each of them can be strengthened in at least one area. While most tools are transferable (low time and resource requirements) and have legitimacy (open access with transparent methods), tools have variable saliency (holistic scope inclusive of local priorities) and credibility (use scientific design

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principles and quality assurance processes). For a subset of 11 tools collecting multidimensional performance data, analysis of 263 identified indicators showed there is a bias towards economic measures (notably income, yield, and resilience), while certain social (e.g. land tenure, traditional knowledge retention) and environmental (e.g. climate mitigation) aspects are regularly overlooked. Through a multidisciplinary process engaging experts across 8 countries, we develop a Holistic Localized Performance Assessment for agroecology (HOLPA) framework that integrates and builds on positive features of existing multidimensional agroecology performance assessments tools and overcomes key limitations. The HOLPA framework for analysis, agroecology indicators, key performance indicators, and low-cost localization process can be used to strengthen agroecology performance assessments, empowering landscape actors to identify evidence-based pathways towards agrifood systems where both people and nature can thrive.

1. Introduction

Our reliance on industrial agriculture is failing to bring smallholder farmers out of poverty (Woodhill et al., 2022; Schneider et al., 2023) or eliminate malnutrition (Steiner et al., 2019; Reardon et al., 2021). It has concentrated power and finances among large agribusinesses with vested interests in delaying change (Clapp, 2021; Sanderson Bellamy, 2018). Yet the agrifood system is exacerbating biodiversity loss (Jaureguiberry et al., 2022) and a root cause of catastrophic global warming (IPCC, 2023; Crippa et al., 2021), with environmental and health impacts costing society at least $10 trillion per year (FAO et al., 2023).

Agroecology is gaining traction as a means to shift to socially just and planet-safe agrifood systems (Gliessman, 2016; Wezel et al., 2020a; Altieri et al., 2012) supported by a growing body of empirical evidence showing its food security (Bezner Kerr et al., 2021), socio-economic (Mouratiadou et al., 2024; Sánchez et al., 2022; Andrieu et al., 2024), and environmental (Dittmer et al., 2023; Beillouin et al., 2021, 2023) benefits. Agroecology promotes adherence to a set of 10 elements defined by the United Nations Food and Agriculture Organisation (FAO), or 13 principles subsequently proposed by the High Level Panel of Experts (HLPE) on Food Security and Nutrition, designed to create diversified, ecologically healthy agricultural production systems in economically vibrant and socially sustainable agrifood systems (Wezel et al., 2020a).

Different entry points and pathways for putting these principles into practice are emerging at local levels around the world (Jones et al., 2022; Sachet et al., 2021; Duru et al., 2015). Examples include local and diversified sourcing for school meal programmes in Brazil (Valencia et al., 2019), agroecological enterprise development in East Africa (Fundira, 2025), and government-supported natural farming co-operatives in India (Duddigan et al., 2022). The heterogeneity of approaches shows that there are many solutions and no silver bullets in agroecology. Change happens through context-specific, locally co-created and adaptively managed transition pathways (González De MolinaDLopez-Garcia, 2021; López-García and González de Molina, 2021).

Monitoring the impact of these place-based agroecological transitions is important to ensure they improve outcomes for people and nature. Certain agroecological approaches may result in different outcomes dependent on context, or lead to trade-offs across sectors, while others consistently enhance synergies. For example, research shows thatmultiple complementary actions are often more effective than single interventions at simultaneously improving socio-economic and environmental outcomes in farms and food systems. Such strategies include adding diversity to organic cropland at field level (Ponisio et al., 2015), using multiple diversification practices in unison at farm level (Rasmussen et al., 2024; Jones et al., 2023; Rosa-Schleich et al., 2019), designing long-term, diversified intervention portfolios through multi-level stakeholder engagement at landscape level (Estrada-Carmona et al., 2024), and combining demand (shifting diets and trade) and supply side (restoration of unproductive agricultural land, agricultural productivity shits) levers at national level (Mosnier et al., 2023). A systems approach to monitoring agrifood system management and performance is needed to help identify strategies for reconciling trade-offs across agronomic, environmental and socio-economic outcomes (Dornelles et al., 2022).

To facilitate the monitoring of agroecological transitions, many tools have been developed to characterize the integration of agroecology into farms, projects, businesses and policies, and/or to monitor performance. At least 35 tools exist (Wiget et al., 2020; Geck et al., 2023), with several widely used, notably FAO's Tool for Agroecology Performance and Evaluation (TAPE) (Mottet et al., 2020), Biovision's Agroecology Criteria Tool (ACT), Farm ACT (F-ACT) and Business ACT (B-ACT) (BioVision, 2021), the Rural Household Multiple Indicator Survey (RHoMIS) (Hammond et al., 2017) and the Indicator-based Framework for Evaluation of Natural Resource Management Systems (MESMIS) (López-Ridaura et al., 2002). These tools have been used in multiple countries generating evidence for how to create sustainable systems, e.g. RHoMIS revealed differing strategies to increase climate smartness in Tanzania and Honduras, depending on farm size (Hammond et al., 2017).

Yet despite this proliferation of tools over the last few decades and rising awareness of agroecology's benefits, many policymakers and practitioners continue to aspire to an agricultural model that is heavily reliant on external inputs and overlooks the role of ecological practices and social structures in enhancing outcomes in and beyond farms. Entrenched beliefs are hard to shift (Soini Coe and Coe, 2023), and major evidence gaps in how to design effective transitions prevail for certain geographies, stakeholders, and outcomes. Previous reviews of agricultural performance tools suggest that many lack credibility, salience, and legitimacy, due to insufficient robustness and transparency, not being well-adapted to end-user needs, and using measures that are not widely known or accepted (de Olde et al., 2018). Research has further highlighted that tools that rely solely on sets of pre-defined rather than locally co-defined indicators can generate results that lack meaning to local stakeholders (Namirembe et al., 2022), limiting their utility for catalysing transitions (Darmaun et al., 2023a). One review showed that only 14% of frameworks explicitly consider trade-offs across performance themes, in part due to a gap in holistic assessment methodologies (Crossland et al., 2025). It therefore remains unclear whether existing tools can provide the holistic, scientifically robust, locally-relevant insights needed to enable evidence-based agroecological transitions.

In this paper, we conduct a scoping review to evaluate agricultural assessment tools against nine criteria designed to assess their credibility, salience, legitimacy and transferability for supporting evidence-based agroecological transitions. Next, we characterize the coverage and gaps in indicators used in open access, multidimensional agricultural performance assessment tools designed for use at the field, farm or landscape level. Building on the strengths of existing tools while seeking to address key limitations , we develop a Holistic Localized Performance Assessment for agroecology (HOLPA) framework and process for implementation, co-designed with multidisciplinary researchers spanning four continents. Finally, we discuss how researchers and practitioners can leverage holistic data collection tools to identify context-adapted solutions for shifting agrifood systems towards socially just and planet-safe trajectories.

2. Methods

2.1. Review of existing tools and indicators

We conducted a second order scoping review of agroecology performance assessment tools identified from existing published tool reviews. Here, *tool* refers to an assessment framework or methodology. Our review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) protocol (Tricco et al., 2018). Relevant tool reviews were identified by searching in Web of Science (WoS) in April 2023 and updated on 13 January 2025, using the following search string: ("agroecolog*") AND ("adherence" OR "integration" OR "performance" OR "outcome" OR "indicator*") AND ("tool" OR "assessment" OR "analysis") AND ("review"). We included peer-reviewed articles: i) reporting results from a scoping or systematic review of tools for monitoring multidimensional agricultural performance, ii) published in English or French languages. See Appendix A for the PRISMA diagram.

For each included article, we extracted the list of tools identified. We included two additional tools known to the authors (B-ACT, Global Farm Metric). We used information provided in the websites, primary articles, and guides describing each tool, to identify the scale of use, tool format, target production system, and target end-user, and to assess each tool against 9 criteria (Table 1). We developed these criteria to assess the potential use of each tool for enabling evidence-based agroecological transitions through providing credible, salient, legitimate and transferable performance assessments. Here, building on (Cash et al., 2003), credibility refers to the scientific robustness of the evidence, demonstrated by the collection of holistic data and demonstrated design validity; saliency means ensuring the evidence is relevant to end-users; legitimacy refers to the use of transparent and unbiased methods; and transferability involves enabling data collection in multiple contexts including under resource constraints. For each of the 9 criteria, tools were classified as fully (receiving a score of 1), partially (0.5), or not (0) meeting the criterion. Full details of the scoring system applied for each criterion are provided in Appendix B.

Table 1
Criteria used to assess the capacity of existing tools to enable evidence-based agroecological transitions.

Assessment area	Criteria	Description
Saliency	C1.Agroecology adherence	Tool measures the extent to which there is alignment with agroecological elements or principles.
	C2.Multidimensional performance	Tool measures performance across economic, social and environmental dimensions.
	C3.External validity	Local actors are involved in indicator selection and/or defining measures for selected indicators.
Credibility	C4.Design validity	Documentation includes a clearly stated scientific justification for the framework, indicators, measures, and/or aggregation approach.
	C5.Indicator selection criteria	Transparent indicator selection criteria are applied designed to ensure high quality and robust indicators
	C6.Process for ensuring data quality	A process is included specifically to ensure data quality at the data collection stage and/or during post-processing.
Legitimacy	C7.Open access and transparent	Tool and its documentation are publicly accessible, explaining all methodological steps used in constructing the tool, and including clear guidelines on tool use
Transferability	C8.Low technical investment	Tool application does not require advanced technical knowledge (in specialist areas such as processes affecting ecosystem service flows, econometric methods) or expertise (use of specialist computer software, access to multi-disciplinary knowledge to define indicators)
	C9.Low time investment	Tool application requires <5hrs per plot, farm or business, and <5 days per landscape

Next, we reviewed performance indicators used in a subset of the identified tools. Specifically, we extracted information on performance indicators from tools that: i) were designed for use at the field, farm or landscape level, and ii) provided openly accessible indicator and measurement descriptions in English. We excluded tools designed solely for use at project or company level on the basis that the indicator review would inform development of a performance assessment framework for use at the farm or landscape level. See the PRIMSA diagram in Appendix A for further details on the tool screening process. We extracted the indicator (e.g. agricultural productivity), how it is measured (e.g. harvested produce per unit land area), measurement units (e.g. kg/ha), data source (e.g. farmer interview, fieldwork), any thresholds associated with the indicator (e.g. potential water-limited yields), justification of these thresholds, and scale of use. Appendix B provides the full lists of screened and included articles, tools and indicators.

