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Starting points of agroecological transitions in Africa: Why and how farm structure matter

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ABSTRACT

In sub-Saharan Africa, dominant agricultural models such as the Green Revolution have shown limitations, and agroecology is emerging as an alternative. Yet, empirical evidence remains scarce on who adopts agroecological practices and on what types of farms. A widely accepted narrative suggests that smallholders are more rooted in agroecological systems, while larger, better-endowed farms follow "conventional" models. This paper challenges that dualistic view by providing evidence of a wider set of relationship between farm structure and the diversity of agroecological practices across multiple African contexts. For this purpose it informs the diversity of existing patterns of farms structure and starting points of agroecological transition (AET) – defined as current state of agroecological principles implemented by farms along their trajectories. By situating these starting points within the socio-technical context of national and regional AET, we gain valuable insights into which farm structures support different agroecological principles, how socio-technical regime influence these dynamics, and what policy options emerge to foster AET. Using harmonized data from 2721 farms across nine study areas in six African countries, the article shows that starting points of agroecological transitions are highly diverse and influenced by farm structure. Three patterns emerge: smallest farms mostly combine autonomy and income diversification while larger farms tend to combine conventional intensification with crop-livestock integration. Other small to medium scale farms are characterized by more land allocated to legume contributing to soil

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health. Future agricultural policies should consider this diversity of patterns in providing locally-relevant support to promote sustainable transitions.

1. Introduction

Agriculture is the backbone of most African economies, dominated by family farming, which remains the primary source of food, income, and employment for a rapidly growing population (Davis et al., 2023; Lowder et al., 2019). However, family farmers face significant challenges: reduced availability and security of land (Chamberlin et al., 2014) limited access to capital and knowledge (Gollin, 2023), biodiversity loss (Leisher et al., 2020), ecosystems degradation (IPBES, 2018), increasing climatic risks (IPCC, 2023). Despite these challenges, African agricultural policies largely adhere to the 'green revolution model', promoting synthetic inputs, monocultures, and mechanization (Daum et al., 2025; Losch, 2022). Yet, this model has failed to replicate Asia's development success in Africa (Dorin et al., 2013) and raises serious social and environmental sustainability concerns (IAASTD, 2008; Kehoe et al., 2017; Snapp et al., 2010).

In response, agroecology is increasingly put forward as an alternative paradigm in Africa and globally (AFSA, 2016; Akanmu et al., 2023; Bezner Kerr et al., 2023; Gliessman, 2020; HLPE, 2019; IPBES, 2024; IPES-Food, 2016; Mdee et al., 2019) able to meet deep ecological modernisation (Rocchi et al., 2020). Agroecology combines ecological and social justice principles such as biodiversity, recycling, knowledge co-creation, and fairness (Wezel et al., 2020). Unlike the green revolution, agroecology is context-dependent, requiring culturally appropriate, co-constructed practices. Its implementation follows agroecological transition pathways, defined as gradual shifts in farming systems towards greater alignment with agroecological principles (Gliessman, 2016).

While critics argue agroecology risks trapping farms in low-productivity cycles (Mugwanya, 2019; Muhumuza, 2023), evidence suggests otherwise (Mouratiadou et al., 2024). Recent reviews show that agroecology often improves incomes, food security and nutrition (Bezner Kerr et al., 2021, 2022; Kangmennaang et al., 2017; Lucantoni et al., 2023), climate resilience (Bezner Kerr et al., 2023), gender equity (Cetrone et al., 2021; Kansanga et al., 2024) and ecosystems sustainability (Madsen et al., 2021). However, assessing agroecology outcomes remains methodologically challenging. It is complicated by the development of agroecological transitions over time, driven by the diversity of their contexts and modalities (Andrieu et al., 2025; Darmaun et al., 2023; Wezel et al., 2020) and the lack of metrics capturing both socioeconomic and environmental dimensions of alternative models of agriculture (Geck et al., 2023; IPES-Food, 2016).

But a critical gap persists as little attention has been paid to understanding what factors at farm level, lead to increased use of agroecological practices (Manyanga et al., 2023), putting farm structures, typically land size and dotation in labor and capital, as a black box in the agroecological transitions debates. While studies recognise diverse transitions pathways (HLPE, 2019; IPES-Food and ETC Group, 2021), the starting points of these transitions in Africa remain unclear (Côte et al., 2022).

Existing research either focuses on isolated case studies (Hammond et al., 2017; Berre et al., 2022; Périnelle et al., 2022; Pépin et al., 2021; Lucantoni et al., 2023; Timler et al., 2023) or develops standardized tools like FAO's TAPE (Mottet et al., 2020). The latter has been recently used in Africa to understand the links between agroecological integration and multidimensional performance (Adoyo et al., 2025). However, they do not address the issue of farm structures to grasp starting points in agroecological transition paths.

This paper addresses this gap by providing evidence on the relationship between farm structure and agroecological practices across multiple African contexts, thereby offering insights into how agroecological transitions (AET) may unfold and how policies can effectively support them while considering socio-technical contexts.

For this purpose, this article analyzes 9 case studies across 6 African countries, using a harmonized dataset of nearly 3000 farms from the TPP-Viability project[1] (see Fig. 1). We examine how farm structure relate to the diversity of agroecological practices, identifying three dominant patterns and their implications for transition pathways. Our large-scale, comparative approach provides generic evidence on agroecological transition starting points, highlighting the role of farm structures and informing policy dialogue.

2. Farm structures and agroecology in sustainable transitions

2.1. Relations between farm structures and agroecology in Africa

Two main paths of transformation are identified to improve the sustainability of agriculture. Horlings and Marsden (2011) contrast a "weak" ecological modernisation of agriculture, based on technological progress and economies of scale, with a "deep" modernisation, focused on the protection or restauration of nature and the development of ecosystemic services (e.g. agroecology). These visions tend to associate smallholders with agroecological practices (Altieri et al., 2015; Dittmer et al., 2023), and larger, better endowed farms with conventional agriculture (Dugué et al., 2012; Ebel, 2020), thereby obscuring the real diversity of family farming systems (Herrero et al., 2017; Sourisseau, 2015). Since strong ecological modernization exists only as a niche (Duru and Therond, 2015), it is more useful to ask where and how different farm structures can contribute to the sustainability of agriculture (Sumberg and Giller, 2022).

Regarding land, farm size is strongly correlated with low levels of diversification in crops and livestock (HLPE, 2019; Ricciardi et al., 2021), partly because certain agroecological pratices optimize land use (e.g. intercropping rather than rotation) (Himmelstein et al., 2017). However, Tittonell et al. (2020) stress the urgent need to mainstream agroecology among large-scale farmers, which requires targeted efforts in research and policy.

Labor is a second key dimension. Identify labor availability as a constraint to agroecological transition, given the high labor demands of agroecological practices (Aubron et al., 2016; Daum et al., 2023; Mekuria et al., 2022), recent reviews in Africa reveals a wide diversity of labor requirements and organizational patterns depending on context (Dedieu et al., 2025; Laske and Michel, 2022). Conversely, labor can also act as a lever in AET: in Malawi Timler et al. (2023) identify sustainable intensification pathways combining labor and natural capital; in Tanzania, Ulukan et al. (2022) show that less-endowed farmers can improve their livelihood through practices that mobilise their available labor resources.

Beyond land and labor, other structural factors influence the adoption of agroecological practices, including off-farm economic activities, market access, livestock ownership, membership in farming organization and access to credit (Guo et al., 2020; Manyanga et al., 2023).

Taken together, these findings point to a central conclusion: the debate cannot be reduced to an opposition between small agroecological farms and large conventional ones. Farmers often combine both types of practices within hybrid farming systems (Akakpo et al., 2025), seeking to balance resources efficiency with market access (Ameur and

[1] These surveys were conducted in 2021 as part of the TPP – Viability project: https://www.cirad.fr/en/cirad-news/news/2021/viability-project-agroecological-transition-in-africa

Leauthaud, 2025). This internal diversity within farms must be taken into account when analysing the starting points of agroecological transitions.

2.2. Conceptual framework: starting point of AET in socio-technical context

To examine how different farm structures engage with AEP and may contribute to the broader AE transition we state that the farm level socio-technical innovations is a productive entry point for studying 'society in the making' (Latour, 1990). For this we articulate the 13 Agroecological principles of agroecology (HLPE, 2019) with a farming system approach that focuses on cropping and livestock systems, i.e. combinations of practices implemented, respectively, on a field, a herd, or a farm, for plant or animal production (Darnhofer et al., 2010).

On this basis, we define a starting point is the existing state of agroecological principles implemented by farms, resulting from past trajectories and situated along a potential pathway of agroecological transitions.

Drawing on the multi-level perspective (MLP) framework, which has proven valuable for analysing ongoing and prospective sustainability transitions (Geels, 2002; Geels and Schot, 2007), including agroecology (Levidow et al., 2014; Tapsoba et al., 2023), we use this framework to better understand observed starting points within the socio-technical context. We posit that a starting point reflects both the outcome of past management decisions taken by farmers embedded in a particular socio-technical regime (Geels, 2011) (see Fig. 2) and the foundation from which farmers may initiate alternative practices that support emerging niches within that regime. Agri-food systems are stabilized by the alignments between technologies, policies, user patterns, infrastructures, and cultural discourses that have been consolidated over decades. These elements are reproduced, maintained and incrementally modified by incumbent actors, such as engineers, policy-makers and regulators, and interest groups. The perceptions and actions of these social groups are shaped by entrenched shared rules and institutions, which are called socio-technical regimes (Geels, 2019). In other words, the local context and types of support to agriculture (or lack of) or specific configuration of actors in the socio-technical regime helps explain important changes (Geels, 2011).

