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Integrating agrarian differentiation and labor mobility into TAPE-based assessments of agroecology. A methodological exploration in the Cambodian rice sector

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Agroecology is increasingly considered to be a promising pathway to more sustainable agriculture. The Tool for Agroecology Performance Evaluation (TAPE) is a multiscale interdisciplinary assessment framework that helps tackle the complexity of such transitions. We critically engaged with TAPE and explored ways to enhance the approach based on empirical case studies conducted in Cambodia, in two rice-based agricultural landscapes with contrasted degrees of agricultural intensification. We complemented the TAPE framework by clarifying and operationalizing perspectives on the political-economic dynamics of agrarian change, including the reconstruction of agrarian history, a farming-system typology based on the distribution of land, and other assets and explicit consideration of off-farm work and migration. We then assessed TAPE at the local level, using focus group discussions with farmers' collectives, in-depth household surveys, and interviews with village authorities and public administration at the local and provincial levels. The study helped frame agroecological performance from the perspective of the recent agrarian dynamics that have emerged in each area and have largely favored conventional agriculture models that rely on synthetic agro-chemicals and mechanization to achieve higher production and exports. This modernization pathway has unfolded in both landscapes and has resulted in rapid differentiation between smallholder farming households in terms of asset structure and labor processes. Our approach provides a basis for understanding why farmers' production logic, constraints, and opportunities to engage time and resources in more sustainable farming practices vary considerably between and within landscapes. We argue that enriching the TAPE approach with such political-economic questions of agrarian changes makes it possible to link scales and to understand how agrarian modernization intersects with transition to agroecology. We see it as an important component for tailoring meaningful policies and practices that embrace the daily labor realities of smallholder farming households.

KEYWORDS

agrarian political economy, Cambodia, farming systems, migration, off-farm activities, rice, sustainability

1 Introduction

Agroecology is on the move. Originally conceived as a scientific discipline and a set of agricultural practices to achieve agro-environmental sustainability, it has evolved into socio-political and emancipatory movements to move agricultural production and food systems toward more resilience and justice (Rosset and Altieri, 2017; Wezel et al., 2020). Much is at stake, given the unprecedented rate of environmental degradation and associated impacts on ecosystems, health, and livelihoods (IPBES, 2019; Pendrill et al., 2022; Shukla et al., 2019) and the dominant food regime that subjects smallholder farmers and consumers interests to the logic of agrarian capitalism (McMichael, 2013).

Transitioning to agroecology is therefore not smooth sailing. The enablers and lock-in factors that influence the process are multidimensional (political, technical, economic, cultural, legal, etc.) and are at play across spatial and temporal scales. Supporting the transition requires building unconventional forms of knowledge and social interactions that embrace this complexity. Questions concerning methods then come to the fore, i.e., how to assess the potential and the pathway of an agroecological transition?

The Tool for Agroecology Performance Evaluation (TAPE) represents an important step in consolidating a structured and comprehensive methodology to measure the performance of agroecological systems (FAO, 2019). The approach is multidimensional as it is related to the FAO (2018) 10 elements of agroecology. It proposes a multi-scale assessment that integrates farming practices at household level and policies, market structure and stakeholders at landscape levels (Mottet et al., 2020). A review of 28 agroecological transition frameworks suggests that TAPE is among the few that integrate four overarching dimensions: interactions between sustainability components and indicators, stakeholder interactions, learning produced by interactions and the participation and adaptability in the evaluation process (Sean et al., 2026).

However, our reading of TAPE revealed two shortcomings that stem from its conceptualization of rural transformations. First, even though political-economic questions concerning agrarian changes are not absent in the tool, they are insufficiently scrutinized and operationalized. TAPE positions farmers within their associations and networks, but does not clearly address how social relations of production are embedded in the wider dynamics of agricultural and food systems. This stance overshadows dynamics of social differentiation, which we define broadly as the process whereby systemic inequalities arise among social groups (Illien and Perez Niño, 2026). Agrarian differentiation occurs precisely when social differentiation unfolds as farming households diverge into different groups according to their asset's endowment (land & equipment), their capacity to generate technical change and their control over labor process (Bernstein, 2010; Akram-Lodhi, 2005; van der Ploeg, 2018). These agrarian dynamics shaped by power relations exist everywhere across the global south, particularly where resource commodification and agricultural commercialization are advanced. In TAPE, however, the role of power is not systematically integrated in context analysis, and not addressed beyond specific scores assessing producers' individual empowerment

and women's ability to raise their voices in decision making (FAO, 2019). The tool does not clearly expose how power relations shape land distribution through market transactions (sale/purchase and lease in/out) and non-market arrangements. It therefore sidelines the dynamics of social differentiation and their importance in agroecological transitions.

Second, as a result of uneven asset distribution, a growing number of smallholder farming families need to resort to labor mobility and migration to ensure their reproduction. A consistent trend observed in many smallholder farmers' communities in Southeast Asia and across the global south is labor diversification outside farming (Rigg, 2006; Scoones, 2015; Yokying, 2025). Off-farm job opportunities result in the reconfiguration of household livelihoods across rural and urban landscapes (Bremen, 2010; Lawreniuk and Parsons, 2020). TAPE has a strong focus on farming, but does not capture the entire potential of labor diversification in rural livelihoods. Questions of migration are mainly envisaged through scores focusing on youth migration in relation to their future aspirations in agriculture (FAO, 2019), without clear guidelines on how to address the wider questions of wage labor mobility or seasonal labor movements.

Agrarian differentiation and labor mobility are two key processes in current agrarian transformations across the global south. They reconfigure livelihoods in ways that change farmers' logic of production and labor processes, which in turn shape their constraints, and opportunities to invest time and resources in agroecology and more sustainable farming practices. Migration is double-edged in this regard. It can be seen as a constraint on agroecological transition but it can also generate remittances and provide investment capital for more sustainable agriculture (Vizuite et al., 2024).

Examining agrarian political economy forces is essential for understanding and accompanying transitions to sustainable agricultural and food systems. From this starting point, our objective is to enhance understanding of the factors that enable or, on the contrary, limit the transition of smallholder farming toward agroecology. We explore an approach that combines the strengths and optimism of TAPE with a more conceptually grounded, critical and relational analysis of the political-economic forces that shape agrarian differentiation and the emergence of social and economic inequalities among rural households. We specifically ask how agrarian differentiation and labor mobility can be better operationalized within a TAPE-based assessment and what additional insights emerge when the revised approach is applied to contrasting Cambodian rice landscapes?

Our study was conducted in the Cambodian rice sector, which is plagued by serious sustainability issues. Across the Cambodian lowland paddies, environmental transformations materialize through increased use of agrochemical inputs (Ngang et al., 2025), land degradation (Ingalls et al., 2018) and changes in the water cycle (Murphy et al., 2013). Agrarian changes are influenced by a high degree of resource commodification (Bylander, 2023; Cramb, 2020; Dayet et al., 2026), supported by an ambitious rice export policy and the incorporation of rice value chains in international food regimes with the support of a complex web of State-corporate actors (Green, 2021). The instability of land ownership and capital through intense land markets and generalized reliance on micro-credit, combined with irregular

irrigation, results in rapid and pronounced social differentiation between smallholder farmers (Diepart and Thuon, 2022; Touch et al., 2025a).

Our analysis is based on qualitative and quantitative field research conducted in two rice-producing areas representing contrasted agrarian contexts: low inputs and single-crop organic rice production in Rik Reay Commune (Preah Vihear Province) and multi-cycle agrochemical-based intensification in the Kanghot irrigation scheme in Battambang Province. Both landscapes are involved in the WAT4CAM (Water Resource Management and Agroecological Transition for Cambodia, 2020–2026) program, whose aim is to promote rice farming productivity and sustainability through the development of agroecology. During the program, support activities were organized in each zone to accompany farmers in an agro-ecological transition. The methodology presented in this article is part of this “research for development” initiative and was conducted alongside the agrarian diagnosis undertaken before the project interventions began.

At the time of the study, the agroecological transition envisaged by the WAT4CAM project in Rik Reay commune consisted of maintaining organic rice production in lowland areas while limiting the use of agrochemicals, and promoting more integrated farming systems (no-till & cover crops, cash crop-livestock integration) in the upland areas of the local watershed. The agroecological transition encouraged in Kanghot entailed changing from rice monoculture to schemes that integrate cover crops and non-rice crops (pulse crops, among others)

and reducing the use of inputs to minimize damage to the soil and biodiversity caused by farming practices.

In the next section, we describe the study area and the methodological approach we used to adapt the TAPE evaluation process. We then present the results we obtained in both sites and show how the approach helps chart more differentiated agroecological transition pathways that account for the varied economic constraints and opportunities of smallholder farmers. Finally, we discuss three key insights gained from revisiting TAPE to assess agroecology through an agrarian political economy lens.