2.2. HOLPA development

2.2.1. Approach to ensuring credible, salient, legitimate and transferable evidence-generation

Our objective was to develop a transferable framework that produces credible, salient, legitimate evidence on how to transition to agroecology for achieving sustainable agrifood systems in specific contexts (de Olde et al., 2018), grounded in insights gained from our review of existing tools and indicators.

To develop a **credible** framework, we started by reviewing theoretical and empirical evidence in literature on agroecology's impact on agrifood system sustainability, factors affecting farmer decisions to transition to agroecology, and the limitations of existing assessment tools identified in our review and previous research. We used this to establish an initial HOLPA framework which was reviewed and improved through a series of dialogues with multidisciplinary topic experts. Emphasis was put on identifying a list of holistic performance themes and key performance indicators (KPIs), based on defined criteria, that capture the most important outcomes across (i) agronomic, (ii) economic, (iii) environmental, and (iv) social dimensions to enable cross-sector trade-off analysis that is meaningful to each discipline. Topic experts included 55 researchers - 29 men and 26 women - representing 9 institutes working with smallholder farmers in 8 countries as part of the CGIAR Transformative Agroecology initiative: Burkina Faso, India, Kenya, Laos, Peru, Senegal, Tunisia, and Zimbabwe. They included nutrition, agronomy, climate, water, soil, biodiversity, gender, equity, and value chain specialists.

To further strengthen the credibility of the data generated through HOLPA, we developed an excel-based quality assurance tool for data collected through household and field surveys used to apply the HOLPA framework (see Data availability). Survey data can contain errors, some of which can be readily fixed during the data cleaning stage and others which cannot, meaning the data point should be excluded. The quality assurance tool enables rapid detection of potential errors that the user should address or consider during analyses, e.g., flagging when the sum of the gender-disaggregated land owned, rented or shared for agricultural purposes does not match the total agricultural land area.

With respect to **saliency,** we considered the needs of local and non-local potential users of data and results. Prevailing uncertainties about agroecology's performance are likely affecting academic, farmer, civil society, government and business decisions on whether and how to support agroecological transitions. These end-users can benefit from assessments that help close data gaps and enable analysis leading to clear messages on which agroecological approaches have positive or negative effects on farms and agrifood system performance, and which individual, societal, policy and institutional factors enable transitions towards positive trajectories. At the local level, such analyses should focus on indicators that are important to individual and collective decisions. In other landscapes and countries, these local indicators may not be directly relevant but broader insights into how agroecology affects food security, biodiversity, climate, and social justice goals in different contexts are highly relevant to research and policy, enabling intra- and inter-country learning. To balance this need to close global knowledge gaps while providing locally relevant evidence, we developed a core set of 'global' Key Performance Indicators (KPIs) that can be collected everywhere, and a process for complementing these with 'local' KPIs selected with diverse stakeholders in each application landscape.

We increased framework **legitimacy** by ensuring a transparent and accessible methodological development and indicator selection process and empowering local end-users to define and apply their own criteria for selecting additional indicators. Finally, we sought to ensure **transferability** of the framework across projects and contexts by defining global KPIs that can be applied at field, farm and landscape level, and that can be collected with minimal equipment and low time requirements. We provide ODK-compatible household and fieldwork surveys that can be used to collect information on context, agroecology adherence and global KPIs for a farm-level assessment (see Data Availability). This reduces the time required to put HOLPA in a useable format compared to pdf-based assessment tools.

2.2.2. Context, agroecology and performance module development

The content of the context, agroecology and performance assessment components were co-developed with the 55 cross-disciplinary researchers involved in the HOLPA framework development, informed by theory and empirical evidence. The researchers iteratively reviewed and provided feedback on a long-list of context variables and agroecology adherence indicators. Then, the researchers used collaborative digital whiteboards - Jamboard and Miro - to co-develop a list of performance themes and potential global key performance indicators (KPIs) during six 1-h online workshops and two to five additional 1-h workshop with a subset of 5-20 researchers, for each of the four performance dimensions.

During the workshops, researchers discussed which performance themes were essential to include and agreed on indicator selection criteria. The researchers brainstormed possible KPIs and measurement methods to use for applying the HOLPA framework, and then prioritized these according to which they considered most important and effective at capturing performance in their area of expertise. To facilitate the KPI selection, the topic experts were initially presented with a long-list of potential indicators under each theme, compiled from existing tools. The indicators were not intended to represent an exhaustive list, and rather to provide a starting point, stimulate reflection and suggestions for improvement. Researchers discussed ways to capture under-reported aspects of sustainability such as farmer agency, holistic human well-being, labour inputs, and whole system yields. Where possible, researchers identified measurement methods that could be used at multiple spatial levels, i.e. field, farm and landscape.

The prioritization process involved researchers with expertise in a thematic area voting to select a single KPI per theme. After the group had voted, a single researcher then reviewed every candidate KPI and i) removed any that did not meet our inclusion criteria, ii) ensured there was at least one indicator for every performance theme, prioritising indicators that had received the most votes. We applied the following indicator selection criteria:

1. Measurability - there is a clearly defined method for collecting data for the indicator.
2. Resources required - the indicator can be measured quickly (hours not days).
3. Relevance - the indicator assesses outcomes relevant to at least one performance dimension (agronomic, environmental, social, economic).
4. Usefulness - the indicator can be used to guide decision-making for sustainability, because meaningful reference points exist or can be established to aid interpretation of scores.
5. Robustness - the indicator is supported by peer-reviewed literature or has proven reliability.
6 Acceptability - easily understood and communicated.
7. Sensitivity to change - the indicator can detect changes in farm or agrifood system management away from or towards agroecology principles.
8. Responsiveness – appropriate duration or delay between action and detectable response.

While these criteria ensured a level of consistency in indicator quality, the process of KPI selection relied on participating researcher expertise and experience. For example, for soil health, six potential indicators were identified, namely: soil bulk density, soil aggregate stability, eDNA, participatory qualitative assessments, earthworm counts, or soil organic carbon content (SOC). Twelve researchers with soil science expertise voted to select a KPI, with SOC receiving the most votes, followed by eDNA, and finally participatory transects. After the indicator selection criteria were applied, eDNA was rejected as potentially failing to meet the usefulness and acceptability criterion. SOC was retained as the preferred KPI, and qualitative assessment as an accepted alternative in contexts where soil sampling is prohibitively expensive.

To facilitate use and interpretation of the final list of KPIs, we developed indicator protocols describing the KPI purpose, how to collect data for it, guidance on indicator computation, and references for further information (Appendix C).

2.2.3. Localisation process

A local indicator selection process (LISP) was developed by reviewing participatory approaches used in existing tools and described in literature (Dossou-Yovo et al., 2024; Mamun and Natcher, 2023; Khatri-Chhetri et al., 2019) and using this to define the objectives and develop an initial workshop-based approach for LISP. Researchers from each of the CGIAR Transformative Agroecology initiative 8 focal countries and topic experts gave feedback on the draft LISP approach, which was then piloted with two groups of stakeholders in Kenya. Feedback from the pilot was used to finalise the LISP guidelines (Appendix D). Other steps in the localization process were developed through discussions and piloting with farmers, research and development partners in the 8 countries.

3. Results

3.1. A multitude of agroecology performance tools exist yet each can be improved to increase the potential for robust evidence generation

Our scoping review identified 111 articles, of which 4 met our inclusion criteria. These four articles collectively listed 40 unique tools for assessing agroecology adherence and/or agricultural performance (Appendix A). A further 2 tools were identified by the authors. Most of these tools (27, or 64%) are designed for use at a single spatial level, most commonly the farm-household level (18) followed by landscape (3), value chain (3), company (1), project (1) or field (1) level. The remaining tools (15, or 36%) were multi-level, including the farm-household and at least one lower (e.g. plot, field) and/or higher (e.g. landscape, national) level.

None of the 42 tools satisfy all 9 of our criteria for assessing tool usefulness for advancing knowledge on agroecology performance to inform agrifood system transitions, yet 7 tools meet more than half. The best performing tools are Brasilience and MOTIFS, which meet 6 of our criteria, followed by RHoMIS (5.5) then MESMIS, SALT, TAPE and Kc et al. (2016)'s assessment method, which meet 5 (Fig. 1 and Table 2).

Overall, the 42 tools vary substantially in terms of their saliency, credibility, legitimacy and transferability, suggesting there is room for cross-tool learning. In terms of saliency, half (50%) of the tools monitor agroecology adherence (criterion C1). Adherence to agroecology is assessed based on the framework of FAO's 10 elements (3 tools), HLPE's 13 principles (2 tools) or author-defined principles. Only eight tools consider aspects of agroecology at both farm and food system level (Autodiag, ACT, B-ACT, F-ACT, IDEA, Lovell et al. (2010), Lume, MLP, TAPE), whereas most tools limit their assessment to farm-level practices. Many tools (83%) include indicators for at least two of the agronomic, environmental, economic and/or social performance dimensions (C2), and 64% of tools cover all four dimensions enabling holistic trade-off analyses. While many tools partially or fully incorporate measures for assessing agroecology adherence or multiple performance dimensions, only 16 tools do both, of which only 2 fully, *i.e.* capturing all agroecological principles and all four performance dimensions (Lovell et al. (2010), TAPE). Over one third (36%) of tools include processes to engage local stakeholders in some aspect of indicator development, increasing the likelihood that indicators are meaningful to the people who could make decisions based on the data collected (external validity, C3). This engagement generally occurs during the tool development phase to include indicators selected by local stakeholders, including farmers, in each landscape where the tool is applied, fully meeting the criterion. A further four tools engage stakeholders to guide the construction of a single set of indicators applied in multiple sites, or to select indicators from a pre-defined list ('Partial' external validity in Fig. 2).

Regarding credibility, we found that most of the 42 tools (93%) do not explicitly include any process for ensuring data quality (C4). Notable exceptions include RHoMIS and SAFA, with the former including questions for the enumerator on expected reliability of responses together with steps for checking survey duration and data values are within the range of regional norms, and the latter including a user-assessment of data reliability and providing guidance for conducting an external audit. These approaches could be readily incorporated into other tools to reduce the risk of poor data, and misleading conclusions.

