Characterizing highland maize-mixed farming systems of Lao PDR's Xiengkhouang Province (Kham, Moke, Nonghet)

statistical analysis and participatory validation

Adair Zepeda[1], Powell Mponela[1], Phoutthasinh Phimmachanh[2], Tom Louanhsakha[2], Phonepaseuth Phaphoungern[2], Tassilo Tiemann[3], Timothy J. Krupnik[1], and Santiago Lopez-Ridaura[1]

Author affiliation [1]CIMMYT
[2]Lao Farmer Association (LFA)
[3]Independient consultant

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecology and socio-economic settings.

Through action research and development partnerships, the Initiative improves smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities are implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

The Transforming Agrifood Systems in South Asia Initiative (TAFSSA) is a CGIAR Regional Integrated Initiative that supports actions improving equitable access to sustainable healthy diets, that boosts farmers' livelihoods and resilience, and that conserves land, air, and water resources in a climate crisis.

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Abbreviations and acronyms

CGIAR	Consultative Group on International Agricultural Research
CIAT	Alliance Bioversity- International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
DEED	The DEED framework encompasses a series of phases for systems analysis and co-design (Describe, Explain, Explore, and Design).
HCA	Hierarchical Cluster Analysis
HH	Household
SI-MFS	Sustainable Intensification of Mixed Farming Systems Initiative
TAFSSA	Transforming Agrifood Systems in South Asia
WGSS	Within Group Squared Sum
WP	Work Package
HC	Hierarchical clustering process to assign studied elements across PCA dimensions.
Mg	The megagram is defined as 1,000,000 g mass measurement. Is the official name of Ton (Bureau International des Poids et Mesures, BIPM)
PCA	Principal Component Analysis, multivariate method to study relationship across variables to identify the distance between elements.
TLUs	Tropical Livestock Units, estimates a numeric value for the animal individuals within a farm-system according to the type, probable average weight and fodder demand to estimate a general idea of the relevance in the system (Chilonda & Otte, 2006)

1 Introduction

Farmers adjust farming practices and operations to fit varied and changing environments, meet increasing demand for nutritious food and feed for humans and animals, respond to expansive animal and crop based industrial growth, while sustaining ecological health. In recent decades, the change in farming systems has accelerated at an exponential rate with divergent pathways across regions. The transformations range from conversion of land use and cover, extensification, intensification, optimization to modern precision farming.

In Laos, significant change in farming systems have been recorded in the past decade. For instance, a study by Mienmany et al (2024) found that the export market opportunities drives farming system transformation:

> *Through land leasing contracts between farmers and Chinese companies, cavendish bananas boomed in northern Laos, replacing maize, a previous boom crop. Household participation in the banana boom depended on their assets (land and labour), livelihood context and social pressure. However, household income in the two Mienmany,s study villages improved, but differentially. The study found that the better-off, and those with a wider array of livelihood options, used income from bananas to move to primarily non-agricultural livelihoods, while many poorer households became dependent on wage labour in banana production, at the expense of their health. Women reported to be content to escape agricultural labour through land leasing; but many who contributed labour to banana production felt trapped in ongoing heavy labour, with attendant adverse impacts. Mienmany demonstrates how the conjunctures of different household, community and external elements, and crop boom-bust cycles, lead to differentiated ('variegated') household livelihood trajectories and outcomes for households and for men and women, and suggested points of policy intervention.*

In the past years, there has been a cassava 'boom' across Laos for starch exports to China, Vietnam and Thailand, replacing major crops and transforming the ecosystems and farming systems (Laotian Times, 2023; Thipphavong et al., 2023). However, the north western highland region remains maize basket, mainly for the export market to the neighbouring countries (UNCTAD, 2020) and stakeholders explore interventions for increasing productivity and market value of maize products (Phommalath et al., 2024). Sandwiched between three major economies, Laotian farmers venture into new market-oriented crops which drastically shift their resource utilization including land, mechanisation and labour; transform livestock, forages, crop and natural resource systems; and shift production orientation towards income.

In most agricultural development programs, interventions are rolled out using blanket recommendations that assume similarities in environments and farmer capabilities (Kuivanen et al., 2016). Traditionally, farm typologies from household surveys are developed to establish relatively homogeneous stable sub-systems for prioritisation and development targeting (Kuivanen et al., 2016). Recently, with global transformations, typologies are increasingly used to understand and explore development trajectories (Falconnier et al., 2015; Kuchimanchi et al., 2021; Mponela et al., 2023) and differentiated response to interventions (Gómez-Limón et al., 2024; Kaur et al., 2021). In case of Laos, the farming systems change rapidly, such that farm typology shift within short timespans. Nonetheless, with differentiated development trajectories and outcomes based on resource endowments – some farmers step-up, get trapped or step-down while others move out (Mienmany et al., 2024). Therefore, albeit challenging, farm typologies can aid identification of farm shifts and entry points for inclusive policy intervention (Falconnier et al., 2015). This is essential in attainment of gender empowerment and social inclusion (GESI).

This study, therefore, develops a baseline typology of highland maize mixed farming systems of Laos to support co-design of socio-technical innovation bundles (Barrett et al., 2020).

Further, the study engaged farmers and stakeholders to improve their understanding of farming systems, the diversity at the village or community level. Often, statistically based typologies are developed at higher aggregation levels (i.e. district, province, country) and the sampling methods rarely allow to capture the diversity of farming systems within a village or community. Although sharing socioeconomic and biophysical context, within community diversity is usually important and depends on, among other, the needs and objectives of specific farm households, the trajectories, opportunities and their attitude towards innovation and risk.

2 Methods and tools

2.1 Survey

To capture integration of crop-livestock at regional level, the study was conducted in 14 randomly selected villages in three adjoining districts of Xiengkhouang Province: Kham (101), Moke (100), and Nonghet (99) (as depicted in Figure 2.1). These Eastern Xiengkhoung districts have varying extents of livestock and crop integration within highland maize mixed farming systems of Laos. The northern districts have high livestock and natural fodder components in remote areas, followed by livestock and planted fodder, then dominant crop systems in more accessible landscapes and communities.

A farm characterisation household survey was commissioned in 2024 to capture farm attributes on 10 modules (Table 2.1). The questions were translated and carried out in the Laotian language utilizing electronic devices through Survey Monkey web application. The survey was implemented by trained local enumerators supervised by Lao Farmer Association. Data collection occurred between January 2024 and March 2024, resulting in a total of 300 records.

Table 2.1 Farm characterization survey questionnaire modules.

Module		Elements
1	Basic character of the household	Farmer's information (name, contact), geographics, family composition, surface of crops, livestock ownership and the loses due to weather
2	Income	From sale of crop produce, livestock and products and from off farm activities
3	Cropping systems	Major crops (Upland rice, paddy rice (lowland), maize, cassava, Arrow root) and cropping practices (e.g. fertilizers-herbicides management)
4	Livestock systems	Inventory, inventory changes, fodder
5	Interaction between production systems	Animals and kind of fodder, shortage
6	Machinery use	Inventory of equipment, inventory of services, use in production, labor shortage
7	Soil conservation	Soil problems
8	Water conservation	Water constrains, sources and method
9	Future	Technology requirements for future
10	Household consumption	Food purchased, copping strategies events

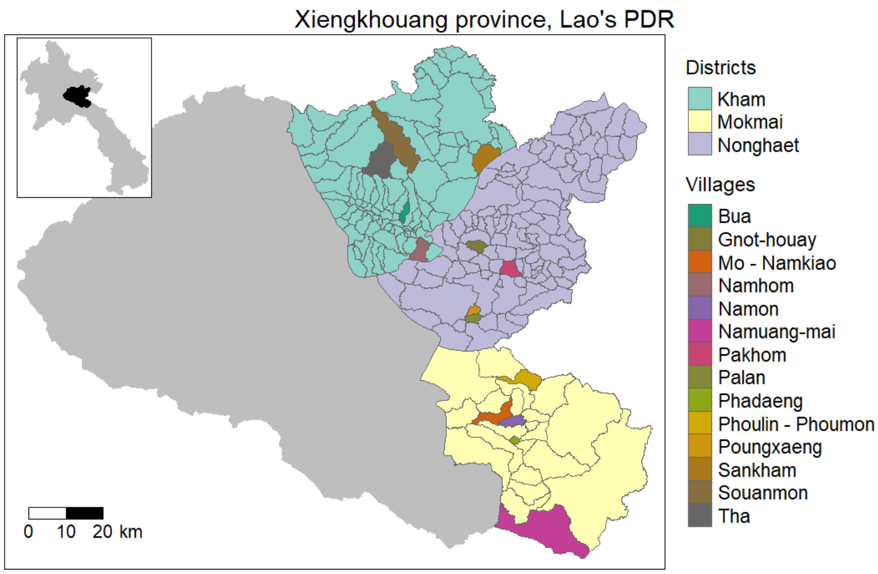


Figure 2.1 Study area of the farm characterization household survey carried out in Lao´s PDR between January 2024 and March 2024.

2.2 Data cleaning: Near-Zero Variance, outliers and collinearity

We first conducted a visual examination of the dataset's variable distributions using boxplots and histograms, with the aim of identifying patterns resembling normal distributions. Selected indicator variables were screened and those having more ≥74% of the data as NA, or a prevalence of ≥80% of 0 (zero) value as responses, were consequently excluded from further analysis. A statistical test, as outlined by Kuhn (2023), was utilized to demonstrate significant near-zero variance. This test relied on the ratio of the most frequently occurring high values to the percent uniqueness of values within all data vectors. To evaluate correlations between numerical variables, Pearson's correlation was conducted. Following Barba-Escoto et al. (2019), a threshold of 0.7 was employed as a discriminating point. Any correlations exceeding this absolute reference value were scrutinized across all related variables, and for interpretation purposes, the most significant variable was selected among those with multiple correlations or varying levels of significance.

Before the cleaning process 77 variables and 300 farmer respondents' data were pre-selected for the farm typology characterization of Xiengkhouang´s Province Kham, Moke and Nonghet districts. 4 variables linked to the identification of each respondent were directly removed. Another 27 variables were removed after the cleaning process. The final farm type definition presented in this document is based on a matrix of 27 variables × 300 farmer household survey respondents. The ratio of surveys to variables in this analysis is 11.1, which exceeds the commonly accepted threshold of 5, indicating the reliability of the analysis.

2.3 Typology construction approach

Farming systems are characterised by biophysical condition of the farm and farmers socioeconomic attributes influenced by external political, biogeochemical, climatic and market forces. The volume and sheer number of attributes and indicators to describe and delineate the farming systems is voluminous. Another level of complexity arises from the level at which farms are characterised: from individual plant, plot, household, landscape, agro ecologies, to regions. To understand farm structure and function, the study captured the attributes at farm household level. We use the SIAF framework and MESMIS (López-Ridaura et al., 2002; Musumba et al., 2017), to group the components and select measurable indicators. In farming systems analysis, household-level data are critical in delineating internal farm dynamics that include production processes, adaptive strategies, and resilience metrics. Structural variables, characterized by their stability over short to medium-term periods, are key to discerning consistent trends and patterns within farming systems. These variables assist in identifying the strategic choices made by farm households to advance their welfare and nutrition.

With such larger number of variables, the dimensionality of diversity and homogeneity within farm types could be huge. Considering that most of the attributes might be highly correlated and could influence the clustering, Principal Component Analysis was conducted to reduce data dimensionality. The PCA was also used to identify non-correlated indicators used to differentiate (Tittonell et al., 2010).