In particular, we suggest to explore three key dimensions of socio-technical transition: (i) the socio-technical environment in which AET is embedded (ii) the structure and dynamics of stakeholders network, and (iii) the barriers and levers shaping AET development. The first dimension captures the situated nature of AET across biophysical, social, economic, policy, knowledge and farming systems dimensions. Stakeholder networks mediate transitions through information flows, collaboration, and resources mobilisation. Barriers and levers respectively constrain or enable the implementation, scaling, and replication of agroecological initiatives.

Building on this conceptual framework, we investigate which farm structures support different agroecological principles, what role the socio-technical context plays, and what it implies in terms of policy options. We advance two scientific propositions (i) starting points of agroecological transitions in sub-Saharan Africa are highly diverse; and (ii) in comparable socio-technical contexts, generic starting points can be identified, reflecting recurring patterns of agroecological principles underpinned by common farm structure.

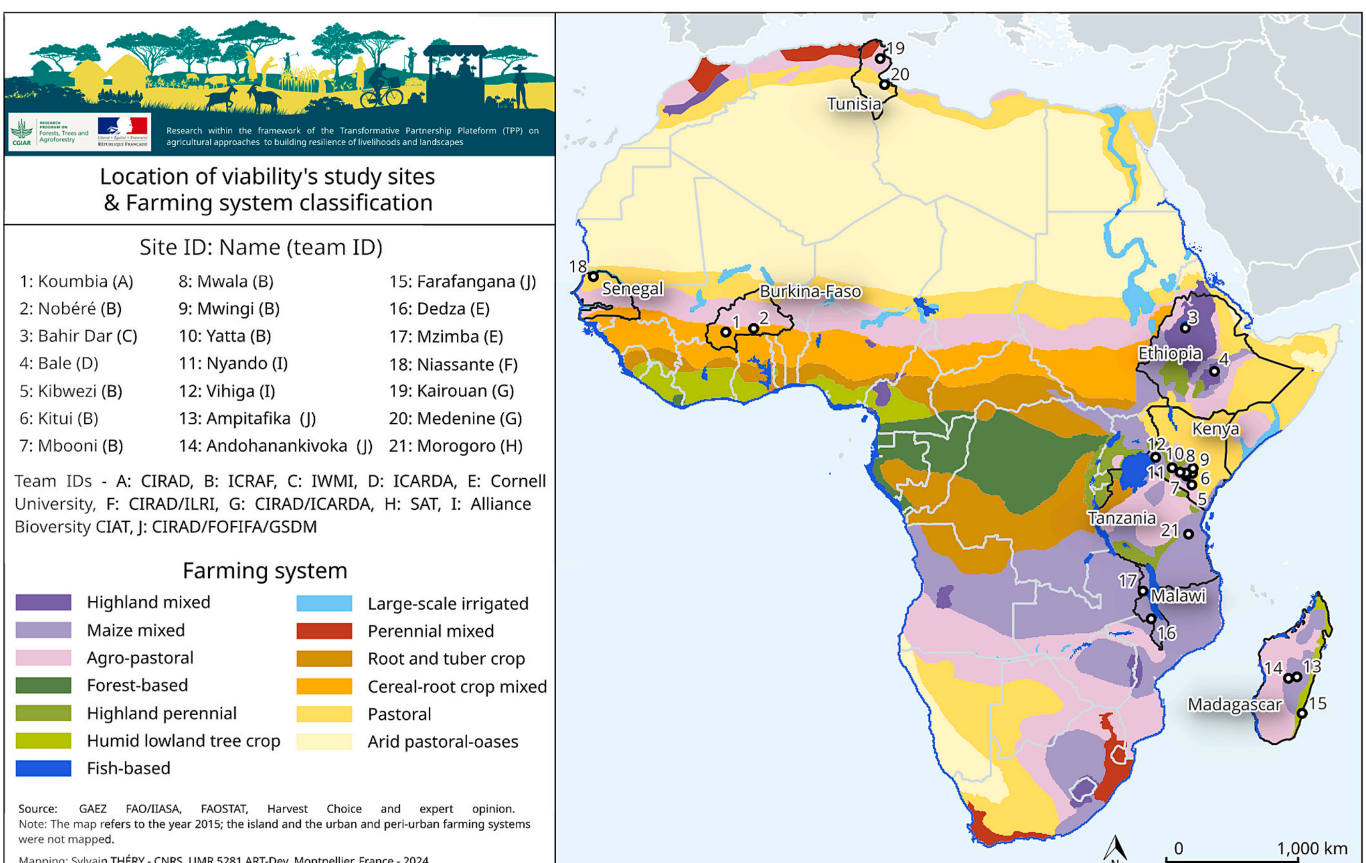

Fig. 1. Location of viability study areas and farming system classification.

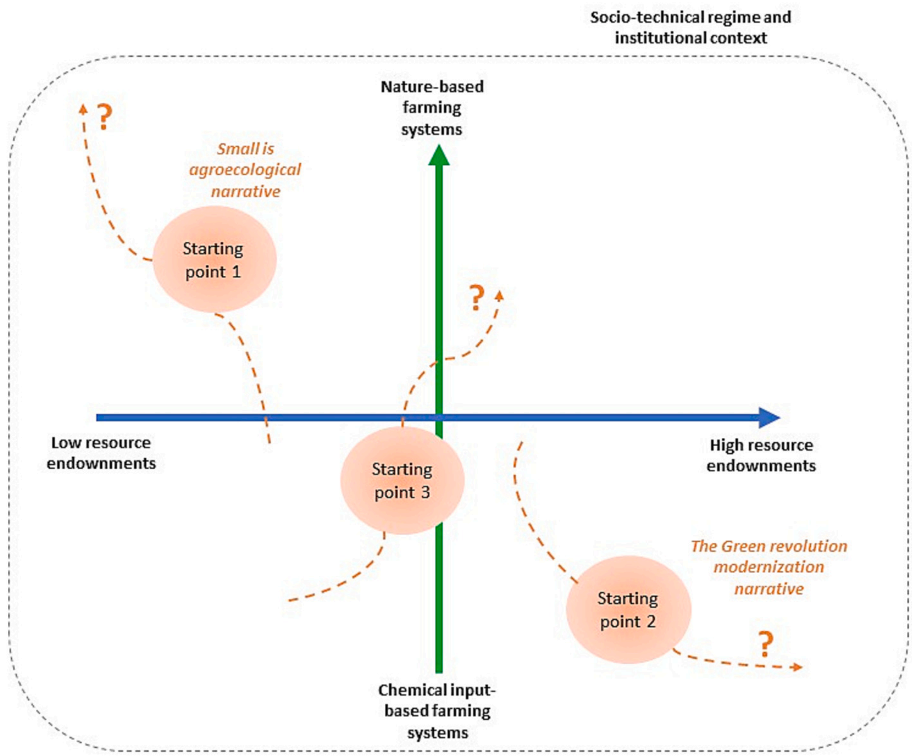

Fig. 2. Patterns of farm structure and starting points of agroecological transition in perspective with dominant narratives.

3. Method

3.1. Study areas and farm surveys

The 9 case study areas belong to the five main farming systems where more than 70% of the rural poor in sub-Saharan Africa live (Dixon et al., 2020). The systems are: the highland perennial farming systems, maize-mixed farming systems, cereal-root crop mixed farming systems, agro-pastoral farming systems, and highland mixed farming systems (see Fig. 1 and Appendix 1). They were selected to display a large diversity of productive contexts including on-going agroecological initiatives (endogenous or supported by research and development projects).

This article uses a farm level database collected using a common questionnaire adapted to the contexts of the 9 case studies. Sampling was based on different modalities according to previous knowledge on each study area by local research partners and current dataset and sampling frames available (see Appendix 2). Most of the study teams implemented random sampling, while others adopted purposive sampling to ensure the representation of each type of farming systems and the implementation of agroecological practices in the region. The 9 sites

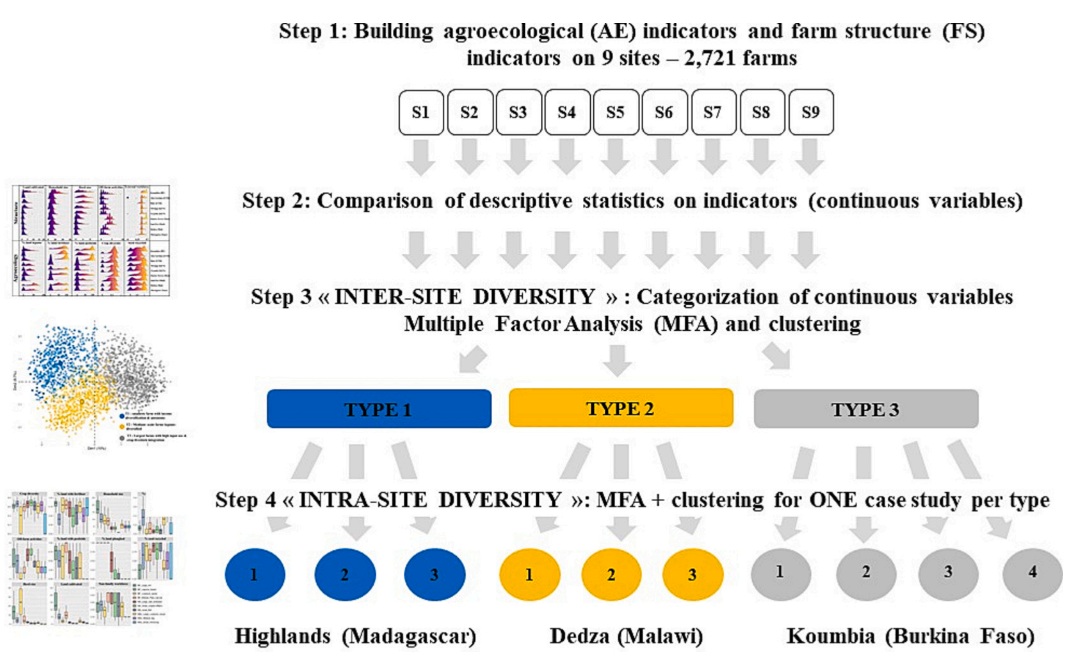

Fig. 3. Methodological diagram.

survey covered a total of 2765 farms but we had to drop some of them to ensure data quality. We performed data analysis with 2721 farms. From this database we implemented several steps to inform starting points of agroecological transitions and find generic starting points reflecting patterns of agroecological principles, which are underpinned by common farm structure (see Fig. 3).