The design validity (C5) – use of scientific theory and methods to develop the tool structure, indicators and aggregation approach - of the tools is variable, with only two tools fully meeting this criterion and a further 16 meeting it partially. This reflects that most tools construct indicators and use aggregation methods that are explicitly, or implicitly, selected by tool developers with no or limited reference to scientific theory, protocols, or standards for ensuring data can be used for robust analyses (i.e., for hypothesis testing ensuring extraneous variables are controlled). We found that a minority of tools apply a clear and robust indicator selection criteria (C6), either fully (14%) or partially (12%). Tools that partially met the criterion used indicator selection criteria focused on data availability not indicator quality.

Concerning legitimacy, most (83%) tool descriptions and guidelines for use are open access (C7). Of note, only a few tools (e.g. B-ACT, IDEA) provide open access digital data collection forms, while most tools provide survey templates or descriptions of how to build these in pdf format only, implying a substantial pre-implementation time-investment for new users.

The resources required to apply tools is an important determinant of how feasible it is to assess agroecology performance in resource-constrained projects and contexts. We found that almost half (48%) of tools require a low level of technical investment (C8), and half (50%) a low time investment (C9) to implement.

3.2. Social and environmental metrics are neglected

We extracted 263 performance indicators from 11 of the tools, corresponding to those collecting data on multiple performance dimensions at field, farm or landscape level, and with open access indicators and measurement descriptions listed in English (further details in Appendix A and Appendix B). While these tools collect data for 22 indicators on average (range 7 to 46) capturing a wide range of performance criteria, 41% of the 263 indicators measure economic performance, followed by environmental (25%), social (21%) and agronomic (13%). Income, climate resilience, and agricultural productivity account for 71% of economic indicators, leaving other economic aspects (e.g., labour productivity, labour stability) under-represented. Certain environmental (e.g., sustainable water use, land degradation) and social (e.g., traditional knowledge retention, employment conditions) outcomes are completely neglected in most tools (Fig. 2).

Over a quarter (27%) of the 55 social indicators identified measure diet quality, generally assessed using the household dietary diversity score, food self-sufficiency, or indicators of food availability. Almost a fifth (18%) of social performance indicators measure farmer agency in

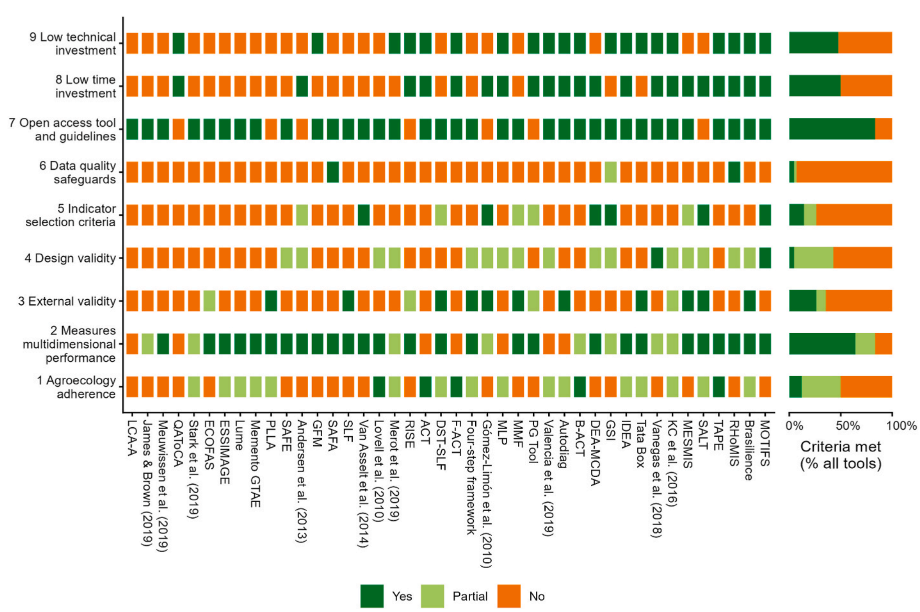

Fig. 1. Assessment of 42 agrifood assessment tools against 9 criteria, showing where each criterion was satisfied (Yes), partially satisfied (Partial), or unsatisfied (No). Full names and sources for all tools are provided in Table 2. See Appendix B for details of how the criteria were applied.

Table 2
Agrifood system performance assessment tools included in our review.

Short name	Full name	Reference
ACT	Agroecology Criteria Tool (ACT)	BioVision (2021)
Andersen et al. (2013)	An indicator-based method for quantifying farm multifunctionality	Andersen et al. (2013)
Autodiag	Self-diagnosis of agroecological practices in family farming	Arango et al. (2019)
B-ACT	Business Agroecology Criteria Tool	BioVision (2021)
Brasilience	Brasilience	Blesh and Wittman (2015)
DEA-MCDA	Data Envelopment Analysis Multi-Criteria Decision Analysis methodology to compute a composite sustainability indicator	Reig-Martínez et al. (2011)
Four-step framework	Four-step integrated ecosystem service assessment framework	Dendoncker et al. (2018)
DST-SLF	DST-SLF Framework	Fernandes and Woodhouse (2008)
ECOFAS	Ecological Framework for the Assessment of Sustainability	Monzote et al. (2012)
ESSIMAGE	Evaluation and Simulation of Agroecological Systems	Trabelsi et al. (2019)
F-ACT	Farm Level Agroecology Criteria Tool (F-ACT)	BioVision (2021)
GFM	Global Farm Metric	Kipling et al. (2024)
Gómez-Limón et al. (2010)	Empirical evaluation of agricultural sustainability using composite indicators	Gómez-Limón and Sanchez-Fernandez (2010)
GSI	Global Sustainability Index	Castoldi and Bechini (2010)
IDEA	Farm Sustainability Indicators	Zahm et al. (2019)
James and Brown (2019)	Participatory resilience assessment	James and Brown (2019)
KC et al. (2016)	Assessing links between crop diversity and food self-sufficiency in three regions of Nepal	KC et al. (2016)
LCA-A	Life Cycle Assessment in Agriculture (LCA-A)	Fan et al. (2022)
Lovell et al. (2010)	Framework for designing agroecosystems integrating agroecology and landscape multifunctionality	Lovell et al. (2010)
Lume	Lume: a method for economic-ecological analysis of agroecosystems.	Petersen et al. (2020)
Memento GTAE	Assessment method for evaluating its effects and the conditions for its development	Levard et al. (2019)
Merot et al. (2019)	Efficiency-substitution-redesign approach to classify conventional-organic farming transition strategies	Merot et al. (2019)
MESMIS	Framework for Assessing the Sustainability of Natural Resource Management Systems	López-Ridaura et al. (2002)
Meuwissen et al. (2019)	Framework to assess the resilience of farming systems	Meuwissen et al. (2019)
MLP	Multi-Level Perspective (MLP)	Vivero-Pol (2017)
MMF	Multiscale Methodological Framework	lópez-ridaura et al. (2005)
MOTIFS	Monitoring Tool for Integrated Farm Sustainability	Meul et al. (2008)
PG Tool	Public Goods Tool	Gerrard et al. (2012)
PLLA	Participatory landscape/lifescape appraisal	Veisi et al. (2013)
QAToCA	Qualitative expert assessment tool for CA adoption in Africa	Ndah et al. (2015)
RHoMIS	Rural Household Multi-Indicator Sur-vey (RHoMIS)	Hammond et al. (2017)
RISE	Response-Inducing Sustainability Evaluation (RISE)	BFH-HAFL (2022)
SAFA	Sustainability Assessment of Food and Agriculture Systems (SAFA)	FAO (2014)
SAFE	Sustainability Assessment of Farming and the Environment	Van Cauwenbergh et al. (2007)
SALT	Sustainability assessment Adaptive and Low-input Tool	Calleros-Islas (2019)
SLF	Sustainable Livelihood Framework	DFID (1999)
Stark et al. (2019)	Ecological network analysis applied to agroecological systems	Stark et al. (2017)
TAPE	Tool for Agroecology Performance Evaluation (TAPE)	Mottet et al. (2020)
Tata Box	Participatory design assessment methodology of territorial biodiversity-based agriculture	Audouin et al. (2019)
Valencia et al. (2019)	Comparative study to assess impact of government policies on use of agroecological practices and on household diet	Valencia et al. (2019)
van Asselt et al. (2014)	Protocol for evaluating the sustainability of agrifood production systems	van Asselt et al. (2014)
Vanegas et al. (2018)	Effect of ecological and conventional managements on soil enzymatic activities in coffee agroecosystems	Vanegas et al. (2018)

decision-making, assessed in diverse ways such as based on the role of farmer associations, ownership structure of farm and decision-making process, and a women's empowerment index. Another fifth assess recreation value, sourced from a single tool (Andersen et al., 2013) seeking to capture the social function of farms. A minority (9%) of social indicators assess human wellbeing, measured in terms of pesticide exposure or working conditions, while subjective and multidimensional aspects of well-being represent blind spots among the reviewed indicators. A few social indicators assess employment conditions (7%) and land tenure (6%), with other aspects of social performance represented in less than 5% of the 55 indicators.

Landscape complexity is the most frequently monitored aspect of environmental performance, representing 21% of the 67 environmental indicators identified and measured as share of non-cropped land area, habitat diversity, or extent of natural land features. Energy and resource use is captured in a further 15% of indicators in this dimension, measured in terms of energy consumption, energy use efficiency, and non-organic material use on-farm. Pollution is assessed by 12% of environmental indicators, spanning air pollution, and soil and water contamination from pesticides and fertilizers. Agrobiodiversity is the focus of a further 12% of environmental indicators, usually measured in terms of richness or abundance of domesticated species. While these indicators can help to close a critical gap in biodiversity monitoring, other types of agrobiodiversity remain poorly captured, with pollinators mentioned in only one indicator (for TAPE) and no indicators explicitly assessing biocontrol species or functional soil biodiversity. Wild biodiversity (10%), climate mitigation (9% of environmental indicators), land use change (6%), sustainable natural resource management (6%), and water use (6%) are the next most measured aspects of environmental performance, with other themes captured in less than 2% of indicators.

Agronomic performance is assessed in terms of nutrient management (39% of the 33 identified agronomic indicators) followed by soil health (33%), crop health (18%) and animal health (9%). Nutrient balance is the dominant indicator for nutrient management, followed by nutrient inputs and nutrient use efficiency. Crop health is assessed mainly in terms of actual or potential crop losses, while soil health is assessed based on various physical and chemical properties. Farm animal health is assessed in only one tool (Global Farm Metric).