Indicator variables are classified into structural and functional. Structural indicators exhibit minimal year-to-year variability such as land surface area, active subsystems within the farm, and land use. In contrast, non-structural functional variables such as crop yields or income change dramatically within a year.

Subsequently, that explained most of the variance and had meaningful loadings were included in a hierarchical cluster analysis. Clusters were interpreted, described and differentiated in relation to the average and dispersion of the main indicator variables within and between groups. First, each farm is a group all by itself, and then at each step, the two most similar groups are merged until only one group with all farms remains. The visual result of these steps (algorithm) is a dendrogram or classification tree (see Figure 3.4). The height of the dendrogram branches represents the average distance (dissimilarity) between the observations within the groups and between groups. The dendrogram provides a visual representation of the variability of data and determination of partitioning, i.e. the number of clusters. Aided with the dendrogram, the optimal number of clusters was subjectively determined by considering (i) the overall appearance of the dendrogram, (ii) the number of clusters and (iii) their interpretability, and (iv) the examination of the height deltas.

The farm types were characterised using mean characteristics of numerical indicator variables which were visually separated based on magnitude and statistically confirmed by Bonferroni multiple comparison test (Table 3.3 and Table 6.4).

2.4 Participatory typology validation

Focus groups are organized of about 5 farmers per farm type and the district representatives of various organizations working in the maize and forage industry.

The participatory approach was used based on methodology developed with communities in India, Mozambique, Rwanda, Zimbabwe, Kenia, Nicaragua, Guatemala, Nepal and Bangladesh.

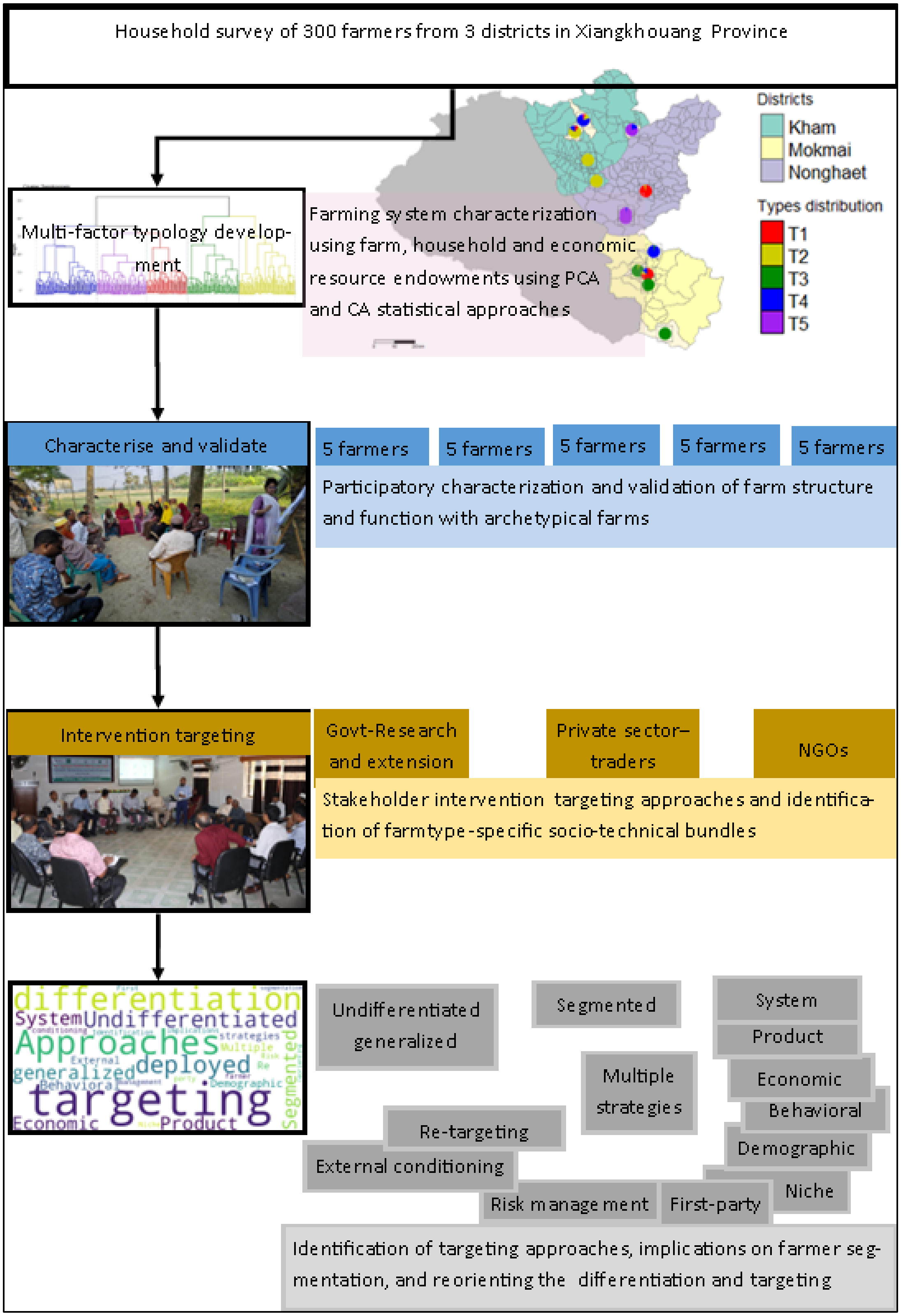


Figure 2.2 Workflow for farming systems typology development, validation and application for targeting interventions

3 RESULTS

3.1 Data dimensions (PCs) and farm clustering (farm types)

3.1.1 Attribute dimensions characterising diversity of farming systems

The definition of the dimensions was based on the eigenvalues of each potential component, with those having eigenvalues greater than 1 considered relevant. The scree lot test served as a visual aid in this process. In this case, a total of 15 dimensions were defined, as outlined in Table 3.1 and illustrated in Figure 2.1. The Pearson's correlation matrix between variables and whole dimensions (axis) can be visited at Figure 6.2.

Table 3.1 Eigenvalues, PC cuts.

	inertia	cum	cum (%)
Ax1	6.61	6.6	13.2
Ax2	4.93	11.5	23.1
Ax3	3.66	15.2	30.4
Ax4	2.97	18.2	36.3
Ax5	2.13	20.3	40.6
Ax6	1.97	22.3	44.5
Ax7	1.85	24.1	48.2
Ax8	1.77	25.9	51.8
Ax9	1.58	27.5	54.9
Ax10	1.40	28.9	57.8
Ax11	1.38	30.3	60.5
Ax12	1.30	31.6	63.1
Ax13	1.20	32.8	65.5
Ax14	1.15	33.9	67.8
Ax15	1.09	35.0	70.0
Ax16	0.98	36.0	72.0

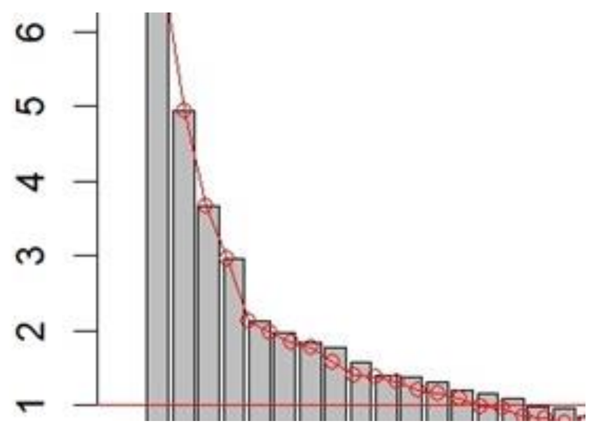


Figure 3.1 Scree test result defining 15 dimensions for PCA-HCA.

Following the preliminary assessment, the farm system components were delineated, and the districts were allocated into these components, as shown in Figure 3.2 and 3.3. This classification was based on the distance of each district's corresponding value in the vector created by each variable and the direction across these components. The significance or weighting of each selected variable can be found in Table 6.3, as provided in the annexes.

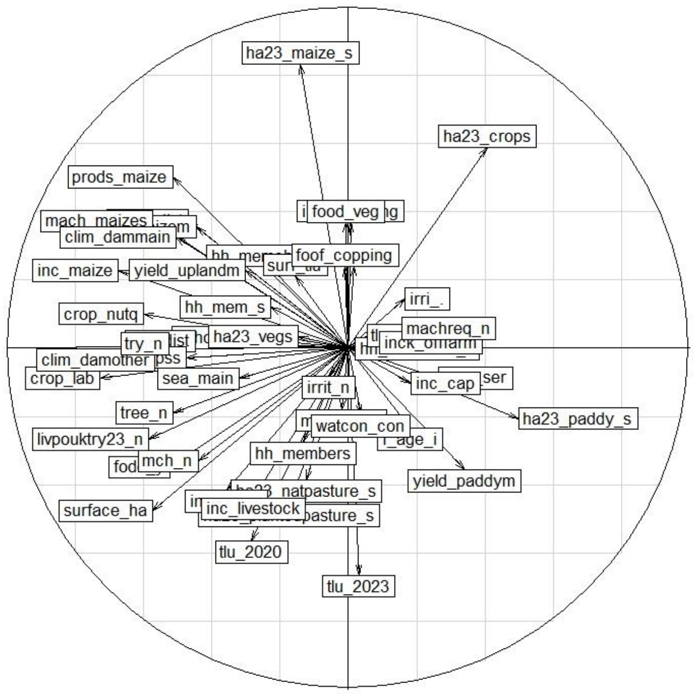


Figure 3.2 Variables weight through PCA.

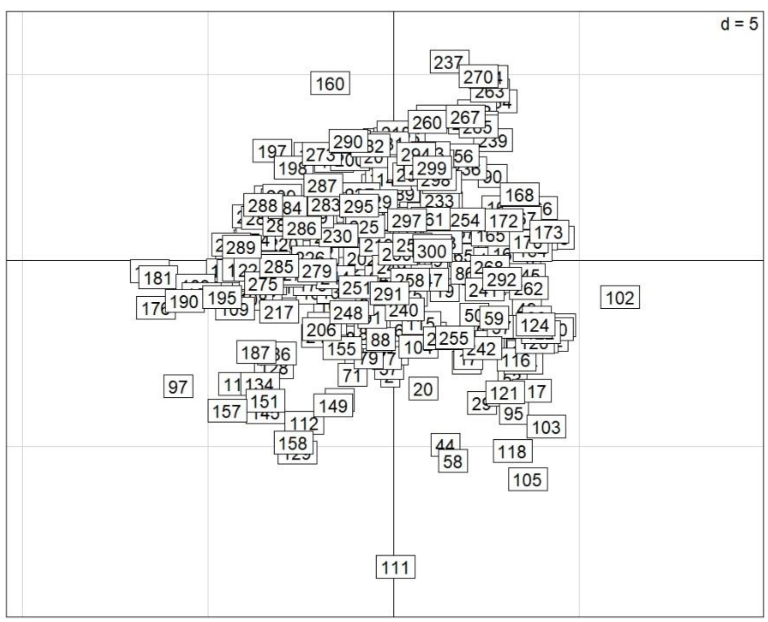


Figure 3.3 Observations in dimension 1-2 of PCA.

3.1.2 Clustering of households into homogenous farm types

In the second phase of the typology construction, the grouping process is established, guided by the Within Group Squared Sum (WGSS) and a hierarchical classification (as depicted in Figure 3.4). Combining the insights derived from both methods, five distinct farm types were defined. Subsequently, each record was categorized and allocated to one of these five groups, as depicted in Figure 3.5. Table 3.2 summarizes the distribution of the records into the different farm types.