3.2. Building farm structure indicators and agroecological indicators in the 9 sites

First, regarding farm structure indicators, we draw on the literature about farming systems typologies (Alvarez et al., 2018) and farm structures on one side, and on reviews of the drivers of the adoption of agroecological practices in Africa on the other side (Manyanga et al., 2023). Farm structure defines an agricultural productive unit in terms of sizes of the land area and livestock herds, the labor force working on the farm and its main characteristics (such as age or working time), the means of production, and legal and organizational aspects of land tenure, farm management and market access (Stanton, 1991). Among a large set of available variables, we selected the 5 following structure indicators reflecting land, labor, animal and financial capitals: cultivated land size, household size, external workforce, livestock ownership (expressed in number of Tropical Livestock Unit), and non-farm economic activities (Table 1). It is important to note that the gender dynamics and the age of farmers were not considered in the description of farm structure, which prevents the integration of these social and demographic factors with the process of agroecological transition in these studied systems.

Regarding agroecological indicators, we followed the agroecological principles defined the High-level panel of experts (HLPE) and reported in by Wezel et al. (2020) covering 5 out of these 13 agroecological principles with 8 proxy indices: biodiversity, soil health, synergy, input use, recycling (Table 2). For each of the principles covered, we tried to select proxies that are relevant for most study areas. Indeed, some AE

Table 1
Farm structure indicators.

Farm structure indicator	Description
Household size	Number of households members. A household is defined as a production, distribution and consumption unit based on the arrangements made by persons, individually or in groups, for providing themselves with food or other essentials for living. These persons can live or not "under the same roof" (for instance, a person living permanently in town and regularly sending/receiving remittances is considered as a household member).
External workforce	Proportion of external workforce compared to total workforce. External workforce consists of number of permanent workforce and coefficient of use of temporary workers. Total workforce includes external workforce and family active workers. Number of permanent agricultural workers + coefficient of use of temporary workers / (Number of family active workers + Number of permanent agricultural workers + coefficient of use of temporary workers) The coefficient of use of temporary workers has been calculated on the number of times the farm hired temporary workers over the reference period.
Cultivated land size	Describes the area cultivated over the reference period (without garden and orchard)
Tropical Livestock unit	Number of Tropical Livestock unit calculated according to this formula produced by FAO TLU = (0.7*n_cattle) + (0.1*n_goats) + (0.1*sheep) + (0.2*n_pigs) + (0.01*n_poultry) + (0.5*n_donkey) + (1.25*_n_camel) + (0.5*n_horse)
Off-farm activities	Describes the sum of off-farm activities done by household members

Table 2
Agroecological indicators used as proxy of agroecological principles.

Agroecological principles	Related indicator	Description
Biodiversity	Crop diversity	Describes the crop diversity based on the Simpson index calculation (Simpson 1949). Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.
	Share of land with trees	Describes the proportion of crop cultivated land with the presence of trees. It does not include plantations.
Soil Health	Share of land ploughed	Describes the proportion of land ploughed with animal or tractor on the farm. It does not include land ploughed with hoe (manual ploughing).
	Share of cultivated land under legumes	Percentage of cultivated land under legume
Synergy	Crop-livestock index	Describes the connexions between farming activities and livestock activities regarding three components: use of manure, production of own feed for animals, use of animals for ploughing. The index sums all components (0 = no component, 1 = 1 component, 2 = two components, 3 = all components)
Input use	Share of land with pesticides	Describes the proportion of cultivated land where farmer used pesticides. It does not consider the quantity of pesticides put on this land. Pesticides includes weedicides, insecticides and fungicides
	Share of land with mineral fertilizers	Describes the proportion of cultivated land where farmers used of mineral fertilizers. It does not consider the quantity of fertilizers put on this land.
Recycling	Share of seed recycled or exchanged	Describes the proportion of cultivated crops with seeds coming from non-market exchanges or savings (own farm seed production and consumption).

indicators may be less relevant for some areas compared to others. For example, crop residues recycling as proxy for the recycling principle may be less widely practiced compared to seed recycling, as crop residue are used in very different ways according to the context. Other principles proposed by HLPE (2019) are less obvious to capture at the farm level such as social values and diets, fairness, participation and land/natural resource governance; and where out of the scope of our farm survey. Moreover, the principle "economic diversification" is considered in the farm structure indicators.

3.3. Statistical analysis

We elaborated two datasets. The first dataset contains quantitative (continuous) variables and is used to test our first hypothesis looking at the diversity of starting points of agroecological transitions in the different study areas (Section 4.1).

For our second hypothesis, we categorized these quantitative variables to form a second dataset in order to implement a Multiple Factor Analysis (MFA) (Pagès, 2013) (Section 4.2 and 4.3). We had to categorize these variables because many of the quantitative variables did not follow the normal distribution (even after log or rank transformation). We used an hybrid approach to define these threshold based on both data (to ensure balanced effective per modalities) and agronomic sense for the indicator to be as explicit as possible. We tested threshold effects. Multiple factor analysis is the factorial method adapted to the study of tables in which a set of individuals is described by a set of variables (quantitative and/or qualitative) structured into groups. We have formed two groups in our analysis: the structure indicators group and the agroecological indicators group (Wickham, 2016). A third group is that of zones, used as an illustrative variable in the MFA.

3.4. Collective validation and interpretation of results

To validate and interpet our results, we had interviews with case study teams that aimed to discuss the typology and deepen the discussion around possible factors that can explain farm diversity and institutional context within one case study, from an expert point of view. To further interpret typologies, we also use qualitative information produced by the TPP project about main characteristics of country and study areas in terms of socioeconomic and political contexts and perceptions on agroecology.

4. Results

4.1. Farm structures and contrasted starting points of AET in sub-Saharan Africa

While the diversity between study areas seems relatively limited in terms of farm structural dimensions, we can identify three general starting points of AE (Fig. 4): a first one where farms make fairly widespread use of chemical inputs, as in Koumbia (Burkina Faso) and Bale and Aba Gerima watershed (Ethiopia). Concomitantly, the Koumbia, Aba Gerima watershed and Bale study areas are also among the largest farms in terms of land and household size, and those with the highest herd sizes. The latter suggests greater levels of synergy principle through integration between agriculture and livestock farming, and the use of organic manure as a complement to mineral fertilizers (as confirmed by the crop-livestock index, as there are very few farms with a low CLI in these sites). A second set of situations at the opposite end of the spectrum, where farms make little or no input use, as in Mwingi (Kenya) or in the Atsimo-Atsinanana area (Madagascar) and where starting point of agroecology manifests itself above all through crop diversity and recycling with relatively high seed autonomy. Third, there are sites where the importance of soil health practices through the inclusion of legumes in crop rotation (on a site-by-site basis) as in Dedza and Morogoro.

4.2. Which agroecological principles according to farm structures: Three contrasted patterns at the continental level

To confirm and expand these initial results, our second hypothesis seeks to identify recurring relations between farm structures and agroecological principles implemented, while considering the local and national contexts of each study area. To do this, based on the categorical variables' dataset (see Appendix 3) we implemented a multifactorial analysis (MCA) and a hierarchical clustering (HCA) on farm structure indicators and agroecological indicators (see Appendix 4).