2 Materials and methods

2.1 Study areas

Rik Reay Commune is located in Rovieng District (Preah Vihear Province, 13°24'07.4"N 105°08'36.2"E), a hilly area in the North of Cambodia (Figure 1). Three villages (Bohs, Doung, and Pahal) are located in the commune, which has a total population of 2,489 inhabitants (533 households) (Schiele, 2020). The commune includes two irrigation schemes, O'Sakarach and O'Kambor, that were built during the Khmer Rouge period and were targeted for renovation by the WAT4CAM project. At the time the study was conducted, only O'Kambor scheme was operational, but the farmers needed to obtain

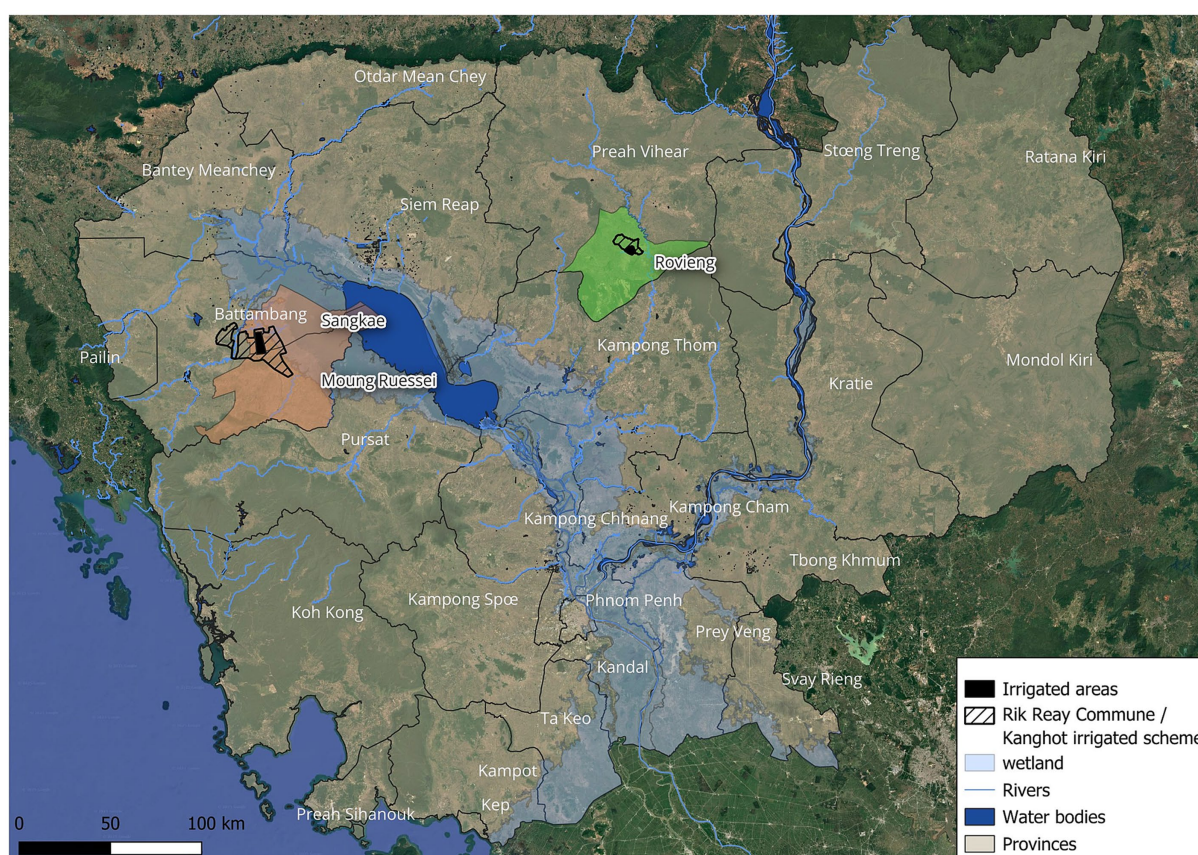


FIGURE 1

Map of Cambodia with the study areas highlighted. On the right, the O'kambor and O'sakarach irrigated areas (black) in the commune of Rik Reay (black stripes) in the district of Rovieng (green), on the left, the Kanghot irrigated perimeter (black stripes), between Sangkai and Moung Ruessei Districts (orange).

irrigation water by pumping from the main canal as no secondary or tertiary canals existed.

Kanghot irrigation scheme (12°59'02.0"N 103°14'50.4"E) is located close to Battambang City in the eponymous province, a landscape of plains, clayey hydromorphic soils close to the Tonle Sap Lake (Figure 1). The Kanghot irrigation scheme (approximately 45,000 ha) has existed since the Khmer Rouge period, but has only been operational since the first rehabilitation phase in 2009. Households started cultivating two rice cycles per year around 2015. The Main Canal no. 2 (MC2) straddles several districts and irrigates a territory that includes ten villages, plus some land belonging to ten other villages, representing a total of 19,744 inhabitants (4,312 households) (Schiele et al., 2020).

2.2 FAO tool for agroecology performance evaluation (TAPE) and its adaptation

The TAPE methodology was developed by FAO as an analytical framework to assess the multi-dimensional performance of agroecology at farm and landscape levels. It aims to support agroecological transition and to inform context-specific policy-making and development initiatives, particularly to leverage the potential of agroecology to attain Sustainable Development Goals (FAO, 2019).

TAPE proposes a step-wise approach that includes a description of the context (Step 0 also including methodological design, tool adaptation and field preparation to secure data quality and relevance; see FAO, 2026), characterization of the agroecological transition (Step 1), assessment of performances in line with SDGs (Step 2), and joint analysis and interpretation of the results (Step 3). While the assessment is mainly conducted at the farming household level, the framework also examines processes such as policies, market structure, certification, among others, at the landscape level.

We incorporated information and analyses relevant to agrarian differentiation and labor processes and articulated them in a slightly revised assessment framework that only concerns steps 0 and 1. The revisions of the TAPE methodology proposed in this article does not address Step 2 and Step 3. Step 2 (Core Performance Criteria) consists of an assessment of system performance based on a set of 10 core criteria, classified into three levels ("unsustainable," "acceptable," and "desirable"), using interviews with household members. Step 3 (Joint Analysis of Steps 1 and 2 and participatory interpretation) consists of synthesizing the previous steps in order to identify trade-offs and synergies between agroecological and sustainability dimensions, validate the framework and findings, and explore possible future pathways through participatory workshops.

The two first steps of the TAPE methodology and our main modifications are shown in Table 1 and the remainder of this section explain why and how these modifications were incorporated.

2.2.1 Contextualizing agroecology transitions

In the TAPE approach, the description of systems and context (Step 0) is a preliminary phase used to contextualize farming systems. Step 0, although identified as essential for contextualizing the results of Steps 1 and 2, has received less explicit and extensive development than Steps 1 and 2. The initial TAPE documents (Mottet et al., 2020; FAO, 2019) used in this study include a brief description of the farm itself: demographic characteristics, key productive assets, the main types of agricultural production, and the commercial versus

subsistence orientation of the production systems. It may also include a brief description of (dis)enabling factors that support the agroecological transition, such as public policies, market structure, standards and certifications, and the network of stakeholders (Table 1). Several successive documents have attempted to provide further guidance on how Step 0 should be implemented. The FAO website now refers to new guidelines for Step 0 (FAO, 2026), which are more comprehensive in terms of study design and methodological framing, local adaptation of the questionnaire and field tools, enumerator training, pilot testing, and final validation. New topics are also addressed in the context of diagnosis, including "historical dynamics of the agrarian system," "Socio-economic context and differentiation," "livelihood strategies" or "governance policy context," but to the best of our knowledge, nothing more than a few short descriptive paragraphs was provided, no theoretical framework, questionnaire template, or interview guide have been proposed.

Understanding the forces that shape agricultural development is key to situating agroecological transition and innovations in a given landscape. The main pathways are quite often geared toward capitalist modernization of agriculture, thereby locking producers into a certain production logic and strategies, and hence constraining agroecological innovations (Dumont et al., 2020; Romero et al., 2024). As Gliessman (2024) suggests, agroecologists must understand and deconstruct these processes and narratives. So, to include the 'description of the farming system and context' in the core of our method, we revised and extended the TAPE approach by making the elements to be studied more explicit and identifying the necessary data collection tools.

2.2.2 Agrarian history

One underlying premise of our approach is that current farming practices are legacies of the past. We analyzed the socio-political and economic forces that have driven transformations of agrarian landscapes, asset distribution, farming practices, and off-farming activities, as well as their outcomes. Reconstructing historical trajectories is not just about tracing a series of events, but also understanding how farmers experienced these transformations and how their asset base and practices changed as a result (Cochet, 2015). This allowed us to identify the dominant territorial development pathway (Romero et al., 2024) and to envisage realistic agroecological transitions (policies, actors, market structures, etc.) as alternative pathways (Lacey and Lefèvre, 2015).