3.3. HOLPA: A framework to strengthen agroecology performance assessments

The small number of tools fully capturing both agroecology

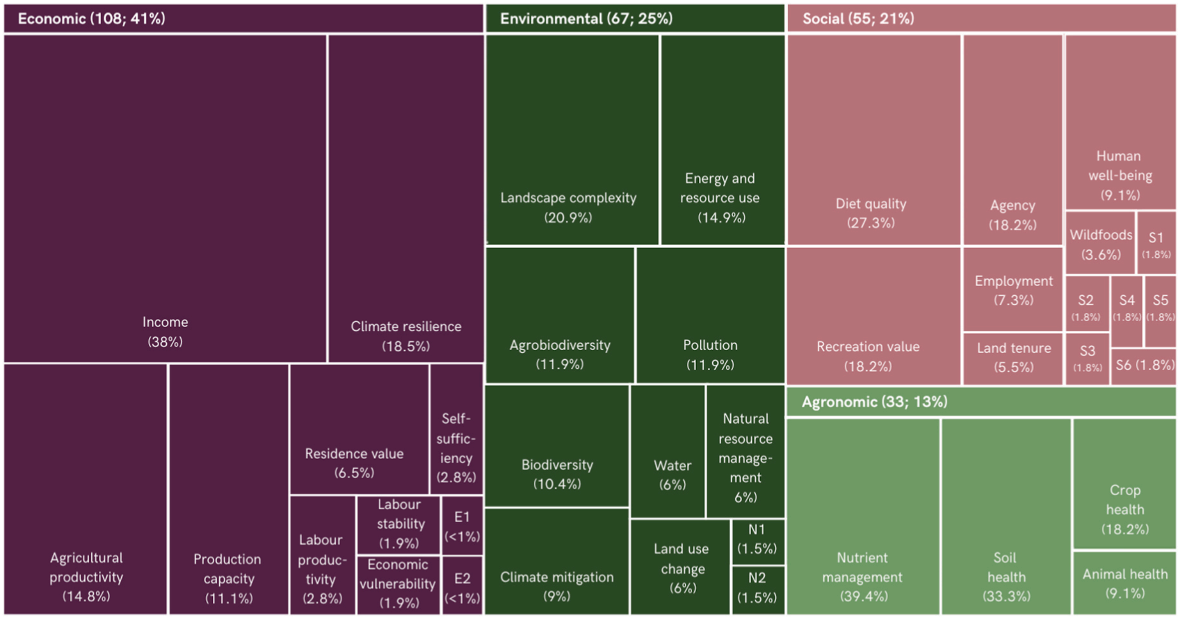

Fig. 2. Distribution of performance themes captured by 263 indicators used in 11 existing multidimensional agricultural performance assessment tools, across agronomic (light green), economic (purple), environmental (dark green), and social (pink) performance dimensions. Labels in parentheses in the dimension headers show the number of indicators in absolute terms and as a percentage of all identified indicators, while labels for each theme show the number of indicators as a share of all indicators within the dimension. E1: Intervention cost; E2: Economic diversity; N1: Land degradation; N2: Use of organic practices; S1: Innovation; S2: Risk of farm abandonment; S3: Knowledge; S4: Dependence on farm; S5: Land sufficiency; S6: Social vulnerability.

adherence and multidimensional performance, and variability in their demonstrated use of credible, salient, legitimate, and transferable approaches (Fig. 1), may be limiting the capacity for these tools to guide sustainable agrifood system transitions. Further, the dominance of a handful of performance indicators and neglect of others in existing agricultural performance tools represents a risk that these tools generate incomplete and potentially misguiding evidence on the impact of agroecology transitions on people and nature. Our framework for Holistic Localised Performance Assessments for Agroecology (HOLPA) aims to address these gaps.

Agroecological theory proposes that increased adherence to agroecological principles will improve holistic sustainability of fields, farms and eventually whole agrifood systems (Gliessman, 2016; Wezel et al., 2012, 2020b), yet the implementation of these principles can vary substantially with local biophysical, social, economic, and political contexts (Jones et al., 2022; Sachet et al., 2021; Duru et al., 2015; González De MolinaDLopez-Garcia, 2021; Blesh et al., 2023; López-García et al., 2021). Grounded in this theoretical framework, HOLPA includes three assessment modules which can collectively be used to monitor the level of adherence to agroecology (*Agroecology module*), the multidimensional performance of the field, farm and/or agrifood system (*Performance module*), and information needed to distinguish the socio-ecological context in which these systems function (*Context module*) (Fig. 3).

Numerous papers have proposed that participatory approaches, where local farmers and other landscape actors are part of the research process, are fundamental to stimulating agroecological transitions (Duru et al., 2015; González De MolinaDLopez-Garcia, 2021; López-García and

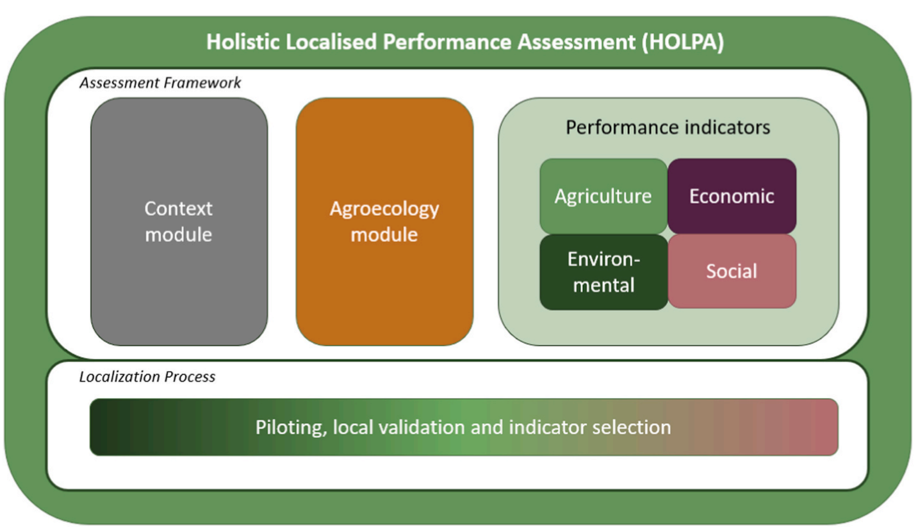

Fig. 3. A Holistic Localised Performance Assessment for agroecology (HOLPA) approach. HOLPA includes an assessment framework designed to enable analysis of performance while controlling for socio-ecological context and agroecology transition stage, and a localization process used to add locally important indicators and develop a place-based assessment tool.

González de Molina, 2021; Namirembe et al., 2022; Pimbert et al., 2022). Yet active use of such approaches remains rare; in our review 36% include steps to ensure that selected indicators are meaningful to local stakeholders. This is consistent with previous research; a review of 347 articles reporting results from agroecology case studies found only 23 used a participatory approach to tool development and indicator selection (Sachet et al., 2021). This trend may reflect a lack of clarity on how to effectively use participatory approaches as part of holistic evidence assessments, or a lack of expertise and resources to do so.

In response, the HOLPA framework includes a *Localization process* aimed at ensuring evidence generated responds to the local context and uses locally meaningful measures within the bounds of research constraints. The Localisation process is used to build a vision of a socially and ecologically desirable future with farmers and other local actors, discuss what agroecological interventions could help to achieve this vision, and co-define targets and indicators for assessing progress towards the vision (Table 3).

We describe how HOLPA's three assessment modules and localization process can be applied through household and fieldwork surveys (see Data Availability) and focus groups to provide farm and landscape-level insights.

3.3.1. Context module

Context variables in the HOLPA framework were selected to include factors known to influence farmer decisions to transition to agroecology, or factors known to moderate agriculture's performance, identified from literature. The purpose of this was to enable an analysis of factors driving agroecological transitions, and to distinguish the effect of extraneous factors on the relationship between agroecology adherence and performance.

Behavioural theory suggests that personal (e.g. perception of financial risks associated with transitioning to agroecology) and societal (e.g. attitudes and propensity of local farmers towards adopting agroecological practices) motivations may influence farmer decisions to transition to agroecology (Soini Coe and Coe, 2023). This is supported by empirical research that shows farmer attitudes, along with institutional (e.g. access to training) and social (e.g. strong social networks) factors, have a strong influence on farmer decisions related to agroecological practice adoption (Sánchez et al., 2024). Evidence suggests that several other factors may influence farmer decisions, including risk exposure (Tacconi et al., 2022), natural (e.g. soil characteristics), physical (e.g. land ownership) and financial (e.g. income) capitals (Sánchez et al., 2024). HOLPA's context module was designed to capture many of these factors, providing a basis for testing and developing behaviour change theories.

In addition, the context module captures extraneous factors that may influence agronomic, environmental, economic and social performance. For example, multiple studies have shown that agronomic performance varies with crop type, soil type, climate, and input intensity (Paut et al., 2024; Zhao et al., 2022; Rezaei et al., 2023). Environmental performance is affected by land use history (Millard et al., 2021; Davison et al., 2021; Turley et al., 2020; Ceaușu et al., 2025), climate (Weiskopf et al., 2020) and natural resource management norms (Westerink et al., 2021; Feng et al., 2023). Economic outcomes are closely tied to labour inputs, product end-use, and local market conditions (van der Ploeg et al., 2019; Luis et al., 2024). Social performance is influenced by education (Derringer and Biddle, 2022), demographics (Lee et al., 2019; Bacon et al., 2023), perceptions of weather (Brennan et al., 2022), community engagement, employment policies and institutional structures (Herrera Sabillón et al., 2022; Deegan and Dunne, 2022). Capturing these factors enables robust scientific hypothesis testing of the effect of agroecology adherence on agronomic, environmental, social and economic performance, by controlling for socio-ecological variables that may directly or indirectly affect this relationship. Contents of the context module could be amended by users to enable testing specific hypotheses and future research reveals new potentially influential factors.

Bringing these components together, the Context module is designed to capture socio-demographic characteristics of the respondent, farm-household and landscape characteristics (e.g. field/farm/landscape size, main crop/fish/livestock systems, location, climate), and knowledge of and attitude toward agroecology (Fig. 4 and Table 4). Dependent on the scale of analysis, data for these variables can be collected as part of a household survey, key informant interviews and desk-based research.

Table 3
Localisation process designed to ensure HOLPA provides locally salient evidence.