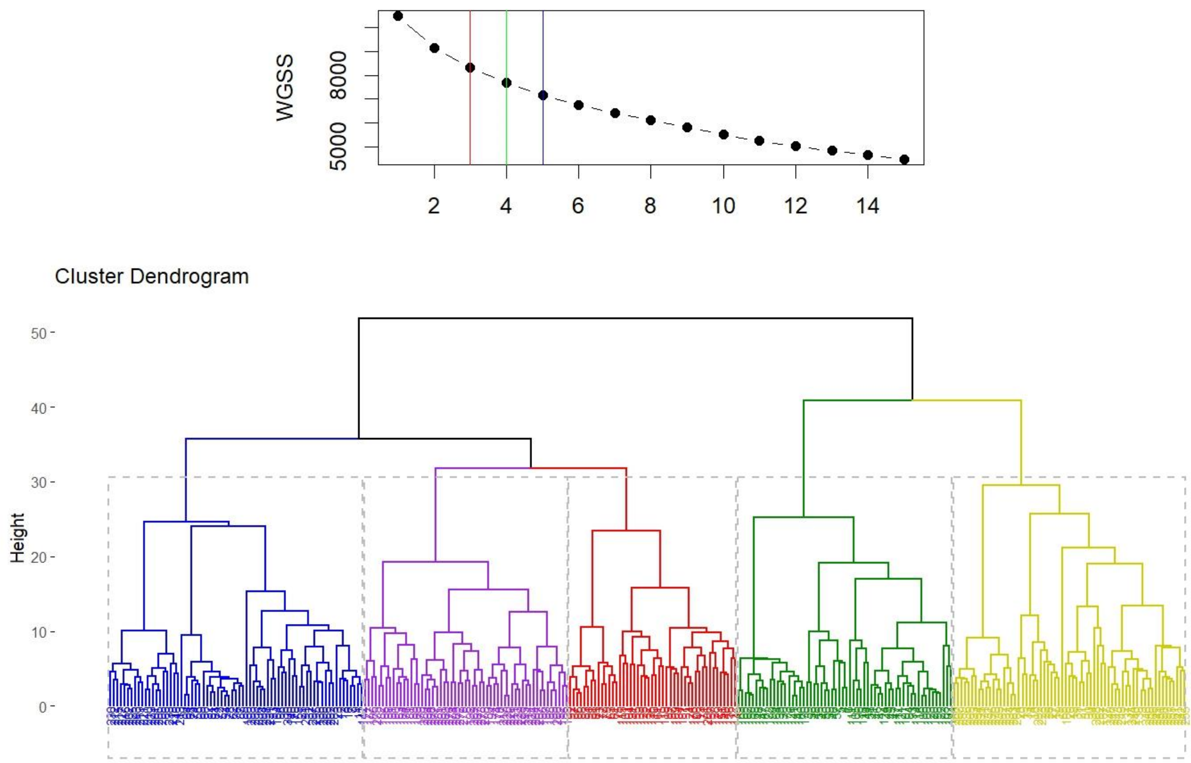


Figure 3.4 WGSS (above) and hierarchical cluster dendrogram (below).

Table 3.2 Farm type distribution across Kham, Moke and Nonghet districts.

District	T1	T2	T3	T4	T5	All
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n***
Kham	4 (4.0)	58 (57.4)		22 (21.8)	17 (16.8)	101
Moke	15 (15.0)	3 (3.0)	60 (60.0)	22 (22.0)		100
Nonghet	28 (28.3)	4 (4.0)		27 (27.3)	40 (40.4)	99
All	47 (15.7)	65 (21.7)	60 (20.0)	71 (23.7)	57 (19.0)	300

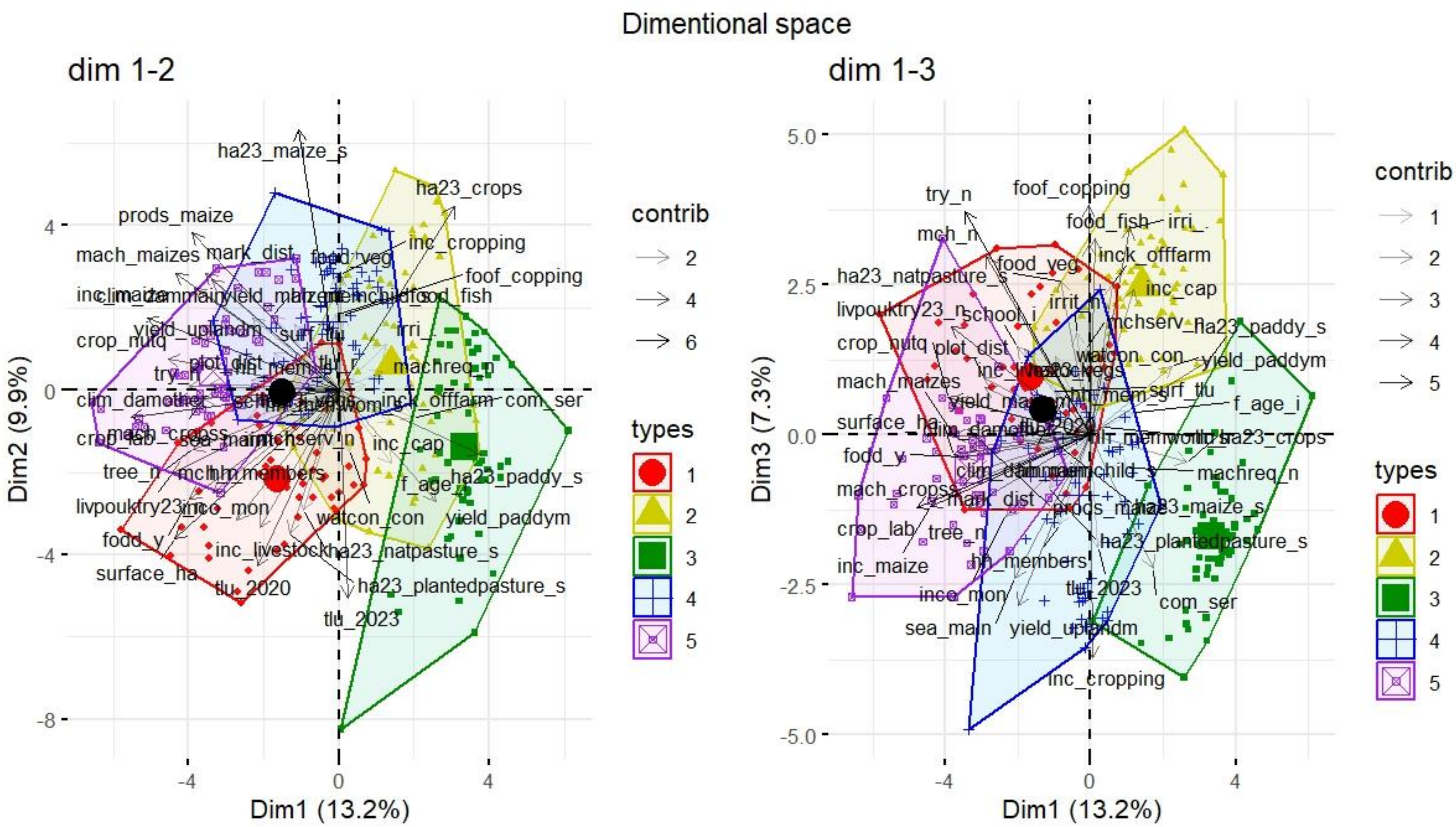


Figure 3.5 Types clustering (dimension 1-2 and 1-3).

3.2 Characterisation of farm types

Five distinct farm types have been identified. It is assential to note that the farm type descriptions presented below provide a relative perspective on the characteristics among these farm types. The variables employed in designing the farm types are visually represented in a heatmap (Table 3.3 and Table 6.4) to emphasize group differences. For each farm type a graphic representation showing the average component characteristics as well as the average interactions/flows between components is given (Figures 2.6 to 2.9).

Several key considerations also include (i) The TLU score (Chilonda & Otte, 2006) is based on ILRI's simplified model, considering only the number of animals reported to assign a value based on weight and fodder needed; (ii) The seasons were clasified (Table 6.6) by the sowing date, considering the 'main' season from March (ມີນາ/Mīnā) to July (ກໍລະກົດ/Kōlākōt); (iii) naming of the farm types was based on key differentiating average attributes.

Supplementary information is available in the annexes, it includes:

i. A map displaying the surveyed farms and their corresponding farm types (Figure 5.1).
ii. The results of a Bonferroni test carried out to assess significant differences between farm types for the definitive variables (Table 5.5) as well as the results of a Chi-squared test applied to analyse the variables (Table 5.6).
iii. A comprehensive visualization of variables across all districts presented through boxplots (Figures 5.2 to 5.7). It's important to note that this information relies on the same dataset; however, additional outliers were removed specifically when examining production. The key topics addressed encompass household information, income sources, land allocations, production, and indicators of system resilience.

T1: larger, mechanized, least share of land to crops, less share of maize as well as rice, larger share of natural and planted pasture, more livestock, higher income, less income from crops, higher income from livestock, more labour, higher maize yield,
T2: small landholding, high share of irrigation, less livestock, least pastureland, vulnerable to climatic events, higher paddy and less upland rice, less income, less income from crops, significant reliance on off farm income, less labour, higher paddy rice yield, rely on non-timber forest products, less mechanised,
T3: least irrigated, small landholding, higher share of land for crops, less share of maize, more paddy rice than upland rice, less livestock income, higher crop income share, less off farm income, less labour, least maize yield, higher paddy rice yield, less reliance on non-timber forest products, least mechanised, consume mostly own rice, share information via local network
T4: small landholding, least irrigated, larger share of maize, less paddy rice more upland rice, least livestock, less planted and natural pasture, less income, least off farm income, moderate labour, mechanised, affected by climate change, mostly buy rice, share information via local network
T5: larger farms, less land for rice, moderate under maize, more livestock with more planted than natural pasture, higher income, more labour, higher maize and upland rice yield

3.2.1 Type 1 (47 n/ 15.7 %) –Large, mechanized livestock-oriented farms with natural and cultivated pasture and higher maize yields

The average age of HH farmer is between 35-54 years old, with an education around Secondary, the higher across HH types. Have a population of 6.4 persons, being women the 48.6%, children the 28.1% and youths the 45.6%. Have the larger number of personal vehicles (1.5). The main source of information come from local network (80.5%) with some internet-related sources (11.6%). Have present some month with copping strategies (2.3). In the case of food purchasing, the larger decreasing share in the year is: meat (34.2%), fish (27.6%), rice (21.8%), fruit (21.8%), and vegetables (14.0%).

These farms present the larger surfaces (10.7 ha); the higher surface per person (1.7 ha) but moderated for livestock (1.1 ha). Have some crop land under irrigation (9.3%, 0.6 ha). The main crops share is the lowest (25.5%), but the larger for fodder (69.1%) and pasture (32.7% natural, 32.7% planted), with very low for vegetables (0.4%); presents the higher restrains to water for irrigation access (2.5). Destine an important time walking to plots (73 min), and relatively low going to markets in motorbike (30.6 min). The common land provides the lower services (1.4 types). 94.7% of crops are under main season, with an average of 1.7 different crops. 13.9% of crops are under mechanization. Demands a moderate amount of labour for cropping (159.1 Person Day).