We collected this information from March to June 2020 through focus group discussions with farmers and knowledgeable villagers (three focus groups were held in Rik Reay with, respectively, 13, 18, and 12 participants; four in Kanghot with 25, 15, 15, and 13 participants). We also discussed with local organizations (cooperatives - two in Rik Reay; four in Kanghot - 1 participant each) and local authorities (one in Rik Reay - 8 participants; three in Kanghot - respectively, 3, 5, and 6 participants) in March 2020. For each focus group discussion, we selected 2–3 village authorities (at least 1 female), 2–3 elderly villagers (at least 1 female), 2–3 representatives of group or association (at least 1 female), 3–5 knowledgeable villagers (at least 2 female) and 2–3 traders/collectors (at least 1 female). Participants worked in three groups for three parallel sessions (i) understanding the changes of land uses, (ii) characterization of rice cropping systems and (iii) description of the food systems and food sources (see Supplementary Appendix 1 for the main themes discussed). Some groups, particularly more vulnerable or less knowledgeable households, may therefore have been

TABLE 1 Key changes introduced to the TAPE methodology.

TAPE			Revised methodology		
Steps	Information sought	Method	Steps	Information sought	Method
Step 0: Description of systems and context	Context: - Environmental, socio-economic, and demographic characteristics of farms - Productive assets and activities Enabling environment: - Public policy, marketing structure, and stakeholders	Landscape level: - Secondary information (published literature and existing metadata) - Semi-structured consultation with key informants Household level: - Interviews or surveys	Agrarian history	- Spatial differentiation of landscape and social differentiation between households - Dominant pathways of agricultural development - Power relations between actors, groups, and networks Value chains and markets	Landscape level: - Review of existing data - Analysis of land cover change - Consultation with commune chiefs and cooperatives Village level: - Focus group discussions Household level: - In-depth interviews with household members
			Farming system analysis	- Socio-economic and demographic characteristics of households - Land and assets - Economic performance of farming systems (productivity, income, added value) - Off-farm activities, including migration (farming considered as part of a wider system of activities)	Village level: - Focus group discussions in the villages Household level: - In-depth interviews with household members (quantitative and qualitative data)
			Farming system typology:	- Evaluation of the diversity of previously characterized actors and associated activity systems, represented by types based on farmers' land, assets, and activities	Statistical classification based on selected variables using Principal Component Analysis and Hierarchical Ascendant Classification
Step 1: Characterization of the agroecological transition (CAET)	- Description of the level of transition to agroecology based on descriptive scales related to the 10 Elements of Agroecology (FAO,2018). - 36 indices scored from 0 to 4 and standardized on a scale from 0 to 100 for each of the 10 elements	Household level: - Self-assessment by producers or community leaders - Guided exercise by technicians, NGO workers, scientists, or government agents	Characterization of AE transition	Similar to TAPE (the number of indices was reduced to 28 and some indices were modified depending on the context and resources)	Household level: - In-depth interviews with household members (quantitative and qualitative data) Village level: - Focus group discussions in the villages

underrepresented. We documented and analysed discussions to identify and summarize the main issues raised by participants. The analysis followed an inductive approach, with recurring topics emerging from the discussions as opposed to *a priori*. The main analytical themes concerned changes in agricultural practices and cropping systems, access to and use of land and water resources, livelihood strategies, economic and social changes, and perceptions of changes over time. We compared information from different villages and participant groups qualitatively to identify differences and common patterns as well as locally specific accounts. We only included items on which there was a sufficiently strong consensus among participants and across villages in the same study area, unless otherwise specified. Finally, we triangulated the focus group discussion outputs with the household survey data (see below) and published articles based on research projects conducted in the same areas.

2.2.3 Farming system analysis and typology

When a large number of households are to be assessed, TAPE recommends designing a typology to simplify the diversity of farming practices observed on the ground into more manageable types (FAO, 2019). In TAPE, farming system typologies are based on the characterization of the agroecological transition, thereby disregarding elements that are crucial to understand the structure and dynamics of farming systems and labor processes (Levard, 2025). We thus moved on from TAPE and developed a farm typology based on a set of variables that capture household and farm structure as well as the households' wider activity system, by focusing on land access, labor processes and income structure. This can be viewed as a proposal for operationalizing the recent developments of the tool introduced by FAO: as part of Step 0, build a farm pre-typology based on farm size, livestock presence, market orientation, labor availability, income

sources in order to understand heterogeneity, identify drivers, create analytical groups (FAO, 2026). With that aim, data was collected through an in-depth household survey using a pre-established questionnaire (see [Supplementary Appendix 5](#)). A group of trained enumerators administered the survey using Kobo Toolbox (see <https://www.kobotoolbox.org/>), an open-source toolkit for data collection that is suitable for quantitative surveys. The survey took place from March to June 2020, in Rik Reay (130 households) and Kanghot (191 households), equivalent to, respectively, 22 and 18% of the total number of households. The sample size corresponded to a sampling error of less than 10% (7.1% for Rik Reay and 5.5% for Kanghot) using the Yamane formula (Israel, 1992). We selected respondents randomly from a list of households provided by the authorities of Rik Reay Commune, with each household having an equal probability of selection. This approach enabled us to have a representative sample of the village's diversity and ensure a good representation of women (50% among respondents). Participation in the survey was voluntary, and the respondents gave informed consent before the interviews. In the case of a non-consenting, absent or unavailable household, we randomly selected another household from the list.

We collected data concerning assets and liabilities (labor, land, equipment, and debt), farm production systems (rice and non-rice crops as well as livestock), and the off-farm component of their labor processes (wage labor and migration-related work). Several indicators suggested in step 2 of TAPE were included in the farming system analysis, particularly those related to the productivity, production costs, and value added of double rice production (Table 2). This data provided a quantified description of farming systems. Working iteratively between the household survey data and focus group discussion transcripts, we could gain an understanding of rural realities that was both statistically representative and contextualized. These elements provided the basis for formulating hypotheses concerning the main

TABLE 2 Variables used for statistical analysis in each study area (crosses indicate variables included in the ascending hierarchical classification).

Abbreviation	Full name	Rik Reay	Kanghot
1.2 LABOR	Active labor (n° people)	X	X
1.4 HIRLA	Costs of external farm labor (USD/year)		X
1.5 NMIG	Labor dedicated to migration (% of household labor force)	X	X
2.2 CLAND	Surface area of cultivated land (ha)	X	X
2.3 RLAND	Surface area of land rented in (ha)		X
2.4 LN. LA	Land labor ratio (ha/active person)	X	X
2.5 PADDY	Surface area of paddy land (ha)	X	X
2.9 UPANN	Surface area of annual upland crop (ha)	X	
2.10 UPTRE	Surface area of perennial upland crop (ha)	X	
3.1 ASSTA	Value of agricultural assets (USD)		X
3.2 ASSTD	Other assets value (USD)		X
3.3 PCOSC	Production costs for all crops (USD)	X	
3.6 DEBTS	Total amount of outstanding debts (USD)	X	X
4.2 CROPINC	Share of income from crop production in total income (%)	X	X
4.3 PADINC	Share of income from paddy production in total income (%)		X
4.7 LIVINC	Share of income from livestock in total income (%)	X	X
4.8 OFFINC	Share of income from local off-farm activities in total income (%)	X	X
4.9 MIGINC	Share of migration income in total income (%)	X	X

characteristics of local agriculture and the factors and processes underlying differentiation among farming systems, including biophysical conditions, resource endowments and socio-economic characteristics. These factors informed the selection of variables used to build the farming systems typology (Alvarez et al., 2018).

We used Principal Component Analysis to reduce the initial set of variables and identify the main dimensions of variation among farming households, followed by Hierarchical Ascending Classification to construct household typologies based on the retained principal components (Alvarez et al., 2018; Jolliffe and Cadima, 2016; Kaur et al., 2021; Teixeira et al., 2018). Multivariate analysis was performed using three RStudio software packages: FactoMineR (Exploratory multivariate data analyses), Factoextra (Extraction and visualization of outputs of exploratory multivariate data analyses), and missMDA (Missing data management for factor analysis methods). The final number of clusters was determined using the inertia-based criterion implemented in the FactoMineR HCPC procedure, which identifies a suggested level at which to cut the hierarchical tree (Lê et al., 2008). We then assessed the resulting clusters for their relevance and interpretability in relation to hypotheses informed by local knowledge derived from focus group discussions and of household survey data (Alvarez et al., 2018).

Although 10 of the 18 variables were common in both study areas, we conducted the analysis separately for the two study areas because the other variables reflected site-specific socio-economic, biophysical and agricultural contexts and trajectories. Alvarez et al. (2018) recommended applying PCA and agglomerative hierarchical clustering separately to each study zone, as the scale of analysis influences the visibility of farm diversity and the delineation of farm types. They argued that analysing data at a finer spatial scale revealed farm types that could have been masked or aggregated at a broader scale. Four clusters were retained in each study area, providing a concise and interpretable representation of household heterogeneity. The resulting types were compared based on similarities in household characteristics, farming practices, resource endowments and livelihood strategies, while accounting for differences in local contexts and historical trajectories.