Step	Activities
1. Multistakeholder local indicator selection process (LISP)	1.1 Conduct a workshop where diverse stakeholders – including youth and women groups - envision a sustainable future for their landscape and select key indicators to use to monitor progress towards it. 1.2 Integrate the locally selected indicators from 2.1 into the place-based version of HOLPA.
2. Adapt the global HOLPA survey to create a place-based version	2.1 Translate the HOLPA survey into the local language, if needed 2.2 Tailor selected question and response options to fit with the local context, including local concepts, terminology and sensitivities.
3. Pilot the survey with local farmers, researchers and practitioners	3.1 Answer all parts of the survey to find and fix errors introduced during steps 1 and 2. 3.2 Pilot the survey with at least one local researcher and one producer or practitioner familiar with the local farming and food system, to ensure questions and response options are correctly understood and culturally appropriate. 3.3 Fix any issues or gaps identified in 3.2 to produce a final place-based HOLPA survey.

3.3.2. Agroecology module

The Agroecology module focuses on measuring how closely a field, farm or landscape adheres to agroecological principles. HLPE's 13 principles (Wezel et al., 2020b) were used as a basis for assessing agroecology adherence. For each principle, HOLPA includes one indicator for measuring adherence, assessed using simple Likert scale response options following the approach used by TAPE (Mottet et al., 2020) (Fig. 4 and Table 5).

3.3.3. Performance module

The choice of what performance themes to measure within the HOLPA framework was underpinned by theory and empirical evidence regarding the scope of agroecology's positive and negative impacts, and blind spots in evidence. Agroecology is theoretically designed to improve food security and a suite of nature's contributions to people (Andrieu et al., 2024), a claim which is supported by a growing body of empirical evidence (Beillouin et al., 2021; Rosa-Schleich et al., 2019; Tamburini et al., 2020). Therefore, holistic evidence is needed to understand effects of agroecological transitions on a range of nature's contributions to people, and potential trade-offs.

Drawing on these insights, HOLPA's performance themes were co-selected with topic experts, with the goal of capturing the most important aspects of economic, agronomic, social and environmental dimensions and enable inter and intra-discipline trade-off analysis. This process resulted in the identification of 18 performance themes across the four dimensions (Fig. 4).

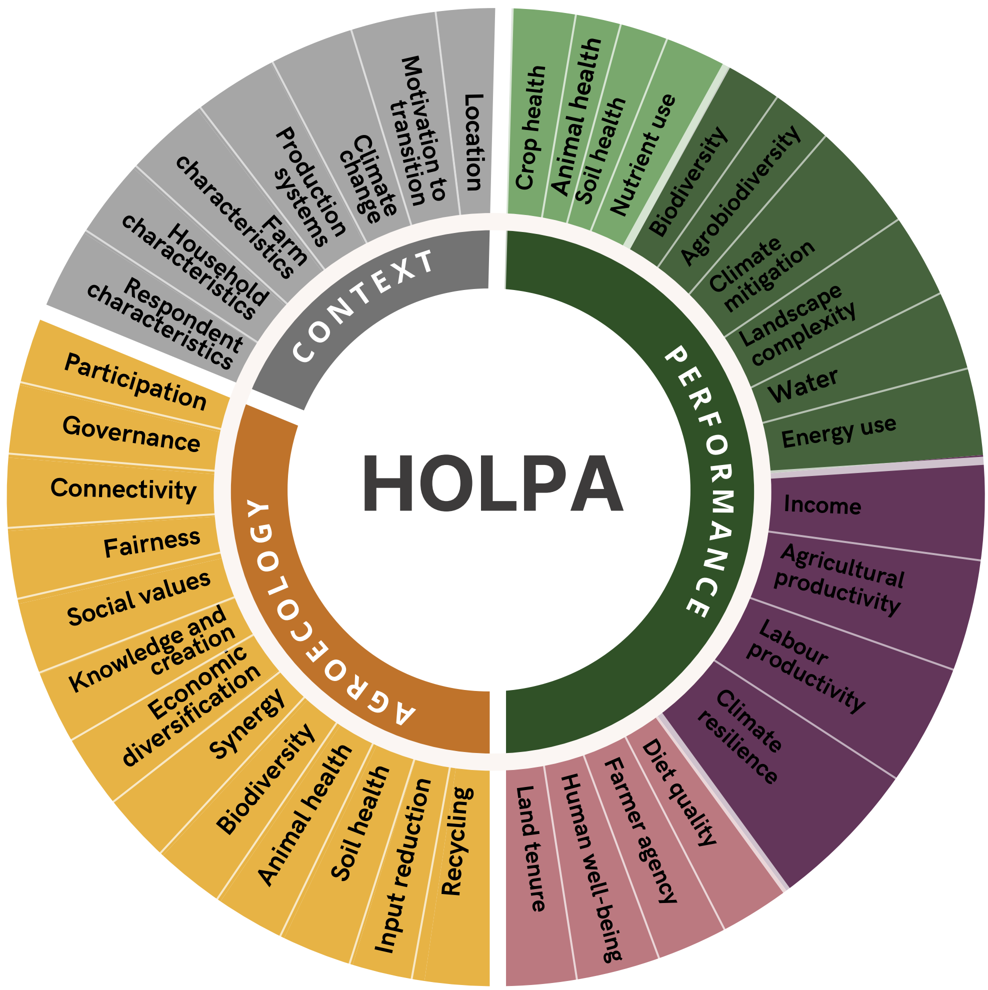

Fig. 4. Holistic Localised Performance Assessment for agroecology (HOLPA) framework. The HOLPA framework includes Context, Agroecology and Performance assessment modules. HOLPA's context module gathers data on the socio-ecological characteristics and respondent attitudes towards agroecology. The agroecology module focuses on assessing adherence to High Level Panel of Experts (HLPE)'s 13 agroecological principles. The performance module gathers data for 18 performance themes spanning four domains (agronomic – light green, environmental – dark green, economic - purple, and social - pink).

3.4. A holistic set of key performance indicators

We identified globally applicable key performance indicators (KPIs) for each of the 18 performance themes designed primarily for use in farm-household level assessments (Table 6 and Appendix C). Many of the KPIs can be directly applied to field-level assessments or aggregated to provide landscape-level insights. More than one indicator was selected per theme in several cases to capture important information that would have been missed using a single KPI.

Agronomic performance includes KPIs across four themes: 1) crop health, 2) animal health, 3) soil health, 4) nutrient use. Crop health is measured as the percentage of crop production lost or damaged in the last 12 months, with qualitative measures of crop health used as a second KPI (Nicholls et al., 2004). Animal health is monitored based on the share of livestock and/or fish with injuries, illness or mortalities, representing a subset of indicators in AssureWel (RSPCA et al., 2018) assessment protocols. Soil organic carbon content is used as an indicator of soil health, recognized for its association with reduced erosion risk, increased soil biota, improved soil structure and other benefits to soil functioning (Lorenz et al., 2019), and can be measured in a laboratory from a composite of soil samples collected on each farm. Perceptions of soil fertility and soil erosion are combined to provide a secondary soil health indicator drawing on farmers' knowledge of their land (Nicholls et al., 2004). Nutrient use is measured as the amount of chemical and/or organic fertilizer or manure applied per area of cropland, integrating guidance from the EU Nitrogen Expert Panel (EU Nitrogen Expert Panel, 2016).

Environmental performance is measured using KPIs across six themes: 1) biodiversity, 2) agrobiodiversity, 3) landscape complexity, 4) climate mitigation, 5) water use, and 6) energy use. Biodiversity is measured as the on-farm diversity of insects (pollinators, pests, natural enemies), birds, mammals, and trees, using methods similar to TAPE (Mottet et al., 2020). Bird diversity is an optional additional indicator, with data collected using a mobile app to record and identify birdsongs (e.g., i-bird). Agrobiodiversity is captured in terms of the crop, livestock and fish species richness per unit area, and share of cropland under diversified farming practices, following the Agrobiodiversity Index approach (Jones et al., 2021). The proportion of on-farm land covered by natural and semi-natural vegetation is used as an indicator of landscape complexity (Mohamed et al., 2024; Estrada-Carmona et al., 2022). Climate mitigation is assessed by estimating the below (soil organic carbon) and above (in woody vegetation with a diameter >10 cm) ground carbon storage on-farm (Cardinael et al., 2018). We propose a simple farm climate mitigation rating score as a secondary indicator, by assigning a score from 1 (net negative emissions) to 5 (net positive emissions) to each agricultural practice used on farm, based on its climate mitigation potential as assessed by previous meta-analyses (Bell et al., 2018), and then summing the scores (see Appendix C). The KPI for water stress is the number of months with agricultural water stress per year. Sustainability of energy use is measured as the share of

Table 4
HOLPA's global context module variables.

Theme	Variable	Metric	Format
Location	Country, Commune, Municipality, Village GPS point of household	E.g., Peru, Senegal, Burkina-Faso	Categorical
Respondent characteristics	First and last name		Text
	Demographic information: year of birth gender ethnicity marital status education	E.g. Male, female, other/prefer not to say	Categorical
	Relationship with: the head of the household (if not the head of household) person responsible for making decisions on farm activities	E.g. Spouse, sibling, child, parent, non-relative	Categorical
	Number of years living in the community	E.g. 10 years	Continuous
	Primary and secondary occupation in the last 12 months	Agricultural work on your own land Permanent salaried work on other people's land Seasonal wage labour on other people's land Public administration Company (landowner) Salaried (non-agricultural work) Study/education/training Homemaker Can't work Prefer not to say Other (specify)	Categorical
Household characteristics	Number of household members by gender and age (<18, ≥18 and ≤ 65, and >65 years old)	E.g. 3	Continuous
	Current involvement in any agricultural research or development project	Yes, No	Categorical
Farm characteristics	Total area of land the household owns, leases from another person, and holds use rights, either alone or jointly with someone else (disaggregating responses by sex)	E.g. 2 ha	Continuous
	Farmland slope	Steep Moderately steep Slightly steep Flat	Categorical
Production systems	On-farm generated products in the last 12 months	Crops (including perennial crops) Livestock Fish Trees (e.g., for wood, bark, rubber) Honey Other (specify)	Categorical
	Amount of produce used for household consumption, livestock consumption, on-farm use, sales, gifts, wasted/lost, other uses	None 1-25% 26-50% 51-75% 76-100%.	Categorical
	Amount of chemical and non-chemical fungicides/pesticides/herbicides applied to cropland, over the last 12 months	E.g. kg/ha/yr	Continuous
	Approaches employed to manage livestock and fish diseases over the past 12 months	E.g. Vaccination; Antibiotics; Organic treatments	Categorical
Climate change	Perception of temperature/rainfall change over the last 30 years	Increased No change Decreased I am not sure	Categorical
	Do you perceive that the timing of rainfall has changed over the last 30 years?	Rainfall starts earlier/later Rainfall stops earlier/later Rainfall start and/or stop are no longer predictable No change I am not sure	Categorical
	Farmland flood/drought events in the last 12 months	Yes; No	Binary
Motivation to transition	Understanding of the concept of agroecology	3- Clear understanding 2- Some knowledge, but willing to learn more 1- Not familiar with the term	Likert scale
	Agreement with the following statements: - I care a lot about nature: - Being in nature benefits me: - I live in a place where most people take good care of the land and nature: - I take care of the land and nature on my farm: - I identify myself as an agroecological farmer: - I have the power and freedom to change farm production practices if I want to: - If I work together with others in my community, we have power and freedom to solve problems facing farmers: - I make decisions about what food to buy based primarily on price:	5- Completely agree 4- Somewhat agree 3- Neutral 2- Somewhat disagree 1- Completely disagree	Likert scale