Upland rice presents a small surface (3.5%), same for paddy rice (8.0%), and the lower for maize (16.6%). The yield obtained for each crop is: maize (4.7 Mg ha^{-1}), paddy rice (2.1 Mg ha^{-1}), and upland rice (0.6 Mg ha^{-1}). For mechanization, each crop is as follows: maize (57.1%), paddy rice (31.6%, high), and upland rice (16.7%).

The TLU score for 2023 was 12.40, and for 2020 10.0 (the larger). Presents an important fodder shortage across year (50.5%), for poultry (14.4), but moderated for cattle (35.1%). Have the larger inventory for pigs (2.2) and poultry (30.0), and high for cattle (15.0).

These HH presents a high farm income ($80,401 Lak thousands). The most relevant income source are cropping (53.1%, lower) and livestock (39.8%, higher), with low participation from capital (3.6%), and off-farm (3.5%).

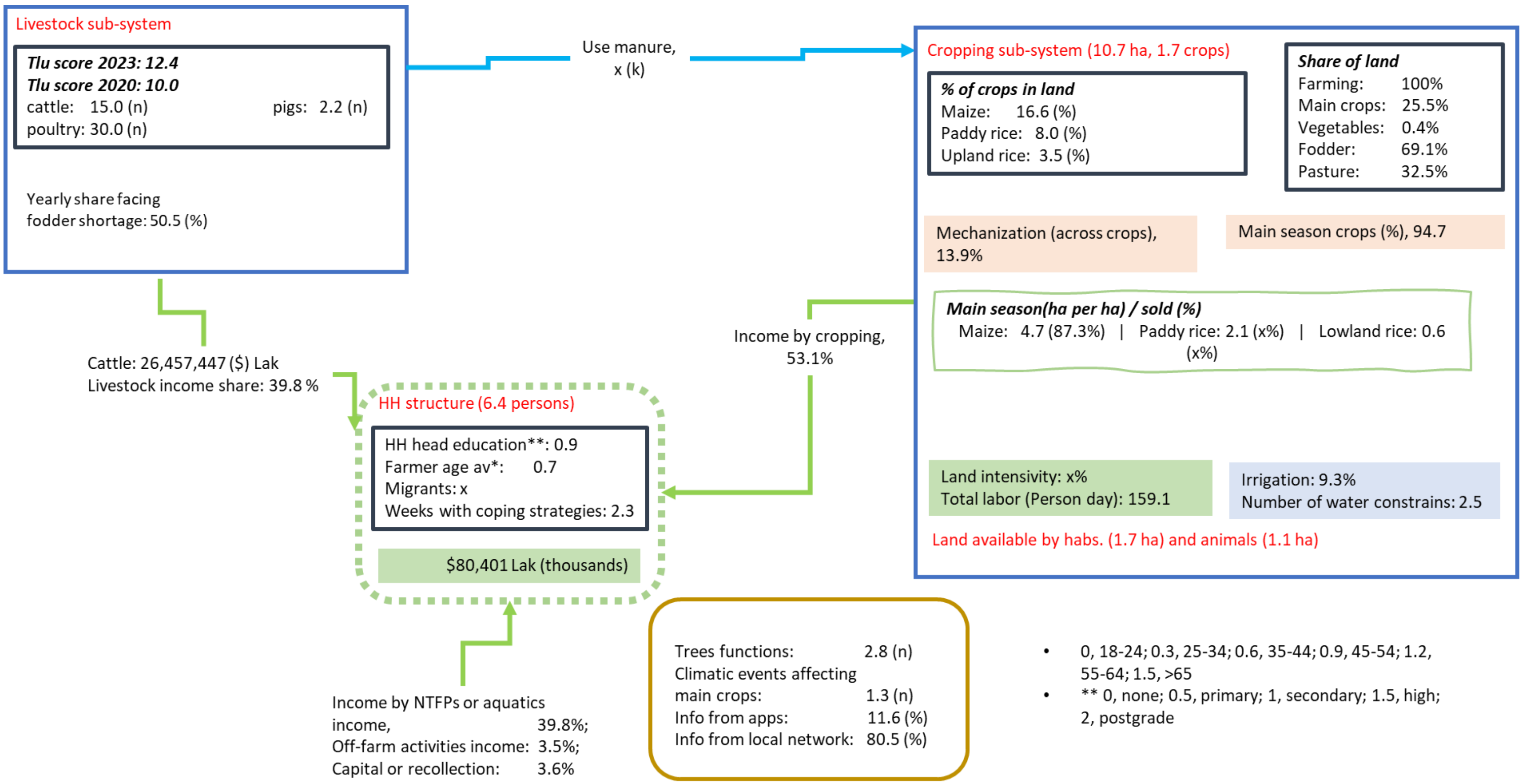


Figure 3.6 Map diagram – Type 1 farms, “Mechanized livestock-oriented large farms” (47 *n* / 14.7%).

3.2.2 Type 2 (65 n/ 21.7 %) –Small, irrigated farms with high paddy rice yields and diversified crop and off-farm income

The average age of HH farmer is around 45-54 years old, with an education around half Secondary. Have a population of 5.6 persons, the lowest, being women the 45.2%, children the 24.1% (lowest) and youths the 42.3%. Have a low number of personal vehicles (1.1). The main source of information come from local network (82.2%) with some internet-related sources (6.6%). Have present the larger period with copping strategies (6.2 months). In the case of food purchasing (the higher in almost all cases), the larger decreasing share in the year is: meat (49.0%), fish (38.7%), fruit (33.7%), vegetables (31.6%), and rice (29.0%).

These farms present the lowest surfaces (2.8 ha); the lowest surface per person (0.5 ha) but moderated for livestock (1.1 ha). Presents the higher crop land under irrigation (41.8%, 1.1 ha). The main crops share is important (65.7%), fodder (28.3%) and pasture (15.0% natural, 10.5% planted, the lowest), with vegetables (1.0%). Destine an important time walking to plots (61.3 min) and going to markets in motorbike (49.6 min). The common land provides some services (2.5 types). 94.5% of crops are under main season, with an average of 1.5 different crops. 9.3% of crops are under mechanization. Demands a low labour for cropping (85.7 Person Day).

The main surface is dedicated to paddy rice (20.7%) but the lowest for upland rice (1.5%), with maize (40.4%). The yield obtained for each crop is: maize (3.7 Mg ha^{-1}), paddy rice (2.8 Mg ha^{-1}), and upland rice (0.1 Mg ha^{-1}, lower). For mechanization, each crop is as follows: maize (34.4%), paddy rice (32.8%, higher), and upland rice (5.9%).

Presents a low TLU score for 2023 (4.8) and 2020 (3.8). Presents the lower fodder shortage across the year (25.4%), for cattle (21.2%) and poultry (1.9%). Have a low inventory of cattle (6.2) and moderated for pigs (1.1) and poultry (9.5).

These HH presents the lower farm income ($41,641 Lak thousands). The most relevant income source are: cropping (57.4%), capital (22.7%, higher), off-farm (14.4%, higher), and livestock (5.5%).

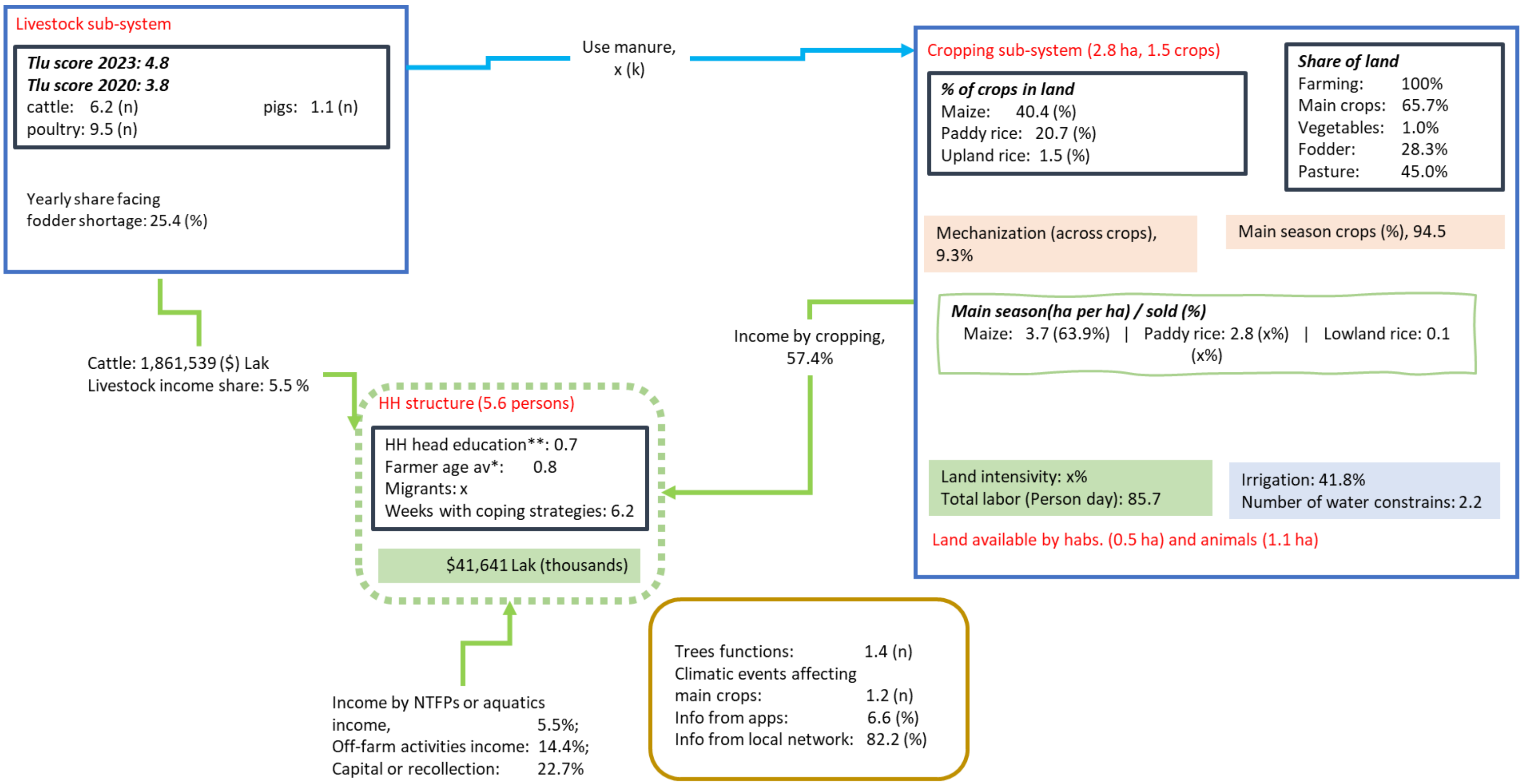


Figure 3.7 Map diagram – Type 2 farms, “Small farms with high irrigation and diversified income” (65 *n* / 21.7%).

3.2.3 Type 3 (60 n/ 20.0 %) –Small, crop-focused farms with minimal mechanization and limited pasture.

The average age of HH farmer is between 35-54 years old, with the lowest education on incomplete Elementary or none. Are the most populated HH with 7.1 persons, being women the 46.5%, however present the lowest proportion on children the 24.3% and youths the 35.0%. Have a moderate number of personal vehicles (1.2). The main source of information come from local network (63.6%, lowest) with some internet-related sources (32.2%, higher). Presents the smaller period with copping strategies (0.9 months). In the case of food purchasing, the larger decreasing share in the year is: meat (51.9%, higher), fruit (20.3%), fish (19.4%, lower), rice (8.9%, lower), and vegetables (6.7%, lower).