2.2.4 Characterization of the agroecological transition (CAET)

Step 1 of TAPE aims to characterize the level of agroecological transition of agricultural systems based on the 10 Elements of Agroecology. Each element is defined by semi-quantitative indices that are scored from 0 to 4 on a Likert-type scale. Our approach is largely based on the CAET method proposed by TAPE, but we adapted it in several ways. First, we kept only 8 of the 10 elements of Agroecology (diversity, synergies, efficiency, recycling, resilience, culture and food tradition, co-creation and sharing of knowledge, and human and social values). The elements “Circular and solidarity economy” and “Responsible governance” were removed because they were difficult to apply beyond the community or local food system level. Second, we modified 12 indices to make their measurement more context-specific and to reduce the risk of misinterpretation by the enumerators or by the respondents. For instance, animal breed, plant variety, and local knowledge are required in the original method, whereas only rice varieties were characterized in the present study. Concerning youth empowerment and emigration, instead of asking a

generic question about young people’s interest in agriculture, we asked a specific question about reliance on migratory work. Third, we removed five indices because they were overly conceptual and difficult to answer. The table in [Supplementary Appendix 2](#) includes the list of indices from the original TAPE methodology, an indication whether they were used as is, modified, or removed, a justification for the modification or removal and a short description of variables used for score attribution. In the end, we measured 25 indices compared with 36 in the complete TAPE methodology.

The CAET method was applied to each household, and scores for each index were attributed based on the information collected during the in-depth survey, then averaged according to farm type. We summed the scores for all indices within a given element, divided the total by the maximum possible score for that element (number of indices $\times$ 4) and then multiplied by 100 to obtain a percentage. This method is applied to each of the 10 agroecological elements to obtain standardized scores (0–100%) for each element (FAO, 2019). The weights of an index in the calculation of an element may differ because not all elements have the same number of indices—as is already the case in the original TAPE method. This difference in weight between the indices is offset by treating the elements and the indices that comprise them for what they are, namely, numerical representations of complex social-ecological processes, which can not be described and compared simply with quantitative scores. For each TAPE indice, we calculated average scores as the mean across households with available data for that indice. Missing values were excluded only for the corresponding indices, while the available scores of the same households were retained for all other indices.

To minimize the risk of statistical circularity, we sought, as far as possible, to ensure that most variables used to construct the household typology had limited relationships with the variables contributing to the TAPE scores. Nevertheless, some overlap between the two frameworks was unavoidable, as they capture related dimensions of households’ economic conditions. Only two cases presented a potentially stronger relationship. First, household debt was used in the typology as a characteristic of the production system, whereas its relative magnitude compared with household income in TAPE provides an indication of the household’s ability to bear this debt. Second, three distinct measures of production costs were used in the typology or to calculate TAPE scores: total crop production costs, including inputs, services and hired labour, as an indicator of the household’s capacity to invest in cropping systems; total input costs for crops and livestock, to characterize the importance of external input use; and total production costs for crops and livestock, including inputs, services and hired labour, to assess the household’s ability to bear production costs in the event of shocks (see Appendix 2 for more details about calculation). These two cases were taken into account when interpreting relationships between the household typology and CAET scores.

3 Results

3.1 Agrarian history and differentiation at the landscape level

The recent history of each area was reconstructed using the information collected during the focus group discussions and triangulated

with multiple sources (household surveys and published articles). According to the respondents, the dominant transformation pathway in both landscapes involved the commodification of agricultural inputs and outputs, along with a shift from subsistence-oriented farming toward cash crop production, namely conventional rice in the Kanghot area, and upland crops (annuals and perennials) and organic rice in Rik Reay Commune. This led to the major reorganization of the agrarian landscape and the structure of farmers' income (Figure 2).

Before 1998, farmers in Rik Reay Commune cultivated lowland rice in paddy fields located close to the village (approximately 1 ha of land per household) and upland rice/vegetables using swidden practices on more distant plots (1–2 ha of land cultivated for three years, then left fallow for up to 20 years). Cattle raising and the collection of timber and non-timber forest products were also widespread. From the end of the 1990s on, resource commodification and agricultural mechanization led to a reduction in the length of the fallow periods and to the progressive replacement of upland shifting cultivation by permanent cropping of soybean, cassava, and cashew (Figure 2). Based on FGD participants' testimonies, this transformation was driven by access to new high-yielding cashew varieties (e.g., M23) and the influx of land investors from neighboring provinces. It resulted in rapid and widespread deforestation, a decline in grazing areas and in the size of herds (Figure 2), and in increased reliance on mechanization and agro-chemicals in these new cash crop plantations. According to the household survey, in 2020, fertilizers, herbicides, and pesticides were used in 50–60% of the upland cultivated area. In lowland areas, one rice cycle was previously cultivated per year using relatively low-input farming practices and a low level of

mechanization. The bulk of the lowland area (78%) was dedicated to the production of organic rice under a certification scheme facilitated through contract farming by the rice miller AMRU and local agricultural cooperatives that were members of the provincial federation called “Preah Vihear Meanchey Union of Agricultural Cooperatives” (PMUAC). The main intensification factor was labor (an average of 54 man-days per hectare for rice production, see Supplementary Appendix 3). The relatively small size of organic rice landholdings, combined with labor shortages resulting from job migration out of the commune and the higher income from upland crops, reinforced not only the intensification of upland cash crops but also the adoption of labor-saving techniques in rice production, such as rice broadcasting (Dayet et al., 2024).

Before 2015, rice cultivation in the Kanghot area consisted mainly of one rain-fed cycle of medium or late rice varieties. Between 2005 and 2015, slight intensification occurred with the adoption of power tillers and a gradual increase in the amount of fertilizer used which reached 150 kg/ha/cycle. Farmers coped with agricultural labor peaks through labor exchange groups and, marginally, using agricultural wage labor. The first rehabilitation of the Kanghot irrigation scheme that was completed in 2015, resulted in 93% of land receiving complementary irrigation during the wet season and 89% of rice areas were made fit for two rice cycles each year within the portion of the perimeter studied here (Main Canal 2 area). According to FGD participants, this had a massive impact on local rice-growing practices. Farmers started to cultivate two cycles of rice per year, and short-cycle rice varieties gradually replaced long or medium-cycle rice varieties. It also resulted in the increased use of agro-chemicals: farmers started high-rate rice broadcasting (100% of farmers, 150 to 250 kg seeds/ha), while

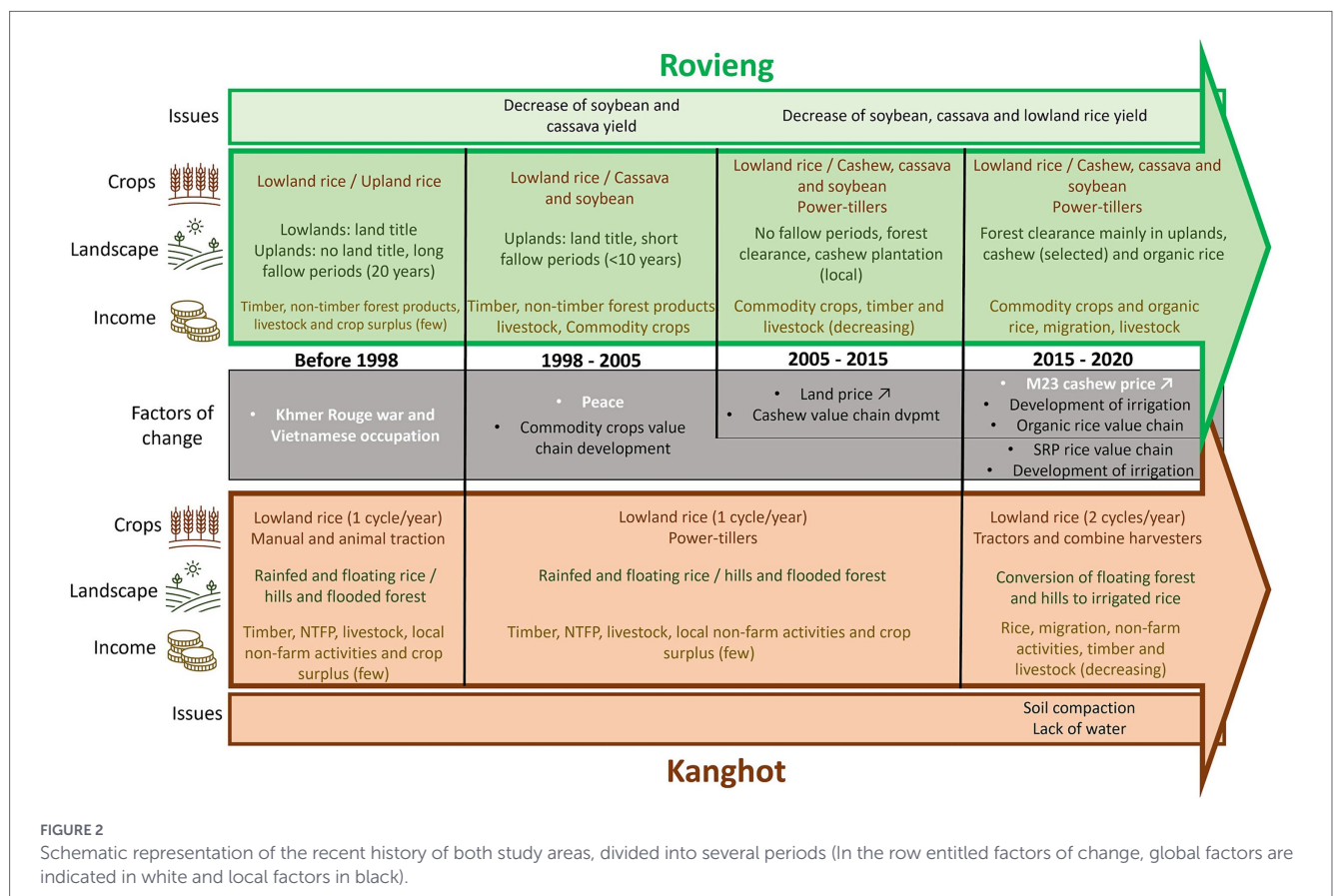


TABLE 3 Summary of main household characteristics used for the principal component analysis and hierarchical ascending classification process for each study area—arithmetic mean values for all households of the sample for 2019, Pearson standard deviation.