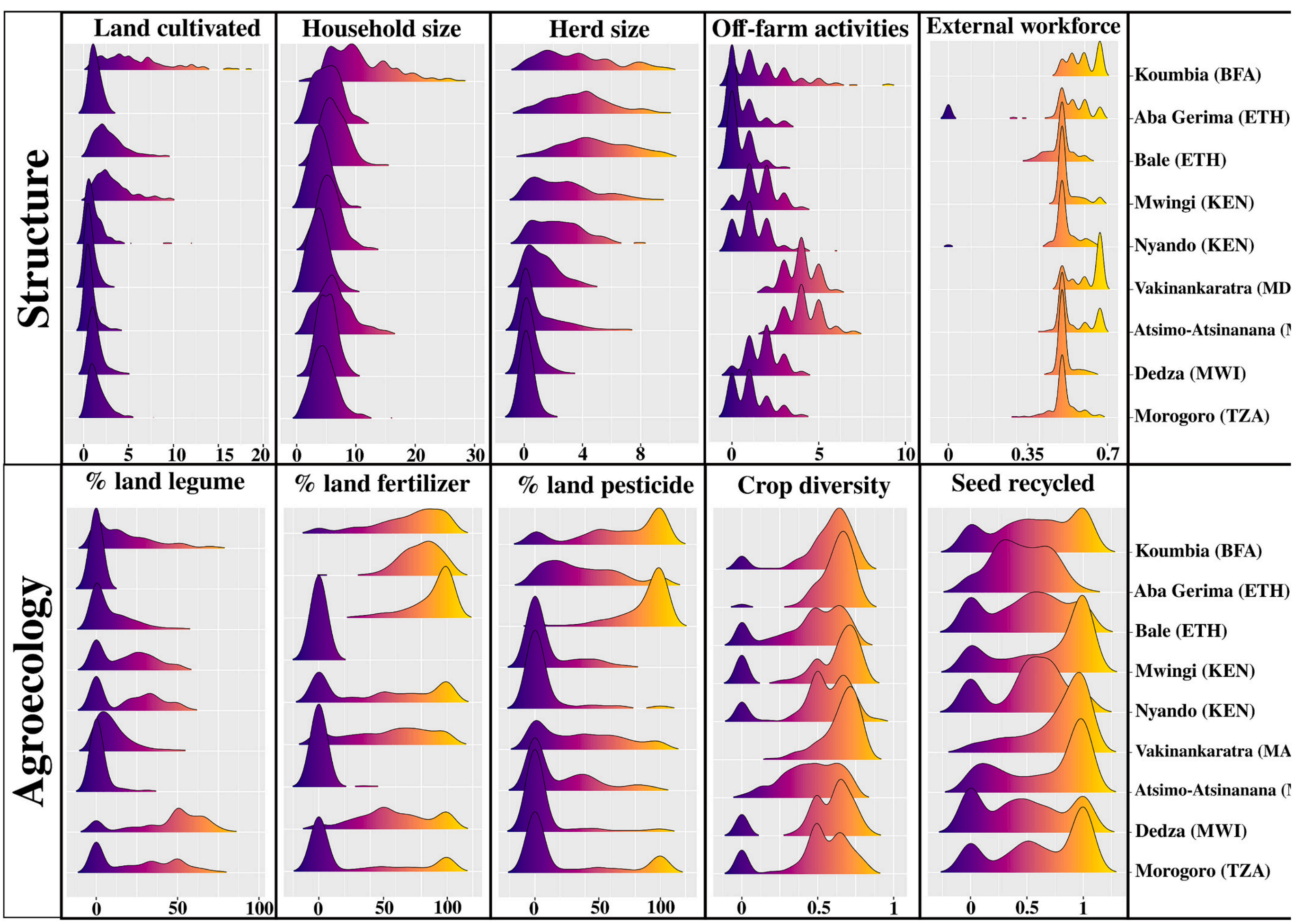

Fig. 4. Distribution of farms in terms of Agroecological practices and farm structure indicators across the 9 case studies; land cultivated (hectares), household size (number of persons), herd size (number of TLU), off-farm activities (number of activities).

MCA results show a clear opposition between, on the one hand, agroecological characteristics marked by low agricultural-livestock integration, low use of mineral fertilizers and pesticides and ploughing practices, and, on the other hand, farm structures characterized by high land and animal assets. In other words, the farms with the most land, animals are those with the most "conventional" farming practices supporting the general assumption in the literature that larger farms use fewer AE practices.

A second result shows a synergy between household size, employment of hired labor and crop diversity. In other words, the largest families tend to employ the most wage workers, and to have more diversified cropping systems, often through intercropping, supporting the assumption in the literature that agroecological practices, at least greater crop diversity, is more labor intensive.

Investigating further the relations between farm structures and agroecological principles, from the coordinates of the individuals on the MFA axes, we performed a hierarchical ascending classification using the first 5 axes of the MFA, which represents 42% of the total variability in the sample (Fig. 5).

We distinguish 3 farm types reflecting core patterns linking farm structure and state of AE principles (Fig. 6 and characterization details in Appendix 4).

When controlling with the study area variable, the three types of farms built on farm structure indicators and agroecological indicators are highly context-dependent (Fig. 7). We can there assume that the typology is mainly driven by the different types of farming systems encountered in each site (agropastoral, maize-based, etc.). That's why the effect "zone" came strongly here. The distribution in each farm types is statistically different for each case studies under the Fisher test (small effectives in the contingency table) with Monte-Carlo Simulation (several modalities) and 100.000 replicates (p-value = 0.00001).

The first farm type (T1) "smallest farms income diversification and autonomy" consists of small pluri-active farming structures mobilizing agroecological principles predominantly based on recycling and crop diversification. These farms are characterized by small cultivated areas (75% cultivate less than 1 ha), families of less than 7 people, and fewer than 4 TLU. They strongly diversify income through non-agricultural activities. Soil health and synergy remain marginal in their strategies: they grow relatively few legumes (¾ grow less than 10%), use few mineral fertilizers and pesticides, and rarely combine farming and livestock rearing. Seed supply relies on self-consumption or non-commercial exchange with neighbors, reflecting a degree of autonomy. Farms of this type are mainly found in the Vakinankaratra and Atsimo-Atsinanana areas in Madagascar, where legume cultivation remains underdeveloped, particulary in Atsimo-Atsinanana.

The second type (T2), "medium scale farms leguminous diversified", displays a strong relation between crop diversification and legume-based intensification, embodied by small and medium-sized farm structures mobilizing agroecological principles based on synergy and soil health. Household sizes and TLU numbers remain moderate, and labor is essentially family-based. Most farms diversify their economic activities, with only 14% specializing in agriculture. Mineral fertilizers and pesticides are used on a small share of cultivated land, and crop-livestock association is practiced through small ruminant manure as organic fertilizer, with little use of animal traction or machinery. The defining feature of this type is legume cultivation: farms grow legumes on average on 30% of their land, often exceeding 50%, playing a significant role in soil fertility renewal. These farms are mostly found in the Mwingi and Nyando (Kenya), Dedza (Malawi), and Morogoro (Tanzania).

The third type (T3) "largest farms, with input and crop livestok integration", combines relatively large farm structures specialized in agriculture with a high input use and strong crop-livestock association. These farms display higher endowments: nearly 90% cultivate more than 1 ha, 42% more than 3 ha, and 65% own more than 4 TLU. More than half have no non-agricultural activity. Integrated fertility management is weak as the vast majority plough over 90% of their land and do not diversity their cropping systems (less than 10% legumes, and rarely practice rotation). However, high inputs use coexists with good synergy scores, as 95% of farms combine agriculture and livestock to a medium or high degree, making use of organic inputs as well. These farms are mostly found in Koumbia (Burkina Faso), Aba Gerima watershed (Bahir), and Bale (Ethiopia).

These results confirm the existence of patterns between farm structure and agroecological principles. But as we see on Fig. 7, the three farm types identified mainly capture variation between location. The type

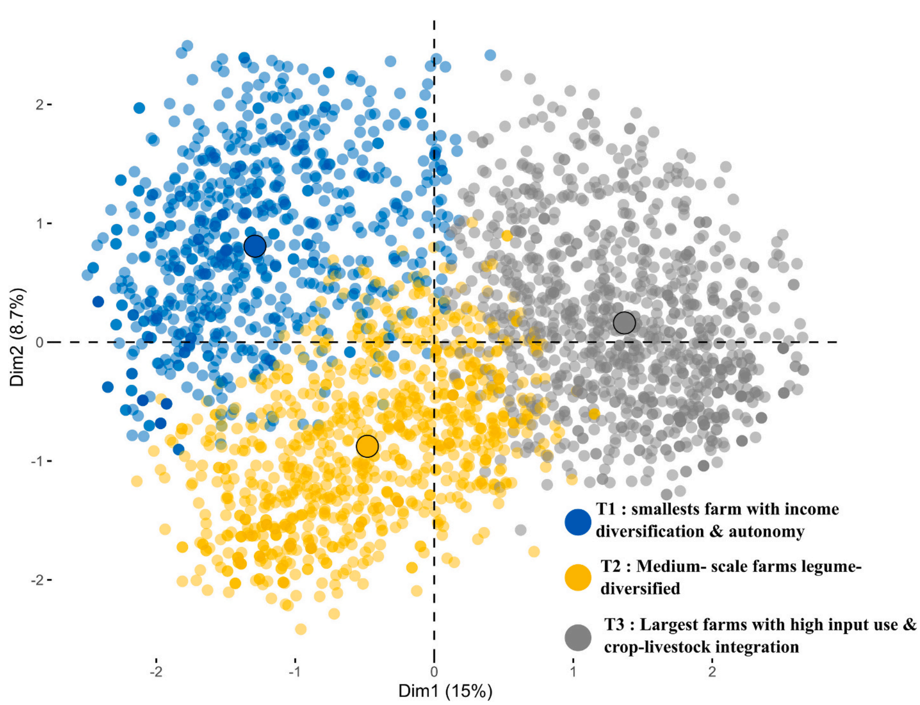

Fig. 5. Projection of the 3 farm types on MFA axes 1 and 2.