These farms present an important surface (4.3 ha); the higher surface per person (1.7 ha) but moderated for livestock (1.1 ha). The majorly of crop land is not irrigated (4.0%, 0.2 ha). The main crops share is the higher (69.1%), fodder (28.5%) and pasture (6.3% natural, 22.3% planted), with no surface for vegetables (0.0%). Spend the lowest time walking to plots (30.8 min) and going to markets in motorbike (14.6 min). The common land provides the higher services (3.5 types). 96.7% of crops are under main season, with an average of 1.8 different crops. 7.9% of crops are under mechanization (the lower). Demands the lower labour for cropping (68.5 Person Day). Are the least interested in change crops/animals, and the least affected by climatic events.

The main surface is dedicated to paddy rice (24.9%, the higher), restricted for upland rice (2.4%), with low share for maize (17.8%). The yield obtained for each crop is: paddy rice (3.5 Mg ha^{-1}, lower), maize (1.2 Mg ha^{-1}, high), and upland rice (0.3 Mg ha^{-1}). For mechanization, each crop is as follows: paddy rice (20.3%), and the lowest for maize (6.7%) and upland rice (3.1%).

Presents the larger TLU score for 2023 (15.5), and moderate for 2020 (6.0). Presents a moderated fodder shortage across the year (36.9%), for cattle (36.7%) but no for poultry (0.0%). Presents the higher inventory of cattle (21.6), but no pigs (0.0) or poultry (0.0).

These HH presents a moderated farm income ($69,112 Lak thousands). The most relevant income source is cropping (91.9%, higher), with very low from livestock (2.6%), capital (2.1%), and off-farm (1.7%).

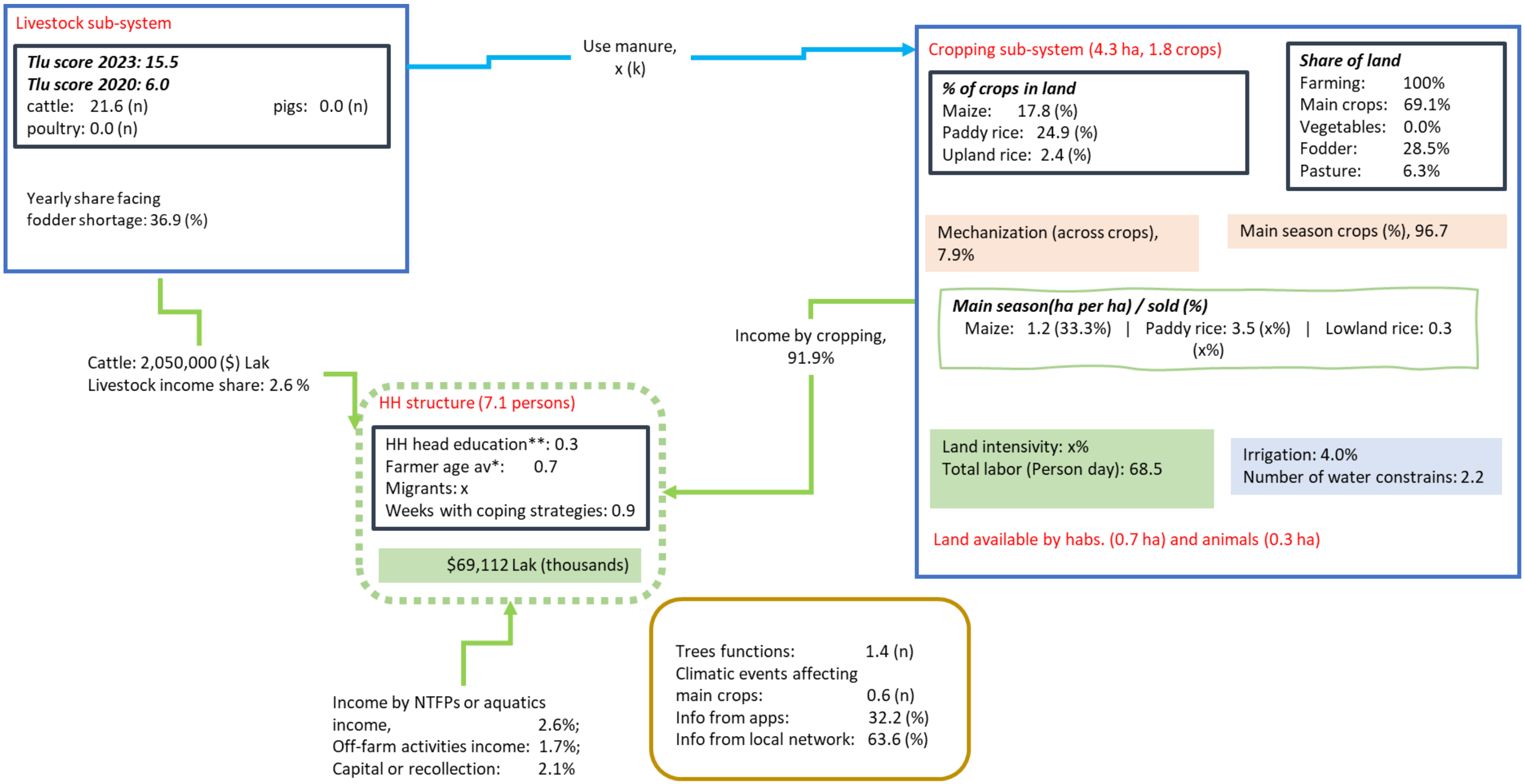


Figure 3.8 Map diagram – Type 3 farms, "Crop-focused, low mechanization small farms" (60 *n* / 20.0%).

3.2.4 Type 4 (71 n/ 23.7 %) –Small, maize-dominant farms with upland rice, minimal pasture, and crop-driven income

The average age of HH farmer is around 35-44 years old, with an education around half Secondary. Have a population of 6.4 persons, being women the 44.8%, with the most elevated share on children (38.5%) and important proportion on youths' share (46.3%). Have the lower number of personal vehicles (1.0). The majorly of information come from local network (91.5%, higher) with almost no information from internet-related sources (5.2%, lowest). Presents some months with copping strategies (2.3). In the case of food purchasing, the larger decreasing share in the year is: rice (44.1%, higher), meat (27.9%, lower), fish (22.7%), fruit (15.5%, lower), and vegetables (14.5%).

These farms present a surface of 3.7 ha; 0.6 ha per person (1.7 ha) but the higher for livestock (1.7 ha). The majorly of crop land is not irrigated (1.0%, 0.0 ha). The main crops share is 59.8%, but the lower for fodder (21.0%) and pasture (5.4% natural, 14.0% planted), and vegetables (0.5%); presents the lower restrains to water for irrigation access (1.3). Destine an important time walking to plots (55 min) and going to markets in motorbike (64.4 min). The common land provides some services (2.6 types). 97.2% of crops are under main season, with an average of 1.6 different crops. 14.6% of crops are under mechanization. Demands a moderated labour for cropping (110.0 Person Day).

The larger shares of land are for maize (57.9%) and upland rice (18.8%), with the lower for paddy rice (1.1%). The yield obtained for each crop is: upland rice (1.7 Mg ha^{-1}), maize (4.5 Mg ha^{-1}, lower), and paddy rice (4.5 Mg ha^{-1}). For mechanization, each crop is as follows: maize (71.6%, higher), upland rice (32.9%), and the lower for paddy rice (4.7%).

Presents the lowest TLU score for 2023 (4.6) and 2020 (2.9). Presents a moderated fodder shortage across the year (29.9%), for cattle (25.2%) and poultry (3.9%). Have a low inventory of cattle (6.3), poultry (9.1) and pigs (0.7).

These HH presents a low farm income ($44,992). The most relevant income source is cropping (84.9%) with some livestock (8.4%) and capital (5.5%), and the lowest off-farm (1.2%).

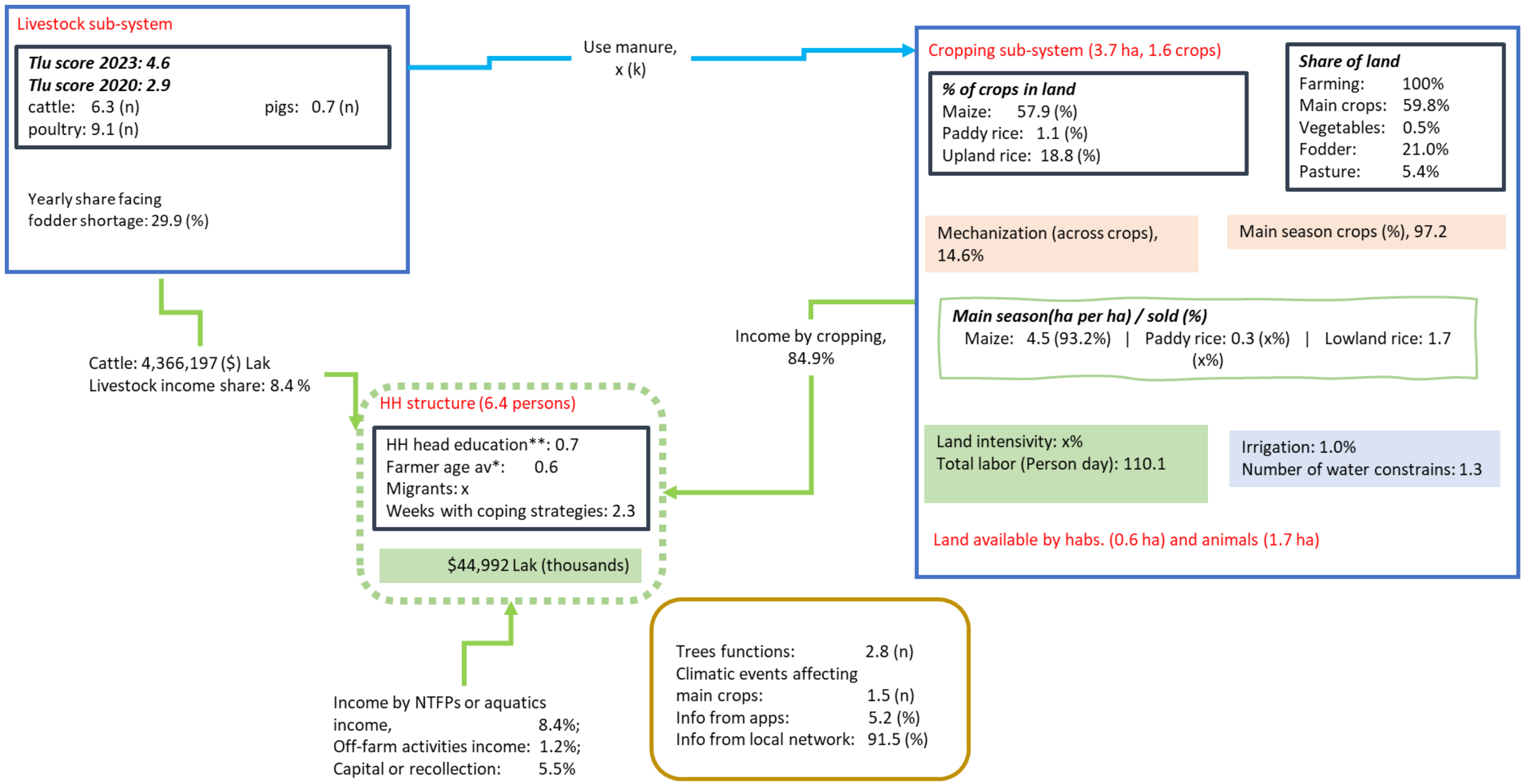


Figure 3.9 Map diagram – Type 4 farms, “Maize-dominant small farms” (71 *n* / 23.%).