Indicators	Rik Reay		Kanghot	
	Mean	SD	Mean	SD
Active labor (n° of people)	3.6	1.6	3.3	1.5
Cost of external farm labor (USD/year)	90	182	50.6	78.2
Labor dedicated to migration (% of household labor force)	14	20	15	21
Surface area of cultivated land (ha)	3.5	3.0	3.7	4.7
Surface area of land rented in (ha)	0.1	0.45	0.9	2.5
Land Labor ratio (%)	179	90	123	180
Surface area of paddy land (ha)	2.2	2.0	3.7	4.7
Surface area of annual upland crop (ha)	0.25	0.7	0.03	0.16
Surface area of perennial upland crops (ha)	0.17	1.7	0	0
Value of agricultural assets (USD)	2,047	1,087	2,393	6,334
Other assets value (USD)	1,380	1,028	1,569	1,554
Production costs for all crops (USD/year)	377	327	994	890
Value of household debt (USD)	1,078	2,320	2,409	7,012
Share of income from crop production in total income (%)	33	31	34	16
Share of income from paddy production in total income (%)	22	23	30	35
Share of income from livestock in total income (%)	23	26	17	28
Share of income from local off-farm activities in total income (%)	30	33	31	36
Share of migration income in total income (%)	16	29	17	30

the use of chemical fertilizers was generalized (100% of farmers, on average 200 kg/ha/cycle and up to 400 kg/ha/cycle in some villages). Farmers also increased the use of herbicides, insecticides, fungicides, among other pesticides, in association with these new rice varieties (98% used chemicals to control pests and diseases and 90% practiced chemical weed control). FGD participants made it clear that agricultural mechanization took off thanks to services (pumps, tractors and combine harvesters) offered by entrepreneurial farming households. Rice intensification enabled by the construction of irrigation infrastructures, the use of agro-chemicals and mechanization provided by external service providers resulted in a decrease in the use of family labor to 8 man-days per hectare per cycle, on average (see [Supplementary Appendix 2](#)).

Rice intensification also resulted in a sharp decrease in grazing and livestock production, and in reliance on common-pool resources. In Kanghot, insecure access to water was rampant despite massive irrigation efforts. Farmers felt that water was not sufficient to grow two rice cycles, particularly in areas located farthest from irrigation channels. The survey took place in 2020, after a sharp drop in prices in 2018 and severe drought events, which had a serious impact on both rice production and income. The farmers who were unable to cope with the adverse economic situation had few options other than to sell their land in order to stay afloat ([Diepart and Thuon, 2022](#)). As a result, a large chunk of agricultural land (varying from 300 to 800 ha per village) has been purchased by wealthy households and by rice millers from surrounding areas. These actors have gained significant power in controlling rice production and harvest across the irrigated scheme. In some cases, they rented out the land to their previous owners, while in others, farmers ended up landless and became local wage laborers or job migrants to Phnom Penh or Thailand. Over this period, several

initiatives involving national rice milling companies attempted to establish a value chain based on the Sustainable Rice Platform¹ (SRP) standard.

In both Rik Reay and Kanghot, the recent agrarian transformations have been shaped by local contexts but shared a consistent trend toward cash crop production associated with the intensification of production via the increased use of high-yielding varieties and agrochemicals (particularly in Kanghot), as well as the advance of mechanization. During the FGD, the participants clearly articulated that farmers' relationships to land and farming were transformed as a result. Labor processes were closely associated with agrarian modernization, both as drivers (increased interest in labor-saving agricultural techniques) and outcomes (mobility out of agriculture).

3.2 Description and typology of the farming system

[Table 3](#) highlights important differences in land use between the two areas: specialization in paddy rice production in Kanghot versus a more diversified land use pattern in Rik Reay. The latter consisted of paddies and upland crops, including cashew plantations (12% of the total area, 6% dedicated to monocropping), cassava (6% of the total area, monocropping, and mixed crops), fruit production, including banana, mango, and papaya (5% of the total area), and soybean (3% of the total area). In both areas, most farmers owned a power tiller, but no farmers in Rik Reay owned a tractor, whereas in Kanghot, five

¹ <https://sustainableice.org/>

farmers owned both a tractor and a disc plow. The purposes of household debt were household expenses (USD371.7) and investment in household domestic assets (USD234.6) in Rik Reay, and farming investments (USD853.2) and land purchase (USD405.8) in Kanghot (average debt per household). This difference in the use of credit clearly reflected the advanced intensification and modernization of rice production in Kanghot.

Standard deviation values were high for most variables, pointing to major disparities within each study area, particularly in terms of access to land (23% of households in Kanghot declared they did not have access to cultivated land), the ability to invest in agriculture (production costs, the extent of land, rented-in land, and agricultural assets in Kanghot) and the diversity of sources of household income.

Two Principal Component Analyses were performed. Figure 3 shows the results obtained for Rik Reay Commune, and Figure 4 for Kanghot. In Figure 3 (Rik Reay), the first two axes explained 41.4% of the total variability. The variables were divided into three groups depending on their position on the first two principal components:

- i Farm production 1 (Rice): Cultivated land (CLAND), surface area of paddy (PADDY), farm production costs (PCOSC), and land/labor ratio (LN. LA)
- ii Farm production 2 (Other): Surface area under perennial crops cultivated in the uplands (UPTRE), income from livestock (LIVINC), and income from crops (CROPINC)

- iii Migration: Number of family members who temporarily or permanently migrate for work (NMIG), number of active laborers (LABOR), and percentage of income contributed by migrating family members (MIGINC)

Another group of variables, including off-farm income, could be mentioned but is not well represented on the first two axes.

For Kanghot (Figure 4), the first two axes explained 44.7% of the total variability. Variables were divided into three groups depending on their positions on these axes:

- i Farm production factors: Cultivated land (CLAND), surface area under paddy (PADDY), land/labor ratio (LN. LA), value of agricultural assets (ASSETA), surface area of rented-in land (RLAND), value of hired labor dedicated to farming per year (HRLA)
- ii Off-farm income: Percentage share of off-farm income in total income (OFFINC)
- iii Migration: Number of family members who have temporarily or permanently migrated for work (NMIG), number of active laborers (LABOR), and percentage of income contributed by migrating family members (MIGINC)

The similarities between the two principal component analyses in Rik Reay and Kanghot were striking despite the fact that the two landscapes have quite different characteristics and past histories. Both analyses revealed that the differentiation between

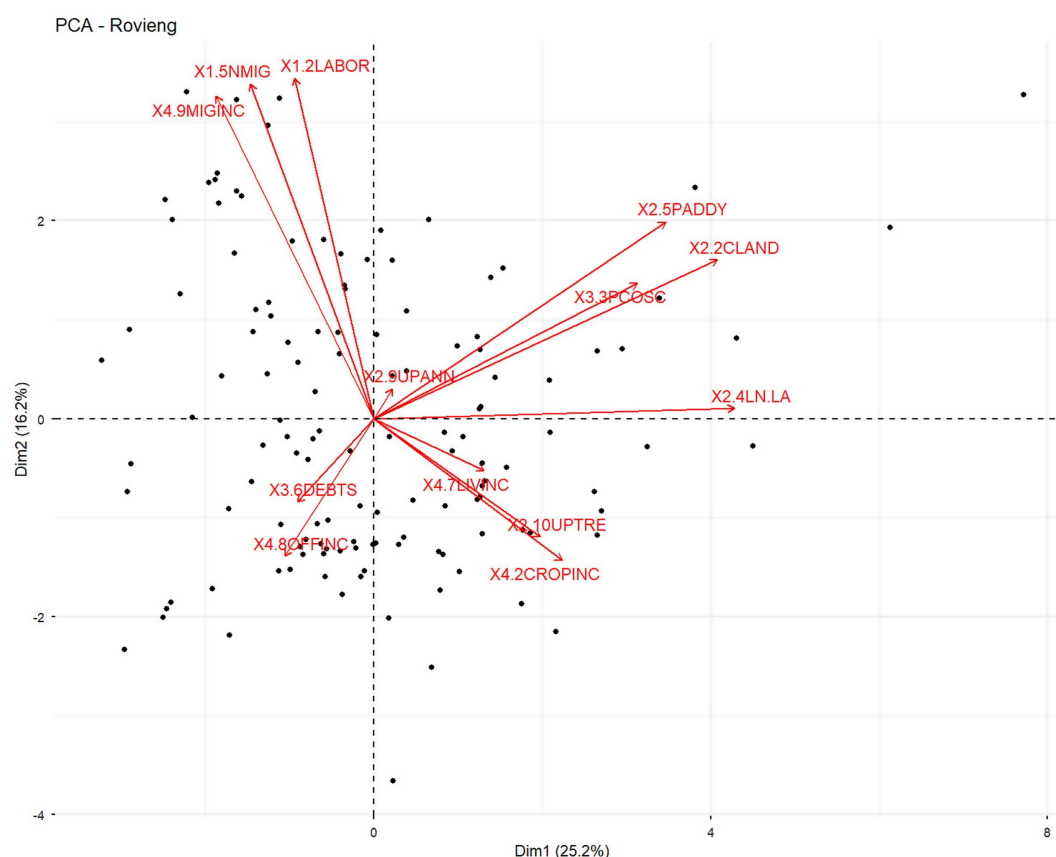


FIGURE 3
Principal component analysis results for Rik Reay Commune, based on selected indicators (see methods section for a description of each indicator).