(continued on next page)

Table 4 (*continued*)

Theme	Variable	Metric	Format
	- I would prefer to eat food that is produced without chemical inputs. - I would prefer to eat food that is grown locally: - I would prefer that the food I buy is produced and processed in ways that provide a fair wage and good conditions for workers: - I think shifting to agroecological farming is a sensible business decision: - Most farmers think current farming systems are working well and do not need changing:		

energy-consuming agricultural activities that use renewable sources. Additional information collected in the environmental theme includes share of locally adapted crops varieties, tree species, livestock breeds, and irrigation water sources.

Economic performance is based on KPIs across four themes: 1) income, 2) agricultural productivity, 3) labour efficiency, and 4) climate resilience. Household income is determined as the total household income relative to the national average income, with income stability and sufficiency as secondary indicators. Agricultural productivity is measured in terms of yield (e.g. t/ha, kg/head) for the main three crops and/or livestock and/or fish produced on-farm (adapted from TAPE). Number of labour hours per year per hectare is used as an indicator of labour efficiency (Sagesaka et al., 2021; FAO and Agri-Gender Database, 2010). Climate resilience is measured using an adaptation of the Resilience Index Measurement and Analysis (RIMA), based on questions related to access to basic services, assets, adaptative capacity, food security, shocks and access to social networks (FAO, 2016). Some additional economic information is collected to provide further insights, including on household debt ratio (closely related to farmer financial stress (Santos et al., 2021)), credit access and credit constraints.

Social performance is measured using KPIs across four themes: 1) diet quality, 2) farmer agency, 3) human well-being, 4) land-tenure security. Diet quality is determined by calculating the household diet diversity score (Global Diet Quality Project). Farmer agency is monitored using a 5-point Likert scale (with open questions to allow for in-depth qualitative analysis) on perceived decision-making power and freedom for male and female members of the household (Petesch and Bullock, 2018). Human well-being is indicated by taking the average score across a series of questions on self-perceived life satisfaction with 5-point Likert scale answers, covering health, nutritional, economic and social security (OECD, 2013). Land tenure security is measured as the share of land the household owns, leases or uses on which they perceive they may involuntarily lose use rights within the next five years (FAO, 2019).

Further details on the global KPIs including protocols for measurement and interpretation are available in Appendix C and at https://holpa.org/(accessed 8 December 2025).

3.5. A transferable localization process

Given the high variability in agronomic, political, and socioeconomic characteristics and priorities between regions and countries, co-creation and co-learning are central parts of agroecology. Specific places may have agronomic, environmental, social or economic objectives that are not necessarily captured in globally relevant standard themes and indicators. Each place may also use specific terminology and concepts to discuss these objectives.

The localization process developed in this study comprises three steps to carry out before implementing the HOLPA framework. Step 1 is the heart of the localization and involves conducting a local indicator selection process (LISP). A major drawback of tools that collect data in the same way everywhere is that the tool can ask questions that are inappropriate or irrelevant for the local context (Namirembe et al., 2022). They can fail to capture context variables or performance aspects that play a role in enabling or constraining an agroecology transition, or in determining agrifood system sustainability in a specific location. The LISP addresses this limitation by incorporating local KPIs and any relevant context variables co-developed with local farmers and other local stakeholders. This step guarantees locally relevant indicators form part of the assessment, and thus the evidence that is generated is useful to people where it is applied.

The LISP involves conducting a one-day workshop with local farmers and other stakeholders, to define and prioritize a set of local indicators to include in HOLPA. Participants brainstorm potential indicators for each of the same dimensions as the HOLPA Performance module (agronomic, economic, social, environmental), that could be used to monitor the types of changes they want to see in their farms and landscapes. After participants agree on a set of evaluation criteria (such as importance, ease of measurement, likelihood of changing), participants evaluate the potential indicators and select approximately three locally relevant indicators per performance dimension to include in the localized HOLPA tool. The LISP could readily be applied to help localize any other agricultural performance assessment tool (see LISP guidelines in Appendix D).

Step 2 involves designing place-based versions of HOLPA data collection surveys. Household and fieldwork surveys to collect global (i.e. not localized) data for HOLPA's context, agroecology and performance modules, are available in English (see Data availability). While verbal translation of the English version of HOLPA is an option, translating HOLPA into the language that the survey will be administered prior to data collection ensures consistency across enumerators. A first version of the translation can be done through automatic translation tools (e.g. deepL) but question and response options need careful checking to ensure the original meaning is maintained. Once the survey is put into the target language, indicators prioritized in the LISP process need to be added into place-based versions of HOLPA. In addition, certain sections need amending to ensure their relevance for the local context. For example, the household survey includes questions on which foods the respondent consumed in the past 24 h across 16 food groups, using questionnaires developed by the Global Diet Quality Project (Global Diet Quality Project) and the list of foods to include in each food group varies by country. Localised versions of the HOLPA household and fieldwork surveys are available in English (tailored to India, Kenya, Laos, Zimbabwe), French (Burkina Faso, Senegal, Tunisia), and Spanish (Peru) (see Data Availability).

Once the local indicators have been included, the survey can be translated and responses adapted to the local context. Step 3 is to pilot the HOLPA survey with at least one local researcher and one local farmer and/or practitioner. The goal of this step is to ensure the survey layout and dependencies are correctly coded (e.g. ensure mandatory questions are not displayed as optional), and to make sure all questions and response options are clear for respondents in the local context. The user should add hints or examples of how to complete the responses in survey sections that can be misinterpreted.

Results of conducting the LISP in the 8 CGIAR Transformative Agroecology initiative focal countries showed a wide range of local indicators were identified. For example, in Madhya Pradesh in India, local farmers and stakeholders reported accessibility to adequate quantity and quality of water as a major challenge. Specific local indicators on water were added to the HOLPA tool, capturing water footprints, water use efficiency and water quality. In Ucayali in Peru, most of the locally identified indicators were already captured by the global KPIs yet several indicators needed disaggregating to capture specific concerns,

Table 5
HOLPA's global agroecology adherence indicators.

Theme	Indicator	Metric	Format
Recycling	Primary sources for seeds, nutrients, livestock breeds, fish seeds, fish feed, and energy	5- 100% self-produced, exchanged or managed collectively. 4- 75% self-produced or exchanged, 25% purchased from the market. 3- 50% self-produced or exchanged, 50% purchased from the market 2- 75% purchased from the market, 25% self-produced or exchanged. 1- 100% purchased from the market.	Likert scale
Input reduction	Approaches employed to manage soil fertility, crop pests, livestock/fish diseases in cropland over the past 12 months.	5- Only ecological practices/treatments. 4- Combination of ecological practices/treatments and organic inputs. Or only organic inputs 3- Combination of ecological practices/treatments, and chemical and organic inputs. 2- Combination of chemical and organic inputs. 1- Only chemical inputs.	Likert scale
	Utilization of dry feed (e.g., grains, hay) for livestock nutrition.	5- Never 4- Rarely 3- Sometimes 2- Often 1- All the time	Likert scale
	Main types of fish feed use in the last 12 months	5- Only natural feed used. 4- Combination of natural and prepared organic feed used. Or only organic feed used. 3- Combination of natural, prepared organic and prepared chemical feed. 4- Combination of prepared organic and chemical feed. 5- Only chemical feed.	Likert scale
Soil health	Number of agricultural practices employed on cropland to improve soil quality and health	5- Four or more practices used. 4- Three practices used. 3- Two practices used. 2- One practice used. 1- No action taken.	Likert scale
Animal health	Number of practices employed on farm to keep livestock/fish healthy and happy	5- Four or more practices used. 4- Three practices used. 3- Two practices used. 2- One practice used. 1- No action taken.	Likert scale
	Health and wellbeing of farm animals	5- Animals do not suffer from stress, hunger, thirst, pain, or diseases, and are slaughtered in a way to avoid unnecessary pain. 4- Animals do not suffer from hunger, thirst or diseases but can experience stress, especially at slaughter. 3- Animals do not suffer from hunger or thirst, but suffer from stress, may be prone to diseases and can suffer from pain at slaughter. 2- Animals suffer periodically/seasonally from hunger and thirst, stress or diseases, and are slaughtered without avoiding unnecessary pain. 1- Animals suffer from hunger and thirst, stress and diseases all year long, and are slaughtered without avoiding unnecessary pain.	Likert scale
Biodiversity	Amount of crop/livestock/fish species per ha.	5- Between the 76th and 100th percentile of crop species per farm, within the sampled landscape 3.67- Between the 51st and 75th percentile 2.34- Between the 26th and 50th percentile 1- Between the 1st and 25th percentile	Likert scale
	Diversity of trees (or perennial woody crops) on farm	5- High diversity: five or more species with different heights, woodiness, or flowering seasons 3.67- Medium: two to four species 2.34- Low: only one species 1-No trees or woody perennials	Likert scale
	Plant diversity in national and semi-natural vegetation on farm	5- High diversity: five or more species with different heights, woodiness, or flowering seasons 3.67- Medium: two to four species 2.34- Low: only one species 1-No natural or semi-natural vegetation on-farm	Likert scale
Synergies	Number of practices implemented to ensure positive relationships between animals, crops, trees, soil, and water.	5- Four or more practices. 4- Three practices. 3- Two practices. 2- One practice. 1- No action taken.	Likert scale
Economic diversification	Number of income sources the household has.	5- Five or more sources of income. 4- Four sources of income. 3- Three sources of income. 2- Two sources of income. 1- One source of income.	Likert scale