3.2.5 *Type 5 (57 n/ 19.0 %) –Large, mechanised and diversified farms with high upland rice yields, cultivated pasture, and balanced income from crops and livestock*

The average age of HH farmer is around 25-44 years old, the youngest, with an education around almost complete Secondary. Have a population of 6.7 persons, being women the 45.4%, with a high share of children (36.2%) and the higher of youths (50.8%). Have a significative number of personal vehicles (1.3). The majorly of information come from local network (91.5%, higher) with almost no information from internet-related sources (7.1%, lowest). Presents some months with copping strategies (2.9). In the case of food purchasing, the larger decreasing share in the year is: meat (36.3%), fruit (28.7%), fish (23.4%), rice (20.3%), and vegetables (17.9%).

These farms present a high surface (8.9 ha); same for surface per person (1.4 ha) and livestock (1.3 ha). Some of crop surface is under irrigation (7.0%, 0.6 ha). The main crops share is low (50.0%), fodder (35.3%) and pasture (2.0% natural, the lowest, 28.9% planted), with very higher for vegetables (1.3%). Destine the larger time walking to plots (103.7 min) and going to markets in motorbike (139.4 min). The common land provides some services (2.5 types). 97.7% of crops are under main season (the higher), with an average of 2.1 different crops. 15.1% of crops are under mechanization, the higher. Demands the higher labour for cropping (267.9 Person Day). Are the most interested in change crops/animals, and the most affected by climatic events.

The crop land is dedicated to maize (45.8%) and upland rice (11.9%), with low surface for paddy rice (2.8%). The yield obtained for each crop is: maize (4.8 Mg ha^{-1}, higher), upland rice (1.4Mg ha^{-1}, high), and paddy rice (0.9 Mg ha^{-1}). For mechanization, each crop is as follows: maize (59.7%), upland rice (44.2%, higher), and paddy rice (15.5%).

Presents a moderated TLU score for 2023 (8.2) and 2020 (7.4). Presents the higher fodder shortage across the year (60.4%), for cattle (40.5%) and poultry (19.9%). Have a high inventory of poultry (21.7) and pigs (1.5), with moderate amount of cattle (10.8).

These HH presents the higher farm income ($87,709 Lak thousands). The most relevant income source is cropping (85.1%), livestock (9.1%) and off-farm (4.7%), and the lowest capital (1.1%).

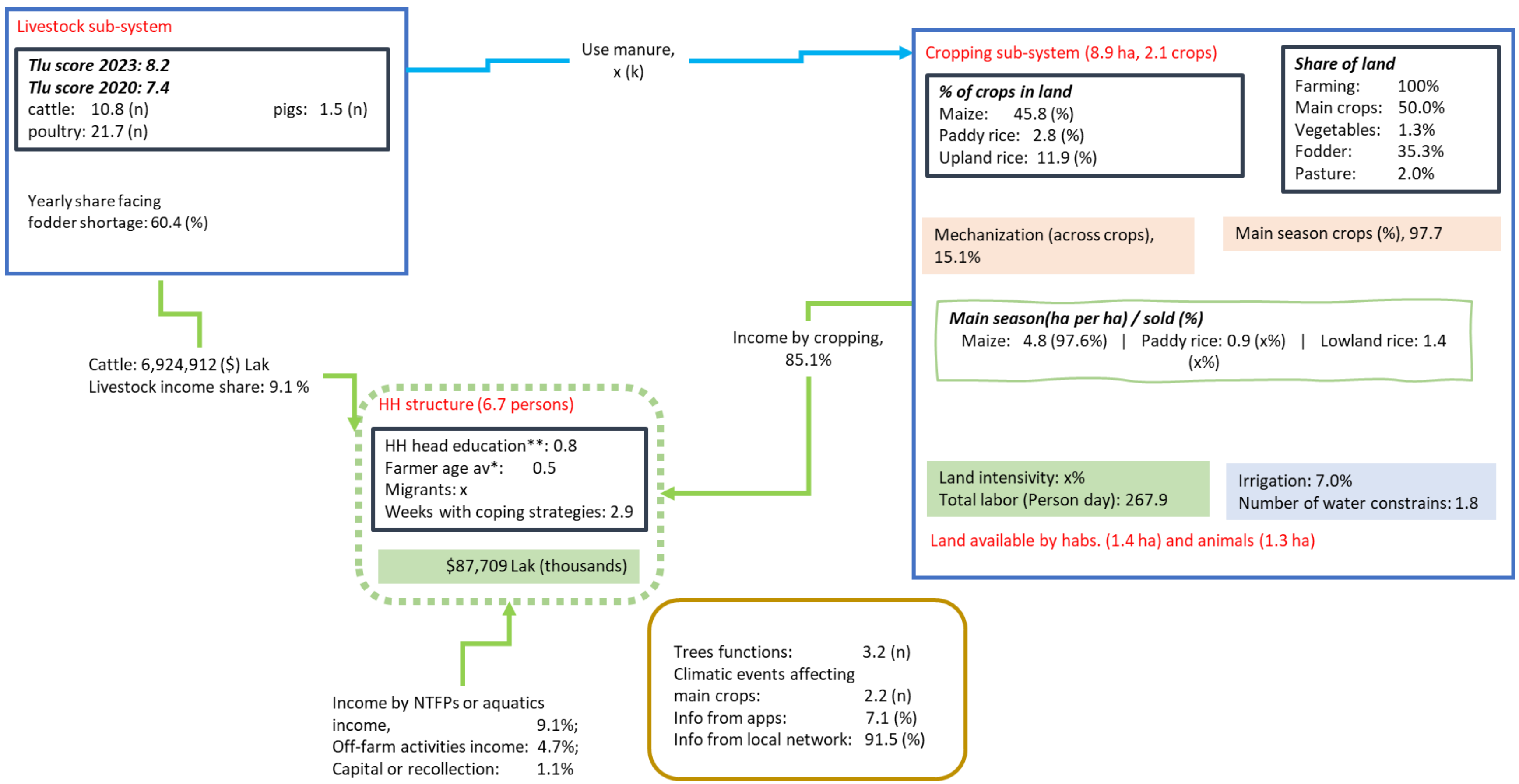


Figure 3.10 Map diagram – Type 5 farms, "High-income, diversified large farms" (57 *n* / 19.0%).

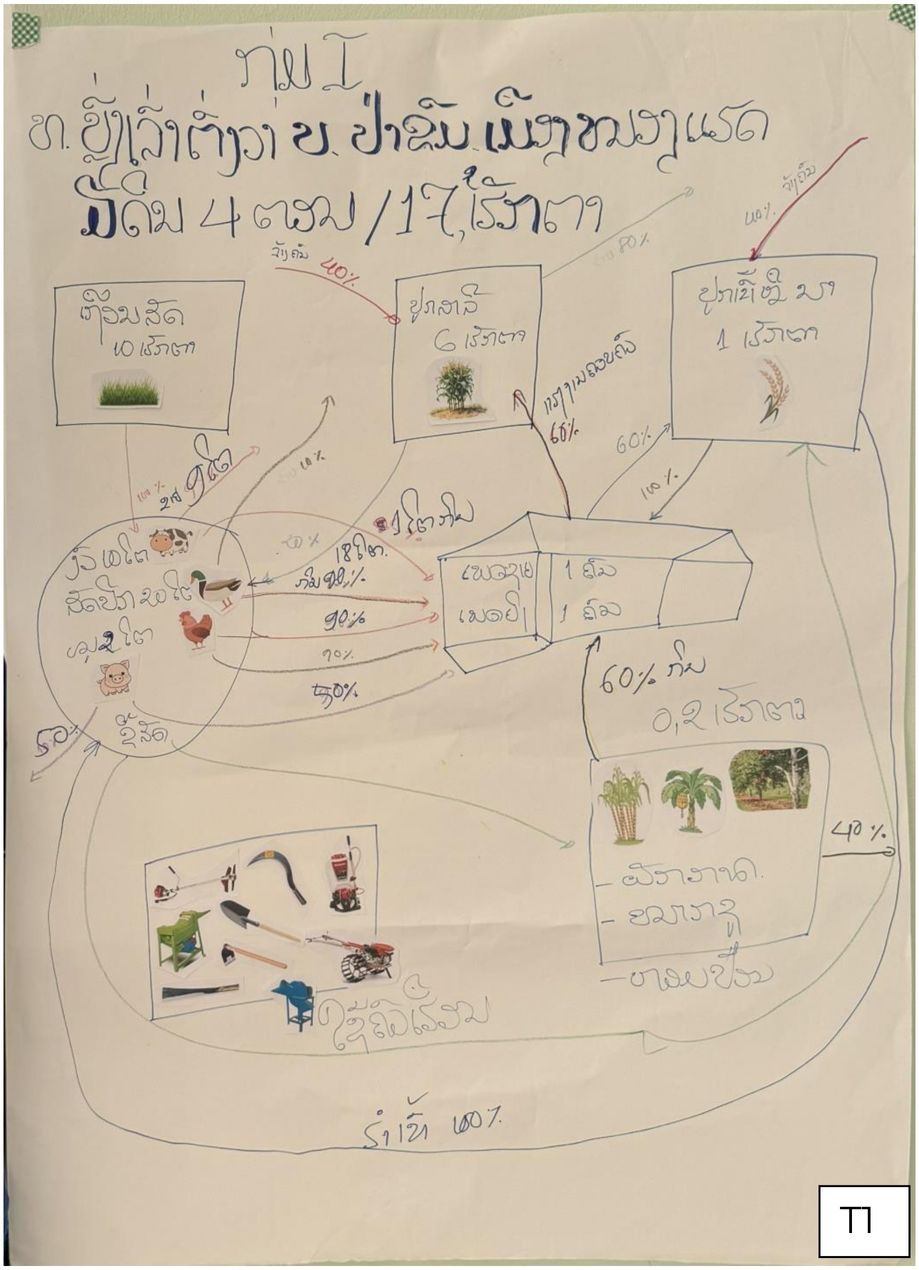
Table 3.3 Heatmap displaying farm type variables, with the variables used for PCA highlighted in grey and aligned to the right. Conversely, variables excluded during the cleaning process (through near zero analysis, correlation, and visualization) are shown in white and aligned to the left.