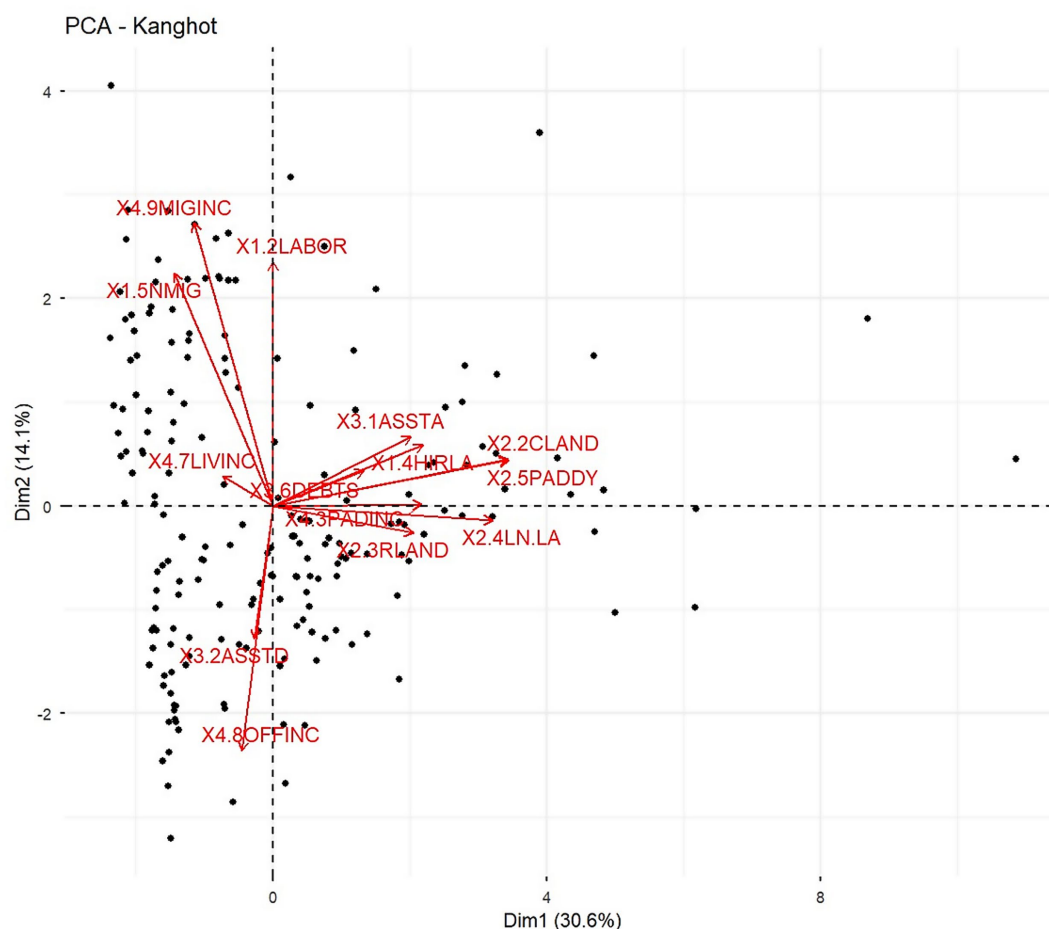


FIGURE 4

Principal component analysis results for Kanghot, based on selected indicators (see methods section for a description of each indicator).

farming/activity systems was articulated around two main axes describing a process of “land – labor” polarization within the agrarian structure and the mobility of family labor. The first axis (component 1) depicted the importance/magnitude of farming activities. Indicators of agricultural land area (rice, other annual and perennial crops if relevant), the share of income derived from agriculture, and the value of agricultural assets were strongly correlated with this component. On the other hand, labor activities outside the family farm (local wage labor or job migration) measured as the number of people involved or the resulting income, were negatively correlated with this component. The second axis of differentiation (component 2) depicted the mobility of family labor away from the family farm. Variables such as the number of people involved and the income derived from migration were positively and highly correlated with the component, while local wage labor income was negatively correlated.

Given these similarities, it is not surprising that the Ascending Hierarchical Classification identified four types of households with similar structural characteristics in each area (Table 4): smallholders with diversified activities, smallholders with migration activities, farm-based multi-activity households, and large entrepreneurial land-owners. A contextualized description of each type in the two areas is provided in Table 4 below. The mean values of some representative variables are presented directly in the table, with an asterisk indicating a significant difference from the overall mean. The means of all

variables and the results of the significance tests are provided in [Supplementary Appendix 4](#).

3.3 Characterization of Agroecological transition (CAET)

CAET assessment results are presented in Table 5 for Rik Reay and Kanghot (see also [Supplementary Appendix 2](#) for more details about scores calculation).

We noted important differences in scores in the two study areas: Rik Reay's average score was 51% and Kanghot's was 32%, while Rik Reay had 4 elements with average scores higher than 50%, versus only 2 elements for Kanghot. These differences were not just an aggregate effect, as 24 indices (out of 25) and 7 elements out of 8 scored higher in Rik Reay than in Kanghot. This contrast echoed previous descriptions of farming systems in each of the study areas and reflected different agrarian trajectories. Rik Reay commune was characterized by a higher cropping diversity, a lower level of mechanization, and lower use of agro-chemical inputs, notably in the context of organic rice certification. In turn, the level of intensification was higher in Kanghot, including higher mechanization, greater use of agro-chemical inputs, and reliance on homogenous and commercial crop varieties underlying rice monocropping. However, Rik Reay was not necessarily more advanced in the agroecological transition; this situation was rather a

TABLE 4 Typology of households' activity systems in Rik Reay commune and in Kanghot.

Type of households (HH)	Rik Reay (130 HH)	Kanghot (191 HH)
Type 1: Smallholders with diversified and local off-farm activities	37 HH (29%) – Households with a low land/labor ratio (1,1*), unable to meet their basic needs with their own farm production due to limited cultivated land. These households depend on local off-farm activities (67%* of HH income), mainly local wage labor in the farming sector as opposed to migratory work (1%* of HH income).	45 HH (24%) - Households with a small labor force, unable to meet their basic needs with their own production due to limited cultivated land (0,8* land/labor ratio) and low endowment in agricultural assets (\$956*). These households developed a local off-farm activity system (74%* of HH income, mainly wage labor in the farming sector), as opposed to migratory work (1%* of HH income).
Type 2: Smallholders with migration activities	38 HH (29%) - Households with a large labor force (5* active members) but still unable to earn their living from farming because they have too little cultivated land (1,3* land/labor ratio). These households employ part of their labor force in local off-farm activities (12%* of HH income), while some family members are engaged in more remunerative job migration activities in neighboring provinces or Phnom Penh (seasonal), or in Thailand (permanent), and remit a share of their income to the family (51%* of HH income).	77 HH (40%) - Households with a large labor force (3,9* active members) but unable to sustain a livelihood from farming because they have too little cultivated area (0,4* land/labor ratio) and low endowment in agricultural assets (\$617*). These households send part of their labor force to undertake local off-farm activities (12%* of HH income, mainly wage labor) while some family members raise livestock (35%* of HH income) or are engaged in more remunerative job-migration activities (40%* of HH income), allowing them to support the family.
Type 3: Farm-based multi-activity households	43 HH (33%) - Households with sufficient land and the financial capacity to meet their basic needs with their farming activities by mobilizing almost the entire household workforce (1,8 land/labor ratio). Unlike type 2, they have access to uplands to grow cash crops (especially perennial crops, 0,3 ha* per HH) and derive a sizable income from livestock (30%* of HH income). They have opportunities to supplement their income with local off-farm wage labor (12%* of HH income), but are almost not involved in job migration (1%* of HH income) as farm-based activities offer enough labor to occupy all the members of the family (61%* of HH income from crop production).	57 HH (30%) - Households with enough land to meet the family's basic needs (5,9 ha* of cultivated land, 1,8* land/labor ratio) and enough investment capacity to intensify rice production (hired labor: \$100/year*, rented in land: 1,24 ha, and agricultural assets value: \$3179), most of the household labor force is used for rice production, but some members selectively engage in wage labor or off-farm activities as opportunities arise (74%* of HH income derived from crop production, 12%* of HH income derived from local off-farm activities).
Type 4: Large agricultural landowner - entrepreneurs	12 HH (9%) – Large landowners who have the largest cultivated area, particularly for rice (respectively 9,8 ha* of crops including 5,9 ha* of paddy. They can afford high production costs (\$887 per year*) and are clearly engaged in agricultural intensification (rice and perennial upland crops, including cashew trees). Their greater reliance on mechanization allows family labor diversification to off-farm labor (30%* of HH income).	12 HH (6%) – Large landowner households with the largest paddy area (17,6 ha*) and the highest value of owned agricultural assets (\$18359*), they can afford to hire outside labor for agricultural tasks (\$119* per year), and to rent in land (7,5 ha*). Agricultural mechanization allows family labor diversification from farming (42% of HH income) to off-farm labor (37% of HH income) or resource-demanding but lucrative job migration (6% of HH income).

contingent outcome of specific agrarian trajectories and local circumstances.