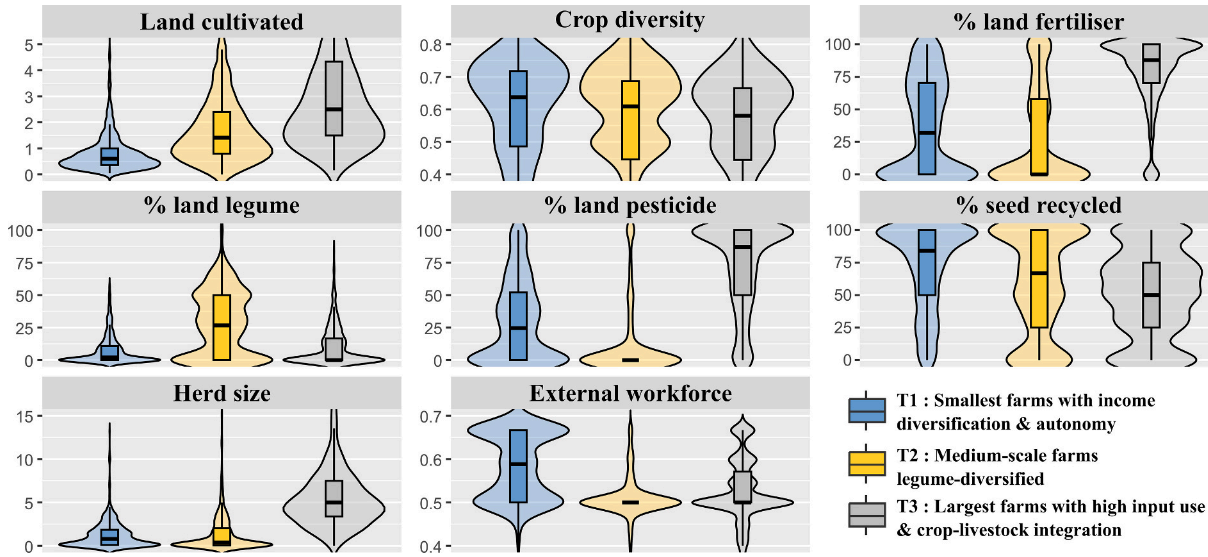

Fig. 6. Boxplot of variables that most discriminate between types; land cultivated (hectares), household size (number of persons), herd size (number of TLU), off-farm activities (number of activities).

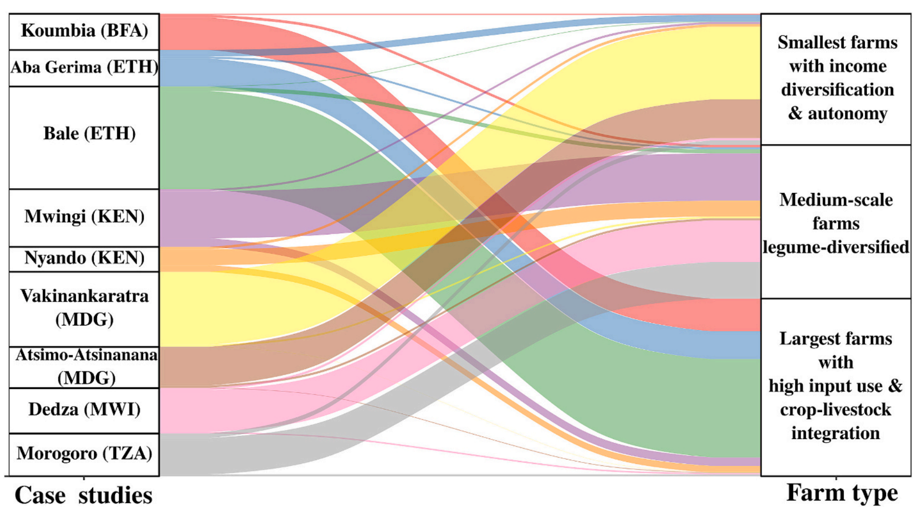

Fig. 7. Relationships between study areas and farm types.

may be confounded with any other factors that vary between locations (climate, socio-political context, etc), rather than within location. Beyond the 3 farm types identified at a "subcontinental" scale, there is diversity in patterns of farm structures and states of agroecological principles within study areas themselves. This enables us to anchor the interpretation of typologies in particular socio-economic and political contexts that the continental scale does not allow.

4.3. Contrasted patterns of farm structure and agroecological principles relations at the case study level

In this section, we dig into one case study for each of the three major patterns identified above to look at the intra-site diversity of relationships between farm structure and agroecological principles: the Vakinankaratra site in Madagascar, Dedza in Malawi and Koumbia in Burkina Faso. The analysis method we have used is the same as in the previous section: for each case study, we performed an MFA and an HCA (hierarchical clustering) on farm structure indicators and agroecological indicators. Results show (Appendix 5) that beyond the predominance of one of the specific patterns described above, in each case study other farm types embody alternative patterns of agroecological principles and structures.

The Vakinankaratra case study is mostly reflected in the first farm type (T1) which consists of smaller farms mainly featured by economic diversification and autonomy. Family farming with very low use of chemical inputs and a diversified cropping system is the dominant farming system in these areas. In each of these areas, most of the farms are small, and there are very few large farms. Farms are differentiated by the proportion of ploughed area, the use of mineral fertilizers and economic diversification. We can distinguish two different patterns. The first one is a combination of ploughing, use of conventional inputs and livestock integration and concerns relatively larger local farms. Yet according to Randriamihary (2018), the average dose of fertilizers in this region on rice is less than 30 kg/ha/year, suggesting these farms are not intensifying in a conventional way. In addition, locally larger farms are often the ones with a few head of cattle, which are used for farm work, milk production and organic manure production (Sourisseau et al., 2019). Pluriactivity is a structural feature of these farms with an average of 4 activities per farm. The second pattern concerns smaller pluriactive farms and is more agroecological to the extent they use less conventional inputs, do not plough and rely more on autonomy for accessing seeds.

Dedza study area is mostly reflected in the second farm type (T2) which set up strong relation between diversification and leguminous based intensification. In Dedza, rainfed farming systems are based on maize and legumes (beans, cowpeas, groundnuts or soyabeans) in combination or in rotation. The legume-based agroecology in Dedza are due to agroecological intervention that supported legume diversification, legume residue incorporation and legume intercropping as ways to improve soil fertility that are accessible to farmers without livestock. Legumes are also preferred because they have lower nutrient requirements and for their valuable nutritional qualities.

But when we go down to an analysis of the diversity of the relations between farm structures and agroecological principles at the scale of the Dedza study area, we observe more varied strategies in terms of the importance of legume. Indeed, we have identified 3 types of farms in Dedza which differentiate which are mostly discriminated by the crop diversity and the share legume: the latter varies from 0% to 60% according to farm type. This is the same trend for crop diversity. Actually, there is a farm type which is characterized by maize monocropping compared to another type which is characterized by a high cultivation of legume and lower use of mineral fertilizers. The last type is characterized by an in-between share of legume (about 30%) and relatively higher use of mineral fertilizers. It is also the only one to use pesticides and farms in this type have relatively higher land size; even if it remains less than 3 ha. Therefore, in Dedza area, AE transition can start from a more input-based point or from a more agroecological and leguminous based point.

Koumbia is mostly reflected in the third farm type (T3) which consists of largest farms that combines relatively large farm structures specialized in agriculture with a relatively high share of land with input use combined with a strong agriculture-livestock association. Crop-livestock synergies and by-product recycling are major factors for agroecology of agro-sylvo-pastoral systems. Livestock farming is extensive, based on the use of natural rangelands for feeding herds. Among farmers, cattle are mainly used for draft power for cultivation and transport, but their droppings also serve to fertilize the soil.

But when we analyze the diversity of structures and agroecological principles in Koumbia, we see that the area cultivated by farms, the number of TLUs, the share of legume and the use of mineral fertilizers are the variables that most distinguish farms from one another. We can therefore observe three main patterns for agroecology in Koumbia which are confirmed by the research team results (Vall et al., 2023). The first is a more “conventional more intensive” starting point in that it concerns larger farms that use the most mineral fertilizers and pesticides, and whose seed supply relies essentially on the market with largest cotton, they also cultivate less legumes. A second, more agroecological starting point concerns smaller farms that use little mineral fertilizer and have a higher share of legume (nearly 40%). Finally, a third starting point characterized by a greater crop-livestock integration (large number of TLUs) but a lower crop diversity and relatively high share of land with mineral fertilization. Nonetheless, even if the amount of land with mineral fertilizer is significantly higher, it is important to note that the average dose of mineral fertilizer in the region remains low (from 31 to 51 kgN/ha according to Diarisso et al. (2015)).

5. Discussion

5.1. Discussing the dominant dualistic narrative on farm structure and agroecology

Results confirm the diversity of starting points of AET in Africa and show how farm structures support them. We found three generic patterns: smallest family farms with income diversification and autonomy (T1), medium-scale farms legume-diversified (T2), largest farms with high input use and crop-livestock integration (T3).

These findings are very much in line with case study findings on AE systems in Africa and bring more generical evidence on their representativity. The study shows strongly contrasting use of agroecological principles among farmers. More importantly the findings bring new insights for the reading of these patterns by informing how different farm structures are or may be able to use specific AE principles. This directly helps to reflect on the dominant dualistic narratives about effective models of transformation of agriculture (Section 2.). Our findings shows that while some contexts present small farms fitting into the agroecological transition paradigm and large farms in the intensive conventional agriculture paradigm, there are many farms mixing both AE and more conventional practices that do not neatly fit into one clear category, making farming system hybrid (Akakpo et al., 2025). Further, beyond the findings at continental level, findings also evidence the fact that contrasted farm types may coexist in a given context.