variable	***unit*** ***n***	***T1*** *47n* *15.7 %*	***T2*** *65n* *21.7 %*	***T3*** *60n* *20 %*	***T4*** *71n* *23.7 %*	***T5*** *57n* *19 %*	***All***
Farmer age index	index (0 18-24, 0.3 25-34, 0.6 35-44, 0.9 45-54, 1.2 55-64, 1.5>65)	0.7	0.8	0.7	0.6	0.5	0.7
Farmer education level index	index (0 none, 0.5 primary, 1 secondary, 1.5 high, 2 postgrade)	0.9	0.7	0.3	0.7	0.8	0.7
Total hh habitants	n	6.4	5.6	7.1	6.4	6.7	6.4
Women share in family members	%	48.6	45.2	46.5	44.8	45.4	45.9
Childrens (0-15) share in family members	%	28.1	24.0	24.3	38.5	36.2	30.4
Youth (15-35) share in family members	%	45.6	42.3	35.0	46.3	50.8	43.9
Time walking from HH to plot	min	73.0	61.3	30.8	55.0	103.7	63.6
Time motorbike from HH to market (for inputs)	min	30.6	49.6	14.6	64.4	139.4	60.2
Total surface in 2023	ha	10.7	2.8	4.3	3.7	8.9	5.7
Surface available per HH habitants	ha per person	1.7	0.5	0.7	0.6	1.4	0.9
Surface available per tlu 2023 score	ha per tlu	1.1	1.1	0.3	1.7	1.3	1.1
Irrigated surface share	%	9.3	41.8	4.0	1.0	7.0	12.9
Irrigated surface in 2023	ha	0.6	1.1	0.2	0.0	0.6	0.5
Total land owned in 2023	ha	10.1	3.0	4.3	3.7	9.4	5.8
General land occupancy for farming activities (no includes others) 2023	%	100.0	100.0	100.0	100.0	100.0	100.0
Land occupancy for main crops 2023	%	25.5	65.7	69.1	59.8	50.0	55.7
Land occupancy for fodder 2023	%	69.1	28.3	28.5	21.0	35.3	34.3
Land occupancy for vegetables 2023	%	0.4	1.0	0.0	0.5	1.3	0.6
Production land destined for upland rice 2023 share	%	3.5	1.5	2.4	18.8	11.9	8.0
Production land destined for paddy rice 2023 share	%	8.0	20.7	24.9	1.1	2.8	11.5
Production land destined for maize 2023 share	%	16.6	40.4	17.8	57.9	45.8	37.3
Production land destined for natural pasture 2023 share	%	32.3	15.0	6.3	5.4	2.0	11.2
Production land destined for planted pasture 2023 share	%	32.7	10.5	22.3	14.0	28.9	20.7
TLU score for 2023	score	12.40	4.80	15.50	4.60	8.20	8.70
TLU score for 2020	score	10.00	3.80	6.00	2.90	7.40	5.70
Yearly share facing fodder shortage for animals	%	50.5	25.4	36.9	29.9	60.4	39.4
Yearly share facing fodder shortage by cattle	%	35.1	21.2	36.7	25.2	40.5	31.1
Yearly share facing fodder shortage by poultry	%	14.4	1.9	0.0	3.9	19.9	7.4
Cows animals in 2023	n	15.0	6.2	21.6	6.3	10.8	11.5
Pig animals in 2023	n	2.2	1.1	0.0	0.7	1.5	1.1
Adult poultry animals in 2023	n	30.0	9.5	0.0	9.1	21.7	13.1
Number of common land services to farm	n (mx 4)	1.4	2.5	3.5	2.6	2.5	2.5
Total income generated at HH, in thousand Lak ($)	Lak ($) thousands	80,401	41,641	69,112	44,992	87,709	62,753
Cropping income share	%	53.1	57.4	91.9	84.9	85.1	75.4
Livestock income share	%	39.8	5.5	2.6	8.4	9.1	11.7
Off-Farm activities income share	%	3.5	14.4	1.7	1.2	4.7	5.2
Capital or recollection income share	%	3.6	22.7	2.1	5.5	1.1	7.4
Number of crops at main season	n	1.7	1.5	1.8	1.6	2.1	1.7
Crops share at main season	%	94.7	94.5	96.7	97.2	97.7	96.2
Summatory of nutrients sources for all crops	n	1.4	1.5	0.3	1.5	2.0	1.4
Total labor for cropping	Person day	159.1	85.7	68.5	110.1	267.9	134.3

variable	unit n	T1 47n 15.7 %	T2 65n 21.7 %	T3 60n 20 %	T4 71n 23.7 %	T5 57n 19 %	All
Average yield per season (main) for maize	Mg per ha	4.70	3.70	1.20	4.50	4.80	3.8
Average yield per season (main) for paddy rice	Mg per ha	2.10	2.80	3.50	0.30	0.90	1.9
Average yield per season (main) for upland rice	Mg per ha	0.60	0.10	0.30	1.70	1.40	0.9
Total production at 2023 of maize	Mg	5.30	3.80	1.30	4.60	4.90	3.9
Total production at 2023 of paddy rice	Mg	2.20	3.10	3.50	0.40	1.00	2.0
Total production at 2023 of upland rice	Mg	0.60	0.10	0.30	1.70	1.40	0.9
Sold share of maize	%	87.3	63.9	33.3	93.2	97.6	74.8
Income from NTFPs or aquatics collection	Lak ($)	1,400,000	2,380,308	186,667	1,939,437	712,281	1,366,733
Income from maize	Lak ($)	27,774,468	17,660,769	7,101,667	37,347,887	71,052,632	31,937,167
Income from cattle	Lak ($)	26,457,447	1,861,539	2,050,000	4,366,197	6,924,912	7,307,400
Total machines in possession related to cropping activities (other machines excluded)	n (max 11)	2.8	1.8	0.4	0.8	2.0	1.50
Total use of services in possession relates to cropping activities (other machines excluded)	n (max 11)	2.0	2.6	1.9	1.6	1.8	2.00
Personal use vehicles (motor and human force)	n (max 4)	1.5	1.1	1.2	1.0	1.3	1.20
Average mechanization across subsystems crops	%	13.9	9.3	7.9	14.6	15.1	12.10
Average mechanization for cropping activities, lowland rice	%	31.6	32.8	20.3	4.7	15.5	20.20
Average mechanization for cropping activities, maize	%	57.1	34.4	6.7	71.6	59.4	45.90
Average mechanization for cropping activities, upland rice	%	16.7	5.9	3.1	32.9	44.2	20.70
Machinery requirement number of motives	n (max 5)	1.3	1.3	1.8	1.1	1.4	1.40
Number of functions provided by trees at farm	n (max 6)	2.8	1.4	1.4	2.8	3.2	2.30
Number of water constrains to access to irrigation	n (max 8)	2.5	2.2	2.2	1.3	1.8	2.00
Number of watering sources	n (max 7)	1.1	1.3	0.9	0.8	1.1	1.00
Number of irrigation types within HH	n (max 6)	1.0	1.1	0.8	0.6	1.0	0.90
Amount of climatic events affecting main crops	n (max 5)	1.3	1.2	0.6	1.5	2.2	1.30
Amount of climatic events affecting other crops	n (max 5)	0.5	0.5	0.0	0.5	1.5	0.60
Amount of reasons for decline crops/animals at 2024	n (max 8)	1.5	0.8	0.0	0.4	2.0	0.90
Amount of reasons to try a new crop or animal	n (max 8)	2.1	2.8	0.1	1.3	3.0	1.80
Information obtained from Apps, share	%	11.6	6.6	32.2	5.2	7.1	12.30
Information obtained from local network, share	%	80.5	82.2	63.6	91.5	91.5	82.20
Food bought per year share, rice	%	21.8	29.0	8.9	44.1	20.3	25.80
Food bought per year share, meat	%	34.2	49.0	51.9	27.9	36.3	39.90
Food bought per year share, fish	%	27.6	38.7	19.4	22.7	23.4	26.40
Food bought per year share, fruit	%	21.5	33.7	20.3	15.5	28.7	23.80
Food bought per year share, vegetables	%	14.0	31.6	6.7	14.5	17.9	17.20
Months with copping practices in the last year	n	2.3	6.2	0.9	2.3	2.9	3.00

Note: The heatmap is based on 3-colour scale for numerical values for each variable, with green for the larger value and red for lowest, to facilitate visual analysis. For deeper analysis in important to evaluate the larger distances between values as a broad description.

3.3 Participatory validation of the farm types

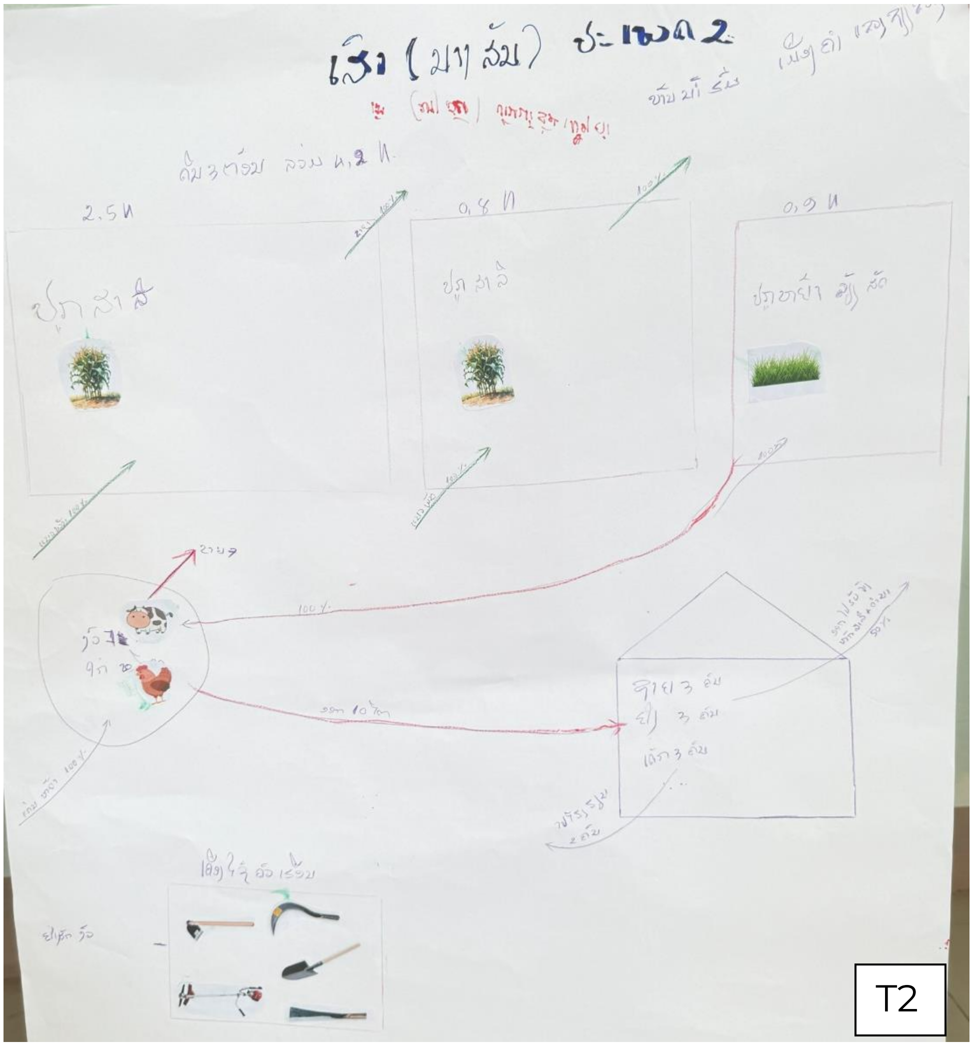


They have large land more than other farmer type around 50%, Smallest 8HT and biggest 46 HT.