(continued on next page)

Table 5 (*continued*)

Theme	Indicator	Metric	Format
Knowledge co-creation	Number of times per year the household exchanged information with extensionists, consumers, food traders, government, NGOs, other farmers, researchers.	5- Five or more times per year. 4- Four times per year. 3- Two to three times per year. 2- One time per year. 1- Never.	Likert scale
Governance	Household engagement in activities and meetings related to the management community's land and natural resources.	5 - Always participates. 4 - Most of the time participates. 3 - Sometimes participates. 2 - Rarely participates. 1 - Never participates.	Likert scale
	Household influence on community land and natural resources management decision-making.	5 - Contribute to all the decisions. 4 - Contribute to almost all the decisions. 3 - Contribute to some decisions. 2 - Contribute to few decisions. 1 - Did not contribute to any decision.	Likert scale
	Perception of community land and natural resources management.	5- Extremely well-managed. 4- Well managed. 3- Moderately managed. 2- Poorly managed. 1- Not at all well-managed.	Likert scale
Social values and diets	Household access to healthy, diversified, seasonal, and/or traditional food.	5- Good access. 4- Fairly good. 3- Moderate access. 2- Limited access. 1- No access at all.	Likert scale
Fairness	Is on-farm income sufficient to support household?	5- All needs are met, and savings are regular. 4- Needs for food are covered, and surplus generates cash for essentials and sporadic savings. 3- Needs for food are covered, but no surplus for savings. 2- Only needs for food are covered, no surplus for other essential needs. 1- Needs for food and other essentials are not met.	Likert scale
	Does the household get fair prices when selling on-farm products?	5 – Always get a fair price. 4 - Usually, depending on the product. 3 - Occasionally, depending on the product. 2 - Rarely get a fair price. 1 - Never get a fair price.	Likert scale
	How would you rate the stability of household income?	5- Income is increasing over time. 4- Income is stable over time. 3- Income varies little from year to year. 2- Income varies from year to year. 1- Income is on a decreasing trend.	Likert scale
Connectivity	What are the various channels through which households may sell at least part of their on-farm produce?	5- Directly to consumers. 4- To farmers' organization/cooperative. 3- To retailers such as supermarkets, grocery stores, or restaurants. 2- To a middleman/aggregator. 1- Household does not sell on-farm produce.	Likert scale
Participation	How many associations or organizations are household members part of?	5- Member of three or more organizations. 3.67- Member of two organizations 2.33- Member of one organization. 1- Not an organization member.	Likert scale
	How effective are farmer associations/organizations at supporting farmers in business?	5 - Exceptional effectiveness in supporting farmers' businesses. 4 - Significant role in supporting farmers' businesses. 3 - Satisfactory support in supporting farmers' businesses. 2 - Limited support with marginal impact on farmer's overall success. 1 - No support provided. n/a - I don't know.	Likert scale

such as separating land tenure by land use (e.g. percentage of cropland owned), distinguishing the origin of dietary products (e.g. proportion of each food consumed that is produced on-farm), and details of seed management (e.g. use of good practices for seed storage). In Zimbabwe, farmers were interested in more precisely assessing animal health through feed diversity. Specific questions were added on feed availability through the year for cattle, goats and chickens. Keeping animals is critical for farmers of the region, especially in 'El nino' years where cereal harvest is constrained and farmers sell livestock to buy food. These findings highlight the value of conducting LISP for ensuring agroecology performance assessment tools capture locally salient information. In our pilots, LISP workshops involved farmers, both men and women and including a diversity of ages and ethnicities, and local non-governmental and governmental representatives. Careful facilitation was needed to manage local power dynamics and gather the perspectives of all stakeholder groups.

4. Discussion

This study shows that while many agroecology performance tools exist, they vary in terms of their saliency, credibility, legitimacy and transferability. All tools could be strengthened in at least one of these areas. Our HOLPA framework provides a scientifically grounded conceptual guide and actionable methodologies (for local indicator identification, context variable selection, and agroecological and performance indicator calculation) designed to increase the potential for future assessments to enable evidence-based agroecological transitions.

Table 6
HOLPA's global key performance indicators. See Appendix C for further details.

Dimension	Theme	Indicator	Metric	Format
Agronomic	Crop health	Percentage of crop production lost or damaged last year	E.g., 10%	Continuous
		Crop health from a score of 1 (lowest) to 5 (highest), for each of the following indicators: • Appearance • Crop growth • Disease incidence • Insect pest incidence • Natural enemy abundance and diversity • Weed competition and pressure • Actual or potential yield • Vegetational diversity • Natural surrounding vegetation • Management system	E.g. for Appearance (and assisted by an example image of each option): 5- Healthy foliage with no signs of deficiency 4- Foliage with very minor deficiency signs 3- Foliage with some deficiency signs 2- Discolored foliage with moderate deficiency signs 1- Discolored foliage with severe deficiency signs No data-I am not sure, or the question is not applicable	Likert scale
	Animal health	Extent of injury, illness, or death of livestock and/or fish due to diseases in the last year	4- None 3- Low 2- Medium 1- High	Likert scale
	Soil health	Saturation of soil organic matter (0-20 cm)	E.g. 5%	Continuous
		Soil fertility and erosion	5-high fertility with no soil erosion 4-high fertility with some soil erosion 3-moderate fertility with some soil erosion 2-moderate fertility with major soil erosion 1-low fertility and major soil erosion	Likert scale
	Nutrient use	Average amount of chemical/organic fertilizer used on cropland per hectare, per crop, relative to local recommendations	E.g. 1.5	Continuous
Environmental	Biodiversity	On-farm insect, bird and mammal diversity	4-High diversity: Abundant presence with a wide variety of species 3-Medium diversity: Regularly seen with several species 2-Low diversity: Rarely seen or limited to a few species 1-None: no insects, arachnids, birds, or mammals observed	Likert scale
		Number and diversity of trees (or perennial woody crops) on farm	4- More than 50 trees (and/or other woody perennials) per ha with at least five species with different heights, woodiness or flowering seasons 3- 50 trees (and/or other woody perennials) per ha, and/or two to four species 2- 20 trees (and/or other woody perennials) per ha and/or only one species 1- No trees or other woody perennials	Likert scale
	Agrobiodiversity	Crop diversity gap	Species richness relative to local maximum	Continuous
		Livestock diversity gap	Species richness relative to local maximum	Continuous
		Fish diversity gap	Species richness relative to local maximum	Continuous
		Use of local adapted crop varieties/livestock breeds	5- Only or mainly locally adapted varieties (or local breeds). 4 – 75% locally adapted varieties (or local breeds), and 25% certified seeds (or exotic breeds) 3 - Mainly certified seeds and some locally adapted varieties are grown (e.g., traditional cultivars, landraces) 2 - Only or mainly certified quality seeds are grown 1 - I don't know, or seeds are neither certified or locally adapted	Likert scale
	Landscape complexity	Landscape complexity, measured as share and diversity of land covered by natural and semi-natural vegetation on land owned, rented or used	Score from 1 to 5, where 1 represents absence of natural or semi-natural habitat and 5 represents a site with more than 50% natural or semi-natural habitat with at least five species of different heights, woodiness or flowering seasons	Continuous
	Climate mitigation	Net greenhouse gas emission score, based on presence/absence and emissions score (from 1 to 5) of a list of management practices pre-rated from high emitting and low carbon storage to low emitting and high carbon storage	Score from 1 to 5, where 1 represents a site with high emission and low sequestrating practices, and 5 a site with low emission and high sequestration practices	Continuous
	Water	Agricultural water stress, measured as share of months of the year it is difficult to access enough water for agricultural needs (e.g., growing crops, drinking water for livestock) during a normal year	%	Continuous
	Energy use	Sustainability of energy use, based on the types of energy used (renewable, non-renewable) and its source (locally produced, or not)	Sustainability of energy use with scores from 1 (Non-renewable and externally produced) to 5 (Renewable and self-produced)	Continuous
Economic	Income	Household income in the last 12 months, relative to national average	E.g. 1.2	Continuous
		Stability of household income	5 - Income is increasing over time 4 – Income is stable over time 3 - Income varies little from year to year 2 - Income varies from year to year 1 - Income is on a decreasing trend	Likert scale

(*continued on next page*)

Table 6 (*continued*)

Dimension	Theme	Indicator	Metric	Format
	Agricultural productivity	Yield gap, calculated based on the harvested produce per unit area (or per animal) for at least the three main crops (or livestock/fish) relative to locally attainable yields	E.g. 0.6	Continuous
	Labour productivity	Number of person hours worked per year, per hectare	E.g. 50 h/yr/ha	Continuous
	Climate resilience	Resilience score based on access to basic services, assets, social networks and adaptive capacity	Score from 1 (low resilience) to 20 (high resilience)	Continuous
Social	Diet quality	Household Food Group Diversity score (FGDS), calculated from 24-hr recall of consumption of foods in 16 food groups	Scores from 0 (no diversity) to 10 (high diversity)	Continuous
	Farmer agency	Perceived individual level of agency in decision-making regarding food production, trade, consumption and other matters, with option to disaggregate by gender	5- Power and freedom to make all major life decisions 4- Power and freedom to make many major life decisions 3- Power and freedom to make some major life decisions 2- Only a small amount of power and freedom 1- Almost no power or freedom to make decisions	Likert scale
	Human well-being	Self-perceived level of life satisfaction based on 10 criteria: standard of living; health; life achievements; personal relationships; physical safety; feeling part of the community; economical/nutritional security; amount of free time; local environment; occupation	Scores from 1 (completely dissatisfied to 5 (completely satisfied)	Continuous
	Land tenure	Likelihood of losing access to land owned, used or rented, within the next 5 years, based on respondent perception of land access security	Scores from 1 (extremely likely) to 5 (extremely unlikely)	Continuous
		Proportion of agricultural land used that is owned	%	Continuous

4.1. *Operationalising agroecology assessment frameworks for transformative change*

Agroecology is grounded in a multidimensional set of principles that can be implemented in a multitude of ways depending on the starting point and socio-political context (Jones et al., 2022; Blesh et al., 2023). The effect of different transition options on agronomic, environmental, economic and social outcomes in specific contexts are often poorly understood, grounded in absent, partially documented or inconclusive evidence (Makowski et al., 2023; Makowski, 2021). With powerful agrifood actors interested in maintaining the status quo (Blesh et al., 2023; IPES-Food, 2016), solid evidence on positive transition pathways and outcomes is vital to dispel doubts and accelerate action to achieve sustainable agrifood systems (Jones et al., 2022; Rasmussen et al., 2024).