Regarding land size, following Himmelstein et al. (2017), we found logics explaining why smaller farms may be more likely to adopt agroecological practices by necessity, but this is not a universal characteristic of all small farms in our study. Indeed, at the local level, some farms in Malawi follow a more “conventional” agriculture based on maize monocropping with a relatively high use of mineral fertilizers. On the other side, farms with most land and animals are those with the most “conventional” farming practices supporting the general assumption in the literature that larger farms use fewer AE practices. This could be because households with greater endowments can afford to purchase the amount of inputs they need, increase mechanization, buy improved varieties. Institutional context may also play a significant role (Section 5.2). Notably, however, we found that crop-livestock integration, which is an agroecological practice, is also used in combination with conventional input use practices.

5.2. Potential AET in Africa from a farm structure lense

This section examines potential transition pathways and how farm structure could shape AET.

Small, diversified, and autonomous farms (type 1) call for specific paths partly explored in the literature. In Madagascar, ecological intensification in Madagascar relies on biodiversity and income diversification Raharison et al. (2022). Timler et al. (2023) in Malawi describe “Seed Saving Peasants” who emphasize local seed systems, post-harvest grain protection, and labor-intensive practices like improving crop residue and manure quality. Reducing external costs by leveraging local resources and ecosystems to enhance self-sufficiency, value addition, and biodiversity is a common farmer strategy to make a living on a small area (van der Ploeg et al., 2019) and can be a transition path for small-scale farms.

Legume-diversified farms (type 2) are well documented (Barnes et al., 2021; Tapsoba et al., 2023). Crop diversification path through the inclusion of legumes in cereal-, root-, or tuber-based cropping systems represents a key sustainable strategy (Rodriguez et al., 2021; Snapp et al., 2010; Zhao et al., 2022) promoted across Africa (CGIAR, 2023; FAO, 2023). A global meta-analysis shows legume-based rotations offer a critical pathway to boost crop production, especially in low-input African systems Zhao et al. (2022).

Largest farms with mineral inputs and crop-livestock integration (type 3) gather a large category of crop-livestock integrated systems over Africa including rainfed mixed system in the Northern African countries (Alary et al., 2024; Ameur and Leauthaud, 2025) and agro-sylvo-pastoral systems in West Africa (CGIAR, 2023; Tapsoba et al., 2023; Vall et al., 2023). By increasing biological diversity, livestock integration reduces economic vulnerability for smallholder farms (Ulukan et al., 2022). Livestock integration represents a pathway for AET but pastoral viability is declining due to limited pasture access, agricultural pressure, and conflicts over communal resource (Orounladji et al., 2024).

Other pathways, like soil and water conservation (Domínguez et al., 2023) are less aligned with the 3 patterns presented in our findings while they are critical especially in arid regions where farms usually have declining soil fertility (Scopel et al., 2013). Farmers may maintain soil fertility through agroforestery (Bayala et al., 2020; Chomba et al., 2020) or direct sowing (Corbeels et al., 2014; Tittonell et al., 2012). Trees also produce feed for livestock, boost incomes, along with other environmental benefits. Despite growing literature on the effects of soil and conservation practices (De Stefano and Jacobson, 2017), there is little evidence to determine where and for whom, sustainable soil fertility can be restored with such practices.

5.3. Considering socio-technical regimes to understand the diversity of patterns

This section integrates key elements of the socio-technical transition approach by examining socio-technical environment, stakeholder dynamics, and levers and lock-ins shaping transitions across selected case studies.

Regarding socio-technical environment, a common feature of Koumbia (Burkina Faso), Bale (Ethiopia) and Dzedza (Malawi) is the strong state-support for input use and cash crops, which reinforces a conventional socio-technical regime and creates significant path-dependence. In Burkina Faso, the dominance of large farms integrating inputs and crop-livestock systems reflects decades of cotton-oriented agricultural policy, still supported by regional frameworks (Kessy, 2023) and research institutions (Daum et al., 2025). In Bale, conventional wheat and barley mono-cropping system, supported by mechanization, high soil fertility, and subsidized inputs (Senbeta and Worku, 2023; Shikur, 2022), has crowed out food legumes and reinforced intensification. Similarly in Dedza, small farm monocropping maize remain highly dependent on mineral fertilizers and hybrid seeds, sustained by large-scale mineral fertilizer subsidy policies since the 2010s (Chirwa and Dorward, 2013).

In contrast, Madagascars agricultural policies, largely centred on conventional intensification until the 2000's (Raharison et al., 2022), failed to deliver expected results. In the Vakinankaratra region, agroecological practices have emerged not through policy support but as a response to severe land pressure: farm sizes have halved since the late 1980s due to population growth, pushing farmers to intensify output per hectare and diversify their income sources (Sourisseau et al., 2019).

Where agroecology operates as a niche within a conventional regime, its promotion depends on structured networks of stakeholders. In Burkina Faso, recent policy signals favorable to agroecology suggest a potential window for regime reconfiguration (Milhorance et al., 2024), supported by producer organizations and NGO, notably the National cotton farmers'union (UNPCB) and Helvetas, whose organic cotton program led to the opening of the first organic cotton factory in West Africa in 2019. In Madagascar, despite decades of NGO and research-led projects and growing policy advocacy, including the 2020 National Strategy for Organic Agriculture, practices such as the system of rice intensification (Serpantié, 2017) and conservation agriculture (Penot et al., 2015), have seen limited adoption. Scaling up remains difficult, particularly given the country's high levels of poverty and food insecurity, which make the conditions for consolidating niche initiatives hard to meet.

In Koumbia, Bale and Dzedza, agricultural policy lock-in generates a strong path-dependence. In Koumbia, credit schemes extension services remain organized around the dominant socio-technical regime (Koutou et al., 2016) and the transition period required for crop-livestock integration, during which farms must recover their ecological balance, lacks adequate risk coverage for farmers. In the Vakinankaratra, land tenure is a cross-cutting barrier, and financial constraints at farm level mean that the adopted practices must simultaneously meet short-term needs (food security, income) and long-term goals (soil fertility improvements). Nevertheless, market dynamics can also serve as levers for transition: the development of the Participatory Guarantee System or protected geographical indications in Madagascar illustrate how value chain mechanisms can create incentives for agroecological practices, even where structural barriers remain significant (Cerdan et al., 2019).

5.4. What does it tell us for policy design?

Agroecological transitions may engage various scales and dimensions, from management decisions on farms to complex transformations resulting from the decisions of various actors within a wider landscape. Policy instruments should consider the diversity of farm structures and starting points but they should also consider socio-technical regimes in which they are embedded.

Considering the diversity of farm structures and starting points is not easy for public policies as in practice, fine-grained farm-level data are rarely available, and overly targeted policies risk creating segmentation. A more inclusive path can be to articulate a universal core of measures (basic advisory support, access to quality local seeds, promotion of legumes, standardization of biocontrol) with incentives modulated through simple observable indicators (share of legumes, presence or value of livestock, approximate farm size), and low-cost territorial mechanisms (rapid participatory diagnostics, simplified observatories, local public procurement). In situations where the socio-technical regime is locked in by structural input subsidy policies (e.g. Malawi or Burkina Faso), States could combine these policies with programmes more oriented towards the mobilisation of organic inputs (e.g. conditioning access to conventional inputs on the implementation of agroecological practices).

Beyond these possible ways for public policies, we must consider that AET, as a complex interplay between exogenous and endogenous factors, is a wicked problem that cannot be addressed through isolated measures. It rather calls for systemic thinking linking structural conditions with farm-level realities, integrated governance and approaches that account for feedback loops, conflicting objectives, and unforeseen consequences (Anderson et al., 2019; Van Bers et al., 2019). This requires a much broader conceptualization of governance and policy. Governance is about how power is exercised to take decisions (in communities, families, policy arenas, etc.) or not and who benefits and who does not from the process of change. It is important to move beyond the notion of policies as a foundation for the scaling of a transformative agroecology and to look at the process, politics and principles of mobilisation and shifting power. Policy is just one governance intervention among many. In other words, supporting AET require to organise the debate between stakeholders.

5.5. Limits of the research

Comparing different contexts with different farming systems in terms of farm size, cropping and livetsock systems makes it a challenge for building indicators. For the sake of cross-site comparability and statistical difficulty of including too many variables in the analysis, the article covers only five HLPE principles (biodiversity, soil health, synergies, inputs, recycling) out of thirteen. We selected these indicators as they cover most of the AE dimensions at the farm level. Other principles such as governance, co-creation of knowledge, fairness, social values and diets are missing from the analysis and it limits the identification of the full "development areas" of an agroecological transition. It may be somewhat difficult to find proxies at the farm level for these dimensions but it represents stimulating areas for further researches. Finally, the analysis of farm structure did not account for gender dynamics or the age pyramid, both of which could provide critical insights into their relations with agroecological princiaples in the studied areas.