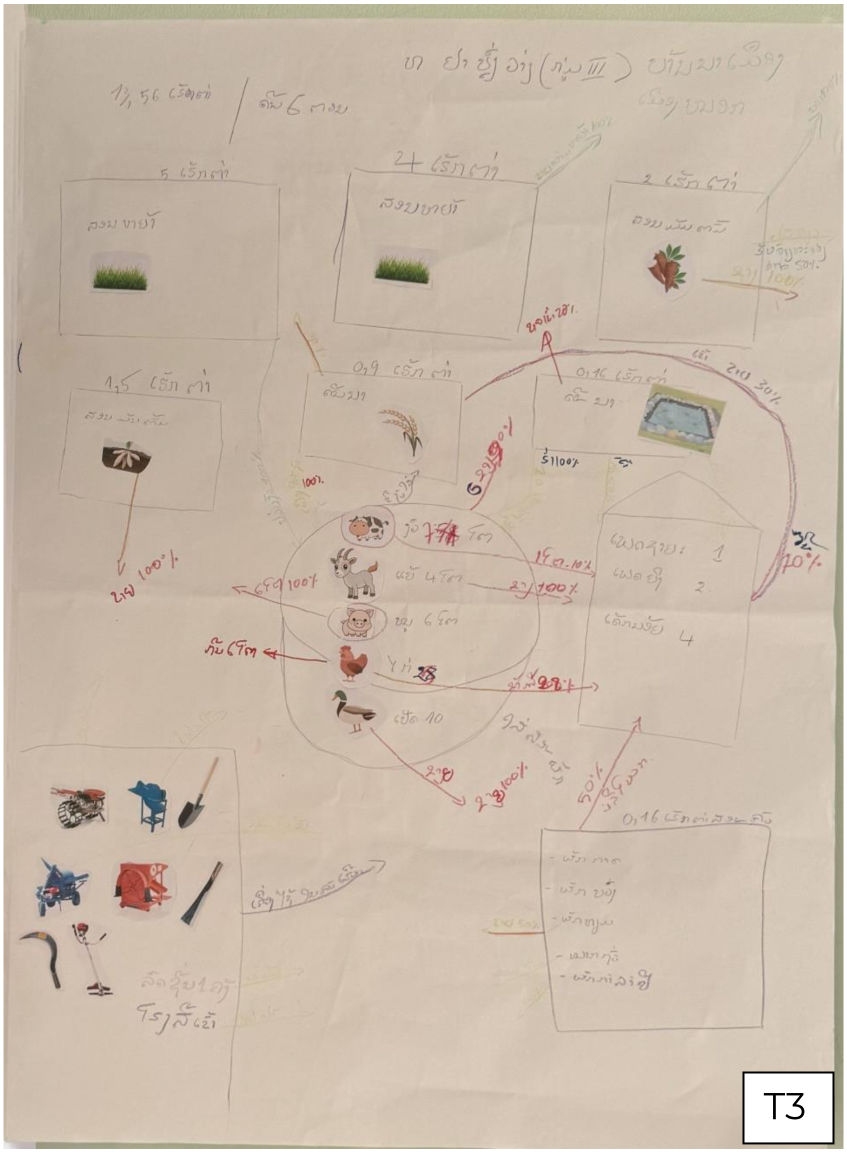
Popular crops are Maize and grass, More than 90% sell maize and more than 90% for grass feed cattle

Main income from Maize, cattle and some for Home-garden

Only one farmer type that can sell vegetables from home- garden around 40% of total productions

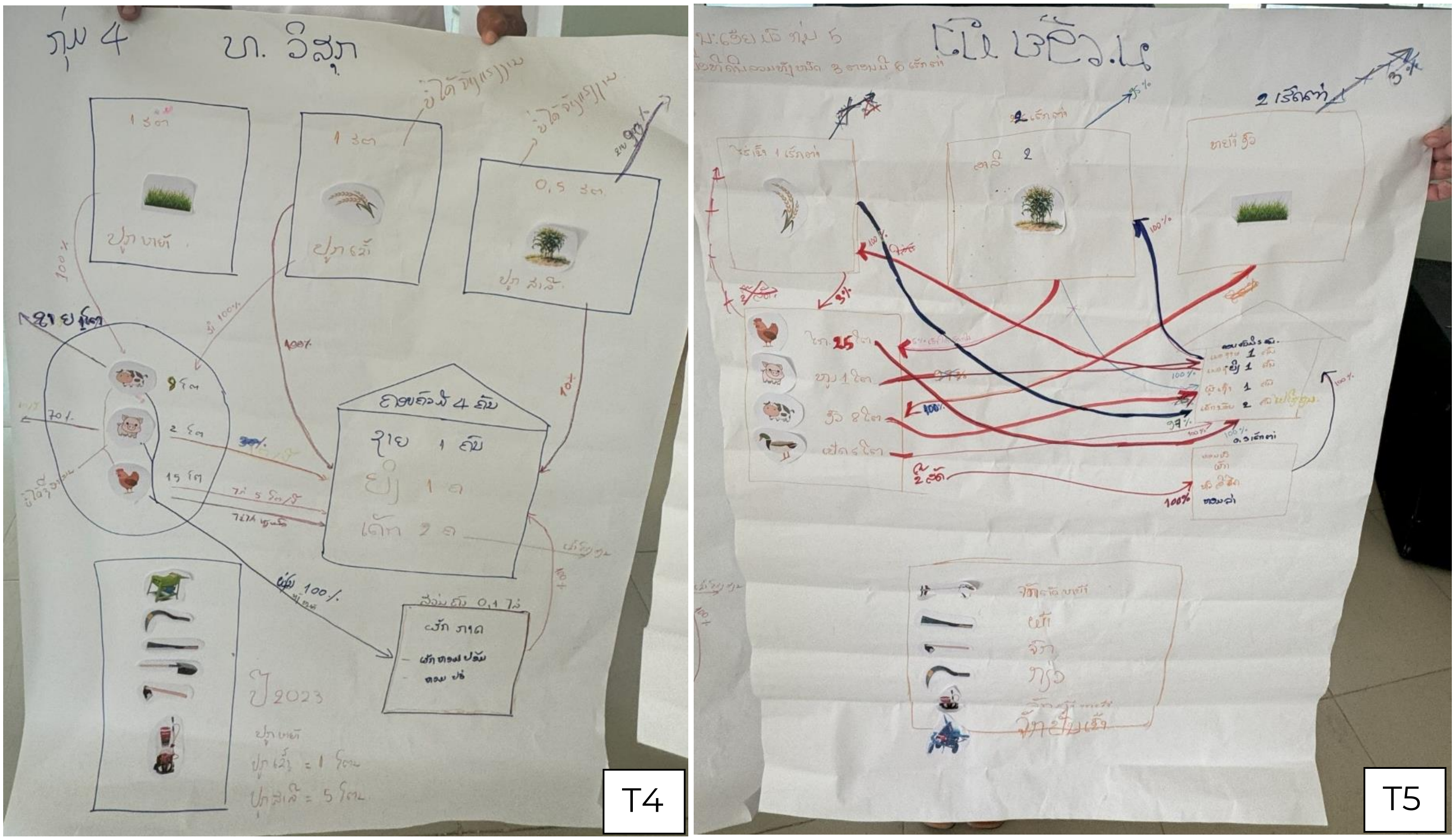


Farmer type 2 land are same farmer 3,4,5, Average around 4 HT per Household
Popular crops are Maize and garlic, more than 90% for sell
This farmer type there are most members household around 34% of total 5 types, and women 35% of total 5 type



T3

Popular crops are rice, cassava and grass for forage (90% sell cassava)
Average 50% livestock farming are sold
Farmer type 3 same farmer type 4 and 5 that go out for lobor around 20%-30% per year



Fram type 4 and 5:

Planted many crops but not too big such as: Rice vegetable, maize, grass. Because they have little lands so 100% manure was used within their household

4 Preliminary conclusions

Small scale farming systems are often complex combining several farm (e.g. crop, livestock, aquaculture) and non-farm activities for the livelihood of rural families. This complexity often generates, within the same region or agroecological zone, a large diversity of farming systems with, for example, different levels of specialisation on certain crops and/or livestock activities, differences in the reliance on farming and non-farming activities for the generation of income or differences in the labour engagement for the different activities carried out by the household.

Capturing such diversity and complexity of farming systems is an essential step towards developing suitable (baskets of) socio-technical innovation bundles (Barret, et al, 2022) that i) address the main challenges for the sustainability of specific types of farming systems and ii) identify distinctive (best fit) opportunities and entry points for improving their performance. Not all farmers are the same and no innovation is a best fit for all farmers.

In this analysis we have identified five relatively homogeneous and significantly different types of farming systems for three districts of Xiengkhouang Province based on a survey applied to 300 farm households in Kham (123), Moke (100) and Nonghet (99) districts: Type 1 (T1) – Agroclimatic resilience livestock-cropping farms; Type 2 (T2) – High-Intensivity paddy-rice cropping systems with food insecurity; Type 3 (T3) – Vulnerable paddy-rice smallholders; Type 4 (T4) – Climate-adapted maize-paddy smallholders units; and Type 5 (T5) – Integrated food security ventures.

For each of these farm household types we have identified their distinctive features, the main components of the farming systems and their relative importance, as well as some internal and external flows. This systemic characterization of the diversity of farming systems in Kham, Moke, and Nonghet districts can be conceived as a first step toward the analysis and design of more sustainable Mixed Farming Systems in Xiengkhouang Province.

In the OneCGIAR SI-MFS initiative the DEED framework has been adopted for the co-design of more sustainable MFS. The DEED framework encompasses a series of phases for systems analysis and co-design (Describe, Explain, Explore, and Design) (Giller et al., 2011). The definition of farm typologies is part of the “Describe” phase of this framework.

Based on this typology developed for Lao´s PDR, further analysis of the detailed dataset for the different types as well as focus group discussions (FGD) and semi-structured interviews, would allow to identify the main limitations and inefficiencies for different types of farming systems, their differentiated priorities and indicators of success and allow to evaluate their performance through multi-criteria assessment. For example:

Type 1 farms (agroclimatic resilience livestock-cropping farms), could be reached through innovations, specifically for cropping mechanization for dual purpose, considering human and animal needs, and income requirements, especially to enhance food security through diversification in diet.

Type 2 farms (high-Intensivity paddy-rice cropping systems with food insecurity), they are mature families with food insecurity, with low labour and vehicles access, and some innovations focused on labour reduction and recycling. The innovations need to be sensitive to low land/income restrictions.

Type 3 farms (vulnerable paddy-rice smallholders), Some important innovations can be yield increasing with double purpose for animals and water efficiency; are the larger families with access to internet information but need diversify vegetables for family.

Type 4 farms (climate-adapted maize-paddy smallholders units), some animals can be introduced under dual purpose crops, putting some efforts in maize efficiency production with restrained income, are youths with local network for information access.

Type 5 farms (integrated food security ventures), they seems to need rice and fodder efficiency under water constrains, specially interested in convert crops and animals, are young families with local network.

Formalising these hypotheses and assessing specific process trough empirical or analytical pathways would need to be carried out during the Explain phase of the DEED cycle.

Exploring the potential effect of specific socio-technical innovation bundles for different types of farm households would allow to identify type-specific areas of improvement and identify potential trade-offs and synergies that need to be addressed or exploited in the process of co-design of more sustainable MFS. Such trade-off and synergies would be different for different farm types and will delimit their specific window of opportunities for improving systems performance and will inform the most promising pathways for successful co-design. Finally, based on action research and informed by previous phases of the DEED cycle, novel practices and systems configurations can be designed, suitable for different types of farming systems and engage in a process of co-innovation where farmers and researchers put together their learning tools to improve the sustainability of mixed farming systems.

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6 Annexes

Table 6.1 Description of the structural variables used for this farm typology analysis.

Variable	Unit	Description
Farmer age index	index (0 18-24, 0.3 25-34, 0.6 35-44, 0.9 45-54, 1.