Tools like TAPE, B-ACT and HOLPA can help demonstrate the multidimensional value of agrifood systems and can be used to pinpoint the socio-ecological context and agroecology approaches that drive up this value. Ensuring the data that such tools generate can reliably answer key questions for unlocking behaviour change requires science-practice collaboration to identify locally important knowledge gaps, co-develop hypotheses, and incorporate missing measures to enable rigorous analyses.

Data from HOLPA can be used to explore which biophysical, social and economic context variables enable or prevent farmers from transitioning to agroecology, for example using multivariate regression models (Pagliacci et al., 2020). Such information could inform investment and policy decisions to accelerate agroecological behaviour shifts. Performance indicators can be analysed to identify the context and agroecological conditions that improve outcomes for single indicators, using hierarchical clustering and multiple factor analysis. This approach was used to analyse HOLPA data collected in Burkina Faso (Orounladji et al., 2025). Alternatively, a performance index can be computed by transforming all indicator values to a standard scale and aggregating following (Jones et al., 2021), or through participatory discussions to develop place-based performance ratings (Orounladji et al., 2024). Such an index can enable farmers, policy and decision makers to rapidly compare farm performance within and across landscapes and prioritize investments towards underperforming areas or typologies of farms.

In practical terms, many existing tools exist and it may not be feasible or desirable to shift to using a new tool, e.g. due to the learning curve. HOLPA's LISP methodology and context variables, agroecology indicators, and global KPIs can be incorporated into existing agricultural performance assessment tools providing a means to capture locally important variables, agroecology transition insights, and currently neglected outcomes.

4.2. *Indicator construction lacks rigour and creates blind spots*

Consistent with previous research (van Asselt et al., 2014), our scoping review finds that many indicators in existing tools were developed in top-down processes by researchers, while bottom-up processes where farmers, technicians, and policymakers drive indicator selection are less common. This may partially explain the dominance of a narrow set of indicators being collected across tools, and consistent neglect of certain social and environmental performance elements. At present, important gaps in evidence exist regarding agroecology's impacts. We found that agriculture is over-whelming judged by its ability to provide economic benefits. Previous studies have similarly shown agricultural performance is often assessed by its capacity to efficiently produce a few commodities, commonly measured in terms of economic indicators, such as yield, income, and returns to labour (Wiget et al., 2020). These simplistic measures do not capture the social and environmental value (and costs) of agricultural systems, and our over-reliance on them is a driver of the hidden harm that simplified, intensive agricultural production systems cause around the world (FAO, 2023).

Single-commodity metrics are poorly adapted to diversified farming systems, where total output from all species needs capturing (Sanderson Bellamy and Ioris, 2017). Reliance on such metrics underpins prevailing conceptions among industry, media and academia that agrochemicals and proprietary seeds are essential to feeding the world (Balmford et al., 2025). Yet evidence from systematic reviews shows the reality depends on how productivity is measured, what crops and practices are used, and the biophysical context. For example, land and labour productivity are higher in agroecological systems in the majority of cases (Mouratiadou et al., 2024), including in Africa (Romero Antonio et al., 2025), pointing to the importance of collecting and using robust and context-specific yield data. Reliance on per unit productivity indicators has also meant that several other performance themes relevant to farmer livelihoods and agricultural business management have been neglected, such as yield stability, income resilience to shocks, and risks associated with farm dependency on external, limited and often costly inputs (Sanderson Bellamy, 2018; Pret et al., 2025). Evidence gaps extend to some aspects of biophysical performance, notably on-farm agrobiodiversity status

(Jones et al., 2021; Pironon et al., 2024), soil health (Wood and Bowman, 2021) and carbon storage capacity (Rosinger et al., 2023), and social outcomes, including dietary diversity, human happiness, social cohesion, and farmer control over resources (Brock et al., 2024).

Widespread adoption of holistic monitoring frameworks like HOLPA is needed to ensure that currently neglected social indicators, such as subjective human-wellbeing and land tenure security, and environmental indicators such as landscape complexity and climate mitigation potential, get accounted for in evidence-based decision-making. HOLPA's global KPIs incorporate recently developed methodologies (e.g. Global Diet Quality project (Global Diet Quality Project)) and novel approaches (e.g. qualitative measure of climate mitigation) that provide a pragmatic, transparent means for measuring these neglected performance aspects.

4.3. Responding to local needs

Our review showed locally defined indicators are absent from many existing agroecology performance assessment tools. One possible reason for the lack of co-development in existing tools is that community participation and co-leadership to define the research questions, develop methodologies for answering them, and analyse outcomes, requires a large time-investment typically drawing on anthropological research methods (Kindon et al., 2007; Guzmán et al., 2012) and featuring long-term research-community engagements to build trust (Méndez et al., 2017). Funding for this type of approach is scarce, because project impacts are highly localized (e.g. tens of households benefit) and scalability is limited (problems and solutions are context specific). Donors favour high-impact projects (e.g. thousands of households benefit) that generate transferable solutions through project-cycles of 1-3 years in duration. Ideally, local farmer-research networks need establishing involving multi-disciplinary researchers in long-term, financially supported community engagements (Richardson et al., 2022).

The localization process presented in this study can be readily applied to other tools and is pragmatic approach to making the evidence generated more relevant to local stakeholders. The LISP promotes co-development and co-creation of knowledge which is a fundamental grounding principle of agroecology. LISP is straight-forward to implement and ensures farmers are part of the tool design, addressing a key limitation of many assessment tools (Darmaun et al., 2023a). Performance assessment tools looking to inform agroecological transitions need to be co-developed with the actors that could change mindsets and behaviours (Soini Coe and Coe, 2023) based on the evidence collected. The participatory indicator prioritization step included in LISP is important for building consensus around the most important metrics but also for constraining the time and data intensiveness of the tool, which can create barriers to large-scale use (Darmaun et al., 2023b).

4.4. Lessons for future action-orientated tool design

The global key performance indicators developed here were selected in consultation with ecologists, hydrologists, agronomists, soil scientists, gender specialists, economists and geographers, to capture the complexities of agrifood systems in a single holistic tool. Every discipline needed to compromise on what to measure and how, to keep the list of global KPIs manageable. For example, the crop productivity indicator involves collecting yield data at farm-level for the three main crops through farmer recall, yet assessing yields based on farmer recall can be unreliable (Fraval et al., 2019), and collecting data on yields for only one crop is suboptimal in multicrop systems. Direct measurement of whole system yields (i.e. weighing harvested produce from a representative sample of all crops per plot) is time-consuming but may become more feasible to include in HOLPA with the development of time-saving image-based yield calculations (The Alliance, 2024). Identifying ways to achieve further time savings would be beneficial, such as by using remotely sensed data to replace selected environmental indicators including tree diversity and landscape complexity (e.g. (Leroux et al., 2022)).

The need for compromise reflects the complexity involved in collecting robust data on multidimensional values (Cooke et al., 2020). Being truly transdisciplinary is hard, both during tool development and implementation. Training, iterative feedback sessions, and willingness to avoid jargon and provide simple explanations to ensure understanding, are vital, especially when the team is working across languages and cultures. Yet system approaches like this are what is needed for scientists and local stakeholders to relate to the worldviews, perceptions and concerns facing others, and be more effective at finding integrated solutions. We hope that this attempt to build a holistic performance assessment framework will encourage further research and tool improvements to facilitate transdisciplinary action research.

5. Conclusion

Data generated from holistic tools can close knowledge gaps on how to transition to sustainable agrifood systems. To make full use of these data, we need a means for assembling and harmonizing data from diverse tools into a statistically analysable, continuously updated open access evidence bank. Tool developers and users could create a collaborative space for performance data integration and interpretation, to support inclusive, rigorous and transparent evidence access for decision-making (Bendersky et al., 2022; Donnelly et al., 2018). For such evidence to lead to positive changes in our agrifood systems, researchers need to continue to learn with and from local farmers and other stakeholders to make sure any recommendations stay grounded in what is best for the farmers, communities and nature on which our agrifood system depends.

CRediT authorship contribution statement

Sarah K. Jones: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Andrea Cecilia Sánchez:** Conceptualization, Data curation, Investigation, Methodology, Software, Validation, Visualization, Writing – review & editing. **Chris Dickens:** Methodology, Project administration, Validation, Writing – review & editing. **Matthias S. Geck:** Methodology, Project administration, Validation, Writing – review & editing. **Chaturangi Wickramaratne:** Investigation, Methodology, Validation, Writing – review & editing. **Veronique Alary:** Methodology, Validation, Writing – review & editing. **Peter Bolo:** Methodology, Validation, Writing – review & editing. **Dennis Junior Choruma:** Methodology, Validation, Writing – review & editing. **Somphasith Douangsavanh:** Methodology, Validation, Writing – review & editing. **Modou Gueye Fall:** Methodology, Validation, Writing – review & editing. **Gatien Falconnier:** Methodology, Validation, Writing – review & editing. **Shweta Gupta:** Methodology, Validation, Writing – review & editing. **Chris Kettle:** Methodology, Validation, Writing – review & editing. **Smitha Krishnan:** Methodology, Validation, Writing – review & editing. **Sylvia Nyawira:** Methodology, Validation, Writing – review & editing. **Guillermo Orjuela-Ramirez:** Methodology, Software, Validation, Writing – review & editing. **Boko Michel Orounladji:** Methodology, Validation, Writing – review & editing. **Piedad Pareja:** Conceptualization, Methodology, Validation, Writing – review & editing. **Telma Sibanda:** Methodology, Validation, Writing – review & editing. **Christine Lamanna:** Conceptualization, Investigation, Methodology, Project administration, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.indic.2026.101374.

Data availability

ODK compatible versions of HOLPA household and fieldwork surveys can be used to collect context, agroecology and global key performance indicators described in this study and are available on Dataverse: https://doi.org/10.7910/DVN/EIRW1G. Excel-based quality assurance tools are available in the same Dataverse repository. Localised versions of the HOLPA household and fieldwork surveys are available in English (tailored to India, Kenya, Zimbabwe), French (Burkina Faso, Laos, Senegal, Tunisia), and Spanish (Peru), created as part of the CGIAR Transformational Agroecology initiative, on request to the corresponding author. Additional guidance on using, localising and analysing data from the HOLPA survey is available at: https://holpa.org/.

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