This said, the dispersion of household scores, measured by the range value, was higher in Rik Reay for 18 indices (70% of the total). This suggests that the agroecological character was not evenly distributed across the commune. Very surprising are the scores of large agricultural land owners-entrepreneurs (Type 4) that were consistently higher than scores of other households, typically than smallholders with diversified and local off-farm activities (Type 1), e.g., 79 and 46% of indices in Rik Reay and Kanghot, respectively. Among these indices are crop diversity, crop-livestock integration, agroecosystem connectivity, diversity of income sources, nutrition, etc. It was counterintuitive because the trajectory of farmers grouped under T4 was geared toward agricultural

capitalist modernization as opposed to agroecological intensification.

In Rik Reay, one strength was crop-livestock integration (synergies) as most households raise both cattle and buffaloes. Livestock not only represented an important item in the income portfolio but also reduced the need to use chemical fertilizers for cropping. It also explained why their “management of soil fertility” score was high. Their “management of rice seeds” (Recycling) was optimal given that the farmers produce their own seeds or exchange them with their neighbors. Finally, regarding “Youth empowerment and emigration” (Element 8: Human and social values), all types had high scores except type 2, as those households had developed a migration-based livelihood strategy. For “trees and other perennials” (Diversity), the higher scores obtained by farmers with abundant land were due to upland perennial crop plantations

TABLE 5 Average scores attributed in Step 1. Characterization of the agroecological transition (CAET).

Elements	Indices	Rik Reay						Kanghot					
		T1	T2	T3	T4	Average	Range	T1	T2	T3	T4	Average	Range
1. Diversity	Crops	39	55	68	67	57	30	6	6	11	13	9	6
	Animals	55	51	62	54	55	12	34	30	39	38	35	9
	Trees and perennials	6	32	47	25	27	41	0	0	2	3	1	2
	Diversity of activities	45	55	49	54	51	10	44	48	44	48	46	4
	“Diversity” average	36	48	57	50	48	21	21	21	24	25	23	4
2. Synergies	Crop-livestock-aquaculture integration	68	84	82	79	78	16	52	45	50	40	47	12
	Soils-plants management	30	42	49	31	38	19	6	1	2	5	4	5
	Agroforestry	35	45	54	38	43	19	8	10	7	0	6	10
	Agroecosystem connectivity	32	32	52	40	39	20	8	6	8	8	7	2
	“Synergies” average	41	51	59	47	50	18	19	16	17	13	16	6
3. Efficiency	Use of external inputs	36	39	44	35	39	8	21	19	22	13	19	10
	Management of soil fertility	74	91	87	90	85	17	6	2	1	5	4	5
	Control of weeds, pests and diseases	74	86	84	77	80	12	9	2	2	0	3	9
	Productivity and household needs	55	27	29	56	42	29	41	29	41	43	39	13
	“Efficiency” average	60	61	61	65	61	5	20	13	17	15	16	6
4. Recycling	Recycling of biomass and nutrients	22	22	24	25	23	3	21	18	23	18	20	5
	Water saving	13	15	14	15	14	2	9	6	16	23	13	16
	Management of seeds	100	100	100	100	100	0	95	98	98	98	97	3
	Use of renewable energy	16	19	20	23	19	7	1	2	0	0	1	2
	“Recycling” average	38	39	39	41	39	3	32	31	34	34	33	3
5. Resilience	Total production costs as a function of total gross product	73	74	82	65	73	17	58	50	59	63	58	13
	Diversity of income sources	41	49	59	54	51	18	29	26	27	25	27	4
	Indebtedness	64	67	67	71	67	7	66	59	68	48	60	20
	“Resilience” average	59	63	70	63	64	10	51	45	51	45	48	6
6. Culture & food tradition	Appropriate diet and nutrition awareness	64	67	74	88	73	24	51	52	55	58	54	6
	Use of local varieties	72	84	77	81	79	11	40	40	13	15	27	28
	“Culture and food tradition” average	68	75	76	84	76	16	46	46	34	36	41	13
7. Co-creation and sharing of knowledge	Involvement in knowledge transfer organizations	32	35	33	29	32	6	26	27	33	28	28	7
	Participation of producers in networks	11	20	13	19	16	8	6	4	10	5	6	6
	“Co-creation and sharing of knowledge” average	22	27	23	24	24	5	16	15	22	16	17	6
8. Human & social values	Women's contribution to labor	51	54	51	50	51	4	46	44	54	50	49	10
	Youth emigration	84	34	95	71	71	62	89	44	88	78	75	45
	“Human and social values” average	68	44	73	60	61	29	68	44	71	64	62	27
Global average		48	51	56	53	52	16	32	27	32	30	30	10

(cashew, fruit trees, etc.), which were often associated with chemical-based agricultural intensification and are not necessarily a sign of a virtuous agroecological transition. The low scores for “participation of producers in networks and grassroots organizations” (creation and sharing of knowledge) indicated that the collective dimension of agricultural development remained narrow. The individualistic nature of agricultural development was even more pronounced in Kanghot. Additionally, the scores of the different elements were low, especially indices that measure agricultural and land use practices (diversity, synergies, efficiency, and recycling). While the high score for “youth empowerment and emigration” reflected the low prevalence of migratory work. It was misleading given the widespread incidence of agricultural landlessness, inverse land tenancy, and local agricultural wage labor.

4 Discussion: methodological insights and implications for agroecology actors

Building on the methodology and results sections, we present the three key lessons we learned from enriching TAPE with agrarian political economy. We are cognizant of the possibility that limitations of our approach might have arisen from how we adapted TAPE but the insights discussed here are limited to elements of the original TAPE methods. We are also aware that the proposed revision of TAPE and the empirical application covers only two rice landscapes. We contend, however, that the agrarian issues discussed in this article (i.e., the importance of agrarian history, agrarian differentiation and labor mobility) are relevant to many other agrarian landscapes in the global south, particularly where resource commodification is in full swing.

4.1 The need to situate agroecology within the complex dynamics of agrarian change

In our study, we examined two distinct agrarian landscapes that have undergone significant reorganization since the late 1990s. The changes resulted from a process of agricultural modernization that has favored the expansion of conventional farming practices. This dominant trajectory has resulted in generalized commodification of all agricultural production processes and heightened the dependence of smallholder farmers on market mechanisms and hegemonic supply chain actors. Agricultural intensification, limited access to factors of production, price volatility, and indebtedness are now what smallholder farmers have to overcome to meet their daily needs, and which influence their production logic, constraints, and opportunities to engage time and resources in more sustainable farming practices (Andersson and Isgren, 2021; Autio et al., 2021; Isgren, 2016). In this context, the agroecological transition will not be able to unfold naturally because current policy incentives, investments in value chain development, and regulatory frameworks still largely favor conventional agriculture. Understanding these lock-in factors and questioning the political and economic asymmetries of the food system are therefore essential to promote and enable alternative practices to flourish (Gliessman, 2024; Pimbert, 2025; van der Ploeg, 2021).

TAPE offers an interesting framework to analyze all dimensions of the agroecological transition. Step 0, initially presented as a preamble to the characterization of agroecological transition, including a description of the social-ecological environment, policies, institutions, and laws that influence the agro-food systems, appears to be undergoing a process of expansion to address these issues (FAO, 2026). Yet, little emphasis is placed on how higher-level structures and dynamics produce local realities (Latour, 2007). Our approach, centered on agrarian history and differentiation, helps establish connections between scales and understand how agrarian modernization shapes the dominant pathway of territorial development (Romero et al., 2024) and produces lock-ins that hamper smallholder farmers' engagement in an agroecological transition. In our case study areas, the revised TAPE avoids a simplified and normative presentation of agroecology, and instead tackles the messiness of real-world transition (McKay et al., 2025).

By comparing two agricultural landscapes regions, we found that higher scores observed in Rik Reay should not automatically be interpreted as evidence of greater progress toward agroecology. They rather reflect different agrarian trajectories, which provides another empirical justification for our proposed revision of TAPE; one where the analysis of the agrarian history is more central. This is relevant to many other agrarian contexts.