6. Conclusion

Considering critical climate and environmental challenges, as well as dependency on conventional farming, African farming systems are wise to move towards sustainability. By comparing 9 different contexts, this article helps grasp the features of farmers' current starting points in agroecological transition paths, taking into account farm structures. We demonstrated that starting points of agroecological transitions in sub-Saharan Africa are highly diverse, and that generic patterns combining farm structure and AE principles show that 'small is agroecological' or 'large is conventional' narratives are misleading. Our approach demonstrates the need to look at local context to understand the diversity of possible transitions to more agroecological farming systems. A deeper understanding of starting points is critical for designing policies that can effectively scale up agroecology. There is no "one-size-fits-all" package to transfer; each situation demands a context-specific analysis of AET in relation to the prevailing socio-technical regime. However, change will not only stem solely from public policies. It also requires the engagement of a diversity actors committed to advancing agroecology. Further research should integrate the full set AE principles at the farm level while expanding analysis of power relations at the territorial and national scales, combining quantitative and qualitative methodologies in a transdisciplinary approach.

CRediT authorship contribution statement

Pierre Girard: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Sara Mercandalli:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **David Berre:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Nadine Andrieu:** Writing – review & editing, Project administration, Methodology. **Rachel Bezner Kerr:** Writing – review & editing, Methodology. **Richard Coe:** Writing – review & editing, Project administration, Methodology. **Benoît Dedieu:** Writing – review & editing, Methodology. **Sidney Madsen:** Writing – review & editing, Methodology. **Eric Scopel:** Writing – review & editing, Methodology. **Woinishet Asnake:** Writing – review & editing, Methodology, Investigation. **Wolde Mekuria:** Writing – review & editing, Methodology, Investigation. **Catherine Dembele:** Writing – review & editing, Methodology, Investigation. **Aymen Frija:** Writing – review & editing, Methodology, Investigation. **Yohana Haule:** Writing – review & editing, Methodology, Investigation. **Christine Magaju:** Writing – review & editing, Methodology, Investigation. **Dejene Kassahun Mengistu:** Writing – review & editing, Methodology, Investigation. **Boko Michel Orounladji:** Writing – review & editing, Methodology, Investigation. **Sitrakiniaina Raharimalala:** Writing – review & editing, Methodology, Investigation.

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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The study was approved by the CIFOR-ICRAF research ethics committee and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Appendix A. Appendix

Appendix 1: Key features of the 9 case study areas.

Case study name (country)	Average altitude above the sea level (meters)	Average annual rainfall (mm)	Dominant farming system region according to Dixon et al. (2020)	Main crops	Livestock	Population density (inhab/km2)
Koumbia (Burkina Faso)	300	800–1100 June to oct	Agro-pastoral	Cotton, maize, legumes and rice	Cattle and small ruminants	48
Aba Gerima watershed (Bahir) (Ethiopia)	1648 to 2578	1343 May to November	Highland mixed	Teff, Fingur Millet, Wheat and maize	Cattle and small ruminants	142
Bale mountains (Ethiopia)	1250 to 3855	Bimodal 600–1000 in lower areas 1000–1400 in higher altitudes Main rainy season: August–January Minor rainy season: March–July	Highland mixed	wheat, barley, and Emmer wheat	cattle and small ruminants	32
Mwingi (Kenya)	1000	2400 All along the year	Maize based	Maize beans	cattle, pig, sheep and goats	95
Nyando (Kenya)	500 to 1900	1800–2000 Major April to June Minor September to November	Maize based	Maize, bean and cowpea	small ruminants No draught animals	360
Vakinankaratra (Madagascar)	1300 to 2600	1300 October to April	Maize based	rice, maize, sweet potatoes, cassava and legumes	cattle and small ruminants	160
Atsimo-Atsinanana (Madagascar)	100 to 500	1500–2000 December and April seasonal cyclones strikes	Humid low land tree crop	rice (irrigated and rainfed), coffee, pepper, perennial fruit trees and food crops, notably cassava	River and sea fishing	155

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Case study name (country)	Average altitude above the sea level (meters)	Average annual rainfall (mm)	Dominant farming system region according to Dixon et al. (2020)	Main crops	Livestock	Population density (inhab/km2)
Dedza (Malawi)	1500	1500 December to April	Maize based	maize, Irish potatoes, sweet potatoes, cassava, groundnuts, beans, pigeonpea and soybeans	small ruminants and poultry aquaculture	250
Morogoro (Tanzania)	600 to over 1250	1000 (october to may)	Maize based	Maize, rice, sorghum, sweet potatoes, beans, cassava, millet, groundnuts	small ruminants, poultry and cattle	45

Appendix B. Details on data collection

Appendix 3: The survey questionnaire is based on 11 sub-section describing the overall farming systems (labor, land use, activities, equipment, finance), the crop and livestock systems, agricultural practices focusing on agroecological practices, and socio-economic information such as richness and food security. The surveys were adapted to fit the context of each site while conserving a common set of data to allow comparison. The surveys were developed under ODK software. An online training has been organized for all teams in May 2021 and an enumerator's manual has been produced. Data collection occurred between June and December 2021 according to the sites. The period covered by the survey is one year and starts from the beginning of the last cropping season.

Country (Research team)	Data collection period	Number of surveys	Sampling method	Sampling frame	Selection criteria	Potential bias	Number of enumerators/supervisors
Koumbia (Burkina Faso)	November–December 2021	220	Stratified purposive sampling based on Vall et al. (2017) Strata: Crop-oriented, livestock-oriented, agropastoral	List of 404 farms elaborated with local authorities (Chairmen of Conseils Villageois de Développement)	Selection criteria within each strata: cultivated area and herd size (TLU)	Overrepresentation of more visible or better-know farms to the local authorities Underrepresentation of small farms located in remote areas Underrepresnetation of transhumant farms which may be moving over the data collection period	3 enumerators 2 supervisors
Aba Gerima watershed (Bahir) (Ethiopia)	July–August 2021	218	Stratified random sampling Strata: Beneficiaries (103) and non-beneficiaries (115) of exclosures (Mekuria et al., 2022).	Official lists of farm households elaborated by agricultural offices at the village level	Random selection within each strata	No	6 enumerators 2 supervisors
Bale Highlands (Ethiopia)	October 2021	601	Random sampling in districts selected for their potential for leguminous production	Official lists of farm households elaborated by agricultural offices at the village level	No selection criteria in the selected districts	No	10 enumerators 2 supervisors
Mwingi (Kenya)	September–October 2021	354	Exhaustive sampling	List of farmers engaged in the IFAD-EC funded restoration project	Being on the project lsit	Risk of overrepresenting project beneficiaries which may have particular characteristics.	5 enumerators 1 supervisor
Nyando (Kenya)	August 2021	146	Stratified random sampling Strata: Beneficiaries and non-beneficiaries of previous agroecological projects	List of project beneficiairies and local lists of farmers	Random selection within each strata	Risk of overrepresenting project beneficiaries which may have particular characteristics.	5 enumerators 1 supervisor
Vakinankaratra (Madagascar)	July – november 2021	455	Stratified random sampling in each purposively selected village to represent the economic, social and agricultural diversity of the region Strata: Beneficiaries and non-beneficiaries of at least one agroecological projects	Electoral list and list of project beneficiairies	Random selection within each strata	Risk of overrepresenting project beneficiaries which may have particular characteristics.	8 enumerators 4 supervisors
Atsimo-Atsinanana (Madagascar)	September – october 2021	241	Stratified random sampling in each purposively selected village to represent the economic, social and agricultural diversity of the region	Electoral list and list of project beneficiairies	Random selection within each strata	Risk of overrepresenting project beneficiaries which may have particular characteristics.	8 enumerators 2 supervisors

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Country (Research team)	Data collection period	Number of surveys	Sampling method	Sampling frame	Selection criteria	Potential bias	Number of enumerators/ supervisors
			Strata: Beneficiaries and non-beneficiaries of at least one agroecological projects				
Dedza (Malawi)	October – November 2021	264	Stratified random sampling Strata: beneficiaries of Malawi Farmer to Farmer Agroecology project and non-beneficiaries from neighbouring villages	List of the MAFFA project beneficiairies List of farms in neighbouring villages	Random selection within each strata	Risk of overrepresenting project beneficiaries which may have particular characteristics.	9 enumerators 3 supervisors
Morogoro (Tanzania)	September–October 2021	266	Stratified random sampling Strata: location of households (upland, lowland)	NGO projecs t lists	Random selection within each strata	Risk of overrepresenting farms involved in agroecological projects implemented by the NGO	12 enumerators 2 supervisors

N·B: the total number of farm surveys is 2765 but 44 observations have been removed during data cleaning leading to 2721 observations used for the analysis.

Appendix C. Indicators

Appendix 3. Description of categorical agroecological and farm structure indicators.