4.2 Characterizing farming diversity based on asset distribution and labor processes

In TAPE, Step 1 consists of characterizing agricultural systems based on the stage they are at in the agroecological transition (FAO, 2019; Mottet et al., 2020). The underlying assumption is that a virtuous transition is underway and is evidenced by an increase in the CAET score. Farmers with a higher score are seen as ‘desirable objects’; they set the course for those following behind. However, such an approach ignores the fact that the entry points to promote agroecology and the lock-in factors that impede it vary greatly among farmers.

In our case study areas, we unveiled two key factors that shape social differentiation between farmers, knowledge of which may help avoid this pitfall: land-labor polarization and the mobility of family labor. On that basis, we developed a typology that captures structural differences between households in terms of land endowment and labor diversification (in and out of farming). The relative importance of these factors may vary in other agrarian contexts but they are worth considering given the extraordinary global forces that reconfigure family farming across the global south.

Instead of categorizing farmers based on their position along a hypothetical transition to agroecology, this typology identifies distinct capabilities and lock-in factors that influence farmers' readiness and ability to embrace agroecology, and can thus help tailor strategies to support its adoption (Teixeira et al., 2018). With this in mind, we encourage the development of typologies as part of Step 0 as it is proposed in the method now, emphasizing that these can be much more than preliminary typologies used to prepare for the analysis of typologies based on degrees of agroecology (FAO, 2026). It makes it possible to develop a more nuanced understanding of how policies and development practices could be tailored to the specific configurations of

constraints and opportunities characterizing each type of farming system. We illustrate such an endeavor with interpretive implications, propositions or hypotheses relevant to the farming systems types identified in Rik Reay and Kanghot:

4.2.1 Smallholders with diversified and local off-farm activities

These households are characterized by small landholdings and the inability to meet their family's needs with their own farm production, they are consequently obliged to rely on off-farm wage labor for survival. As a result, the opportunity cost of their farm labor is high, and these households tend to accelerate their farm work to free up time for other income-generating activities (Diepart and Thuon, 2022). However, the irregular and seasonal nature of wage labor opportunities means they have little control over their labor process. They cannot afford access to larger landholdings through the market. All in all, these families might be more responsive to small-scale and labor-saving agroecological innovations that would gradually help increase home food production, rice yield, and livestock raising at reduced cost.

4.2.2 Smallholders with migration activities

These households are also characterized by small landholdings, meaning they are unable to meet their basic needs through farming. But their deeper engagement in migratory work means that the transition to agroecology is even more challenging for these households, particularly in the dry season when the amount of farm work required is reduced. In this context, agroecology needs to offer credible alternatives to labor mobility, first and foremost in terms of income competitiveness (Dayet et al., 2024). It requires more profitable crops, shorter returns, secured access to the market, and protection against price volatility of both inputs and outputs. In this context, agroecology is as much about production as about marketing innovation.

4.2.3 Farm-based multi-activity households

These households have distinct characteristics. All the land and labor resources of the family are mainly dedicated to farming in a productive environment where all interconnected economic and agronomic risks (price volatility, indebtedness cycles, climate variability, depletion of soil fertility, and yield fluctuations) are incurred by the farmers (Pheap et al., 2025; Srean et al., 2025; Touch et al., 2025b). In the context of an agroecological transition, the need to stabilize the productive processes is the main requirement. Agroecological practices and financial mechanisms such as direct seeding mulch-based cropping systems, crop diversification, agroecological crop protection to reduce the use of pesticides, and crop certification enable farmers to obtain price premiums. Bringing agroecology to scale also requires upfront financial support and extension services that the State usually does not have (Cook et al., 2024). For these farming households, migrations do not necessarily constrain or impede agroecological transition. It may contribute to the diversification of household income in ways that incentivize more sustainable farming practices (Vizuete et al., 2024).

Large scale agricultural landowner/entrepreneurs

These households share the same characteristics as type 3. Additionally, given the scale of their operations, they are likely to rent out agricultural services to other farmers in their community. A large margin of this service income is associated with conventional agricultural practices (plowing, land leveling, application of agrochemicals) (Vernet et al., 2021). To convince them to shift to more agroecological services (no-till seeder, land leveler, that can operate while minimizing the negative impact on the soil resource), it is essential to build an economic model that will not affect their profit margin.

4.3 Agro-ecological scores decontextualized from agrarian dynamics may lead to simplification and misinterpretation

The strength of the CAET scoring system is that it covers a wide range of issues and offers a useful metric that can be compared over time and hence used to monitor changes. However, a score calculated from a Likert-scale derived from a narrow set of questions inevitably obscures the socio-material realities of agricultural development and may result in naïve or even misleading conclusions. A more critical engagement with these scores is therefore needed irrespective of the agrarian context in which the assessment is conducted.

The scores of index 1.3 “diversity of activities, products and services” were distributed evenly across types (low range values) in both Rik Reay and Kanghot. This is mainly because off-farm wage labor is computed as an income-generating activity that helps diversify the income portfolio. While wage labor is crucial for the economic stability of types 1 & 2, it differs significantly from self-employed activities in terms of autonomy and labor management. Wage labor exposes a family to circumstances over which they have very little control and creates an intra-family trade-off between the need to rapidly generate cash on the labor market versus the implementation of agro-ecological practices. As experienced with data from both case study areas, the score blurs this reality and makes these uneven social relations of production almost invisible.

Land tenure security is incorporated in Step 2 but emphasizes the statutory and customary forms of land recognition. The mobility of property rights associated with land transfer (sale/purchase and lease transactions) is not taken into account. However, in Cambodia, land markets are wealth-based and exacerbate land concentration and social inequalities within communities (Dayet et al., 2024; Diepart and Thuon, 2022). Land tenure security differs significantly from the classical separation of capital and labor that prevails between agribusiness companies and smallholder farmers, as captured in the index 8.2 Labor (productive conditions, and social inequalities). Additionally, unequal access to water and agricultural debt strongly affect land tenure and the potential for an agroecological transition in Kanghot (Diepart and Thuon, 2022; Ferreira, 2020; Green, 2021; Lucas and Mias, 2021). Yet they are difficult to identify through step 0, and the CAET method laid out in TAPE.

In both landscapes, the farming system types 3 & 4 usually have a higher agroecological score, while these households often implement more intensive farming practices in terms of chemical inputs and mechanization. They have also invested a lot in

commercial farming systems (upland crops in Rik Reay and rice in Kanghot), perhaps making them more reluctant to change course. Considering them as more ‘agroecological’ is indeed misleading. This inconsistency strongly supports our argument to consider CAET scores in light of the agrarian history and the farming types derived from it.

5 Conclusion

Supporting agroecological transitions requires the knowledge needed to understand agroecosystems and the multidimensional enablers and lock-in factors that shape agroecological transformation. The Tool for Agroecology Performance Evaluation (TAPE) is arguably one of the most advanced instruments to date that addresses this objective. It ties together several frameworks in a cohesive multi-scale approach designed to assess agricultural performances at both farm and landscape levels and to inform context-specific efforts toward agroecological transitions.

TAPE’s attempts to incorporate agrarian political-economy issues, and was partly inspired by frameworks cited as references in this study, for instance “Guide for the evaluation of agroecology. A method for assessing its effects and the conditions necessary for its development” [Levard, 2025 cited by Mottet et al., 2020]. We argue, however, that these issues could be given greater consideration in TAPE, particularly regarding the commodification, the concentration of the means of production and the mobility of labor away from agriculture, as these processes can strongly influence the ability of households to engage in an agroecological transition. We propose to further conceptualize and operationalize them in the TAPE approach. Our revisions include the reconstruction of agrarian history, a farming system typology that captures the dynamics of social differentiation between farming households, and a sharper scrutiny of labor mobility. These changes provide the basis for more a contextualized interpretation of CAET and help situate the assessment of agroecological performance within agricultural modernization processes as envisioned by most recent TAPE documents (FAO, 2026). It also provides a clearer understanding of the diversity of households in terms of their capacity to pursue agroecological development pathways.

Given the complexity of the issues, our contribution is open-ended, not a definitive answer. It aims to promote interdisciplinary and transdisciplinary dialogues on sustainability transitions and to create bridges between agroecology and critical agrarian studies to strengthen smallholder farming in Cambodia and elsewhere.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because there were no ethics committees mobilized in the project, but the authors applied research ethics principles in

accordance with the European General Data Protection Regulation (GDPR), such as informed consent in participating in the survey and interview, anonymity of respondents in the database. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TF: Data curation, Conceptualization, Visualization, Formal analysis, Writing – review & editing, Methodology, Writing – original draft, Software. J-CD: Formal analysis, Visualization, Writing – review & editing, Supervision, Methodology, Conceptualization, Writing – original draft. MS: Writing – review & editing, Validation, Conceptualization, Investigation, Funding acquisition, Supervision, Methodology, Resources, Project administration, Writing – original draft. RK: Supervision, Data curation, Methodology, Funding acquisition, Conceptualization, Validation, Investigation, Resources, Writing – original draft, Writing – review & editing, Project administration. SS: Writing – original draft, Investigation, Writing – review & editing. FT: Supervision, Writing – review & editing, Conceptualization, Investigation, Methodology, Writing – original draft, Funding acquisition, Resources, Project administration, Validation.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2026.1940600/full#supplementary-material>

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