Agroecological indicators	Frequency	%
Crop diversity (active)		
Inf to 0.33	411	15%
0.33–0.66	1387	50%
Sup to 0.66	942	34%
Share of cultivated area ploughed (active)		
Less than 10%	932	34%
Between 10 and 90%	468	17%
More than 90%	1340	49%
Share of cultivated land under legumes (active)		
Less than 10%	1537	56%
Between 10 and 50%	911	33%
More than 50%	306	11%
Share of seed recycled or exchanged (active)		
Less than 25%	546	20%
Between 25 and 75%	1008	37%
More than 75%	1190	43%
Crop-livestock index (active)		
Low	1102	40%
Medium index	1032	37%
High	620	23%
Share of cultivated land with trees (active)		
Less than 10%	1267	46%
Between 10 and 90%	845	31%
More than 90%	642	23%
Share of land with mineral fertilizers (active)		
Less than 25%	981	36%
Between 25 and 75%	690	25%
More than 75%	1069	39%
Share of land with pesticides (active)		
Less than 25%	1302	47%
Between 25 and 75%	663	24%
More than 75%	775	28%

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Agroecological indicators	Frequency	%

Farm structure indicators	Frequency	%
Household size (active)		
Less than 3 members	648	24%
Between 4 and 7 members (included)	1593	58%
More than 7 members	513	19%
Cultivated land size (active)		
Less or equel to 1 ha	1048	38%
Between 1 and 3 ha (included)	1084	39%
More than 3 ha	622	23%
Non-family workforce (active)		
Less or equal to 50%	1613	59%
More than 50%	1141	41%
Number of TLU (active)		
Less or equal to 0.5	858	31%
Between 0.5 and 4 (inluded)	1103	40%
More than 4	793	29%
Number of non-farm activities (active)		
0 non -farm activity	752	27%
1–2 non-farm activities	1101	40%
3 or more non-farm activities	901	33%

Appendix D. MCA and characterization of farm types (* v-test >2 with khi2 test)

The first 2 axes of the MFA explain almost 24% of the diversity between the 2721 farms in the sample. By adding axes 3 and 4, the MFA contributes to explaining 37% of the diversity. In terms of agroecological indicators, ploughing, using mineral fertilizers and pesticides are variables that discriminate between most of the farms. These are then followed by crop diversity and leguminous cultivation. In terms of farm structure, land and herd size are the dimensions that differentiate most farms, followed by the use of external labor and household size.

	Smallest farms with economic diversification and autonomy	Medium-scale farms legume-diversified	Largest farms with high input-use and crop-livestock integration	All sample
Household size				
Less than 3 members	39,3*	27,9*	8*	23,5
Between 4 and 7 members (included)	48,9*	67,3*	56,5	57,8
More than 7 members	11,9*	4,7*	35,5*	18,7
Cultivated land size				
Less or equel to 1 ha	75,4*	35,8	12,1*	38,1
Between 1 and 3 ha (included)	21,7*	47,5*	46,2*	39,5
More than 3 ha	2,9*	16,7*	41,7*	22,4
Non-family workforce				
Less or equal to 50%	34,3*	81,1*	57,7	58,6
More than 50%	65,7*	18,9*	42,3	41,4
Number of TLU				
Less or equal to 0.5	42,8*	55,5*	1,3*	30,9
Between 0.5 and 4 (inluded)	53,2*	36,8*	33,2*	40,2
More than 4	4,0*	7,7*	65,4*	29,0
Number of non-farm activities				
0 non -farm activity	8,7*	14,0*	52,4*	27,3
1–2 non-farm activities	4,5*	74,0*	37,7	39,9
3 or more non-farm activities	86,7*	12,0*	9,9*	32,8
Crop diversity				
Inf to 0.33	10,5*	17,9*	16	15,0
0.33–0.66	46,6*	34,1	55,8*	50,6
Sup to 0.66	42,9*	48	28,2*	34,4

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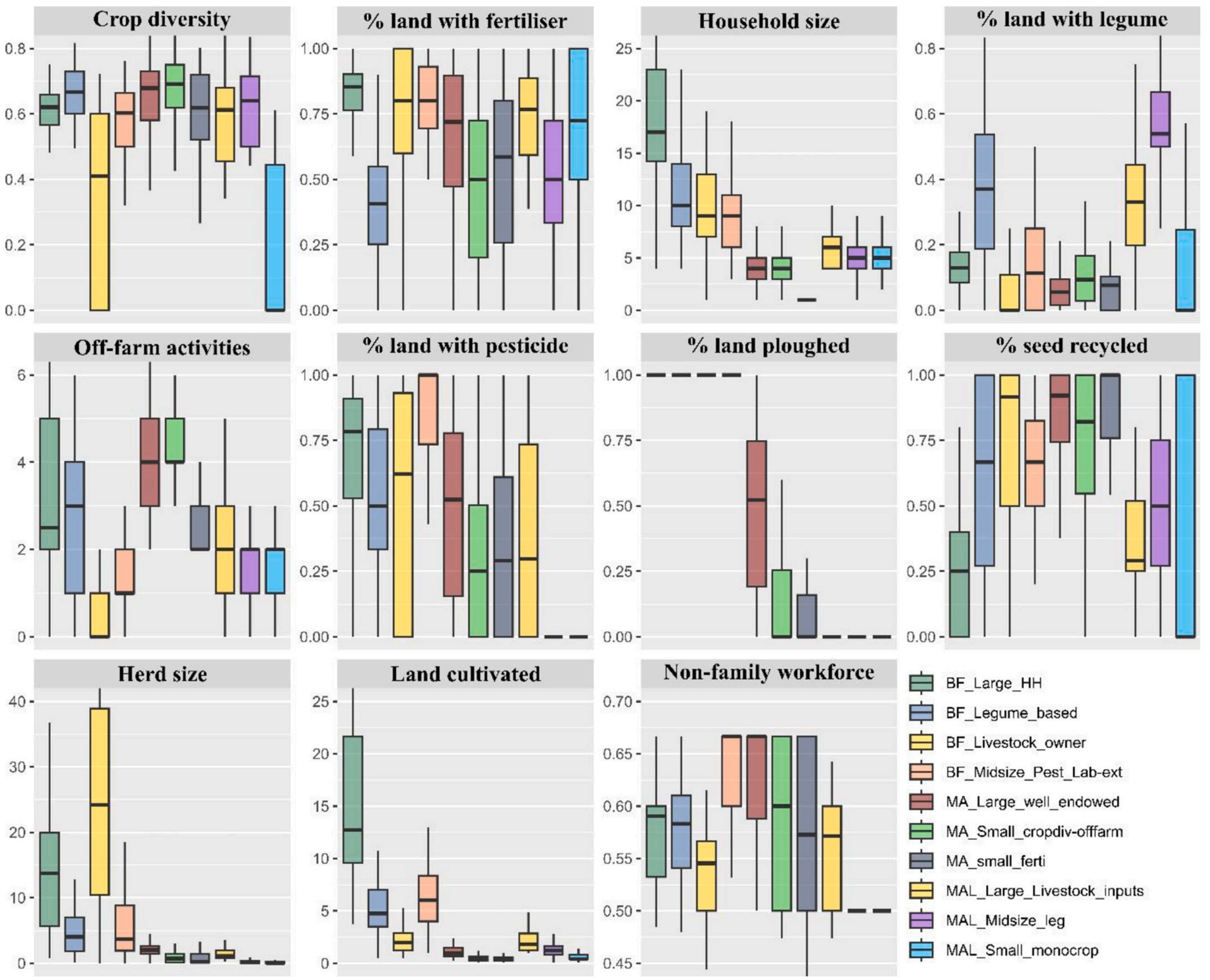
	Smallest farms with economic diversification and autonomy	Medium-scale farms legume-diversified	Largest farms with high input-use and crop-livestock integration	All sample
Share of cultivated area ploughed				
Less than 10%	49,1*	58,7*	2,1*	34,0
Between 10 and 90%	40,7*	5,4*	9,2*	17,1
More than 90%	10,2*	35,9*	88,8*	48,9
Share of cultivated land under legumes				
Less than 10%	73,1*	34,1*	60,4*	55,6
Between 10 and 50%	25,8*	25,8*	25,8*	33,3
More than 50%	1,1*	29,6*	3,2*	11,2
Share of seed recycled or exchanged				
Less than 25%	13,8*	24,0*	21	19,9
Between 25 and 75%	28,2*	30,7*	48,3*	36,8
More than 75%	58,1*	45,3	30,7*	43,3
Crop-livestock index				
Low	72,3*	51,7*	5,8*	39,9
Medium index	23,1*	33,7*	51,5*	37,5
High	4,5*	14,6*	42,8*	22,6
Share of cultivated land with trees				
Less than 10%	26,1*	55,5*	52,2*	45,7
Between 10 and 90%	69,8*	12,8*	16,8*	30,9
More than 90%	4,0*	31,6*	31,0*	23,4
Share of land with mineral fertilizers				
Less than 25%	46,8*	58,4*	8,6*	35,8
Between 25 and 75%	32,3*	23,5	21,3*	25,2
More than 75%	20,8*	18,1*	70,1*	39,0
Share of land with pesticides				
Less than 25%	50,4	84,7*	14,3*	47,5
Between 25 and 75%	38,6	8,7*	26,4*	24,2
More than 75%	11,0*	6,6*	59,3*	28,3
Areas				
zone_ae = BFA_Koumbia	0,9*	1,6*	18,8*	8,0
zone_ae = ETH_Bahir	6,2*	1,1*	14,9*	7,9
zone_ae = ETH_Bale	0,4*	2,4*	54,3*	21,9
zone_ae = KEN_CS1_Mwingi	2,5*	30,4*	6,0*	12,9
zone_ae = KEN_CS2_Nyando	2,3*	10,4*	3,7*	5,4
zone_ae = MDG_HTerres	54,0*	1,4*	0,1*	16,1
zone_ae = MDG_SudEst	28,2*	1,5*	0,3*	8,7
zone_ae = MWI_Dedza	1,8*	27,0*	0,8*	9,6
zone_ae = TZA_Morogoro	3,8*	24,3*	1,0*	9,4

Appendix E. Appendix



Appendix 5: Farm structure and AE indicators for all farm types in the 3 case studies; land cultivated (hectares), household size (number of persons), herd size (number of TLU), off-farm activities (number of activities)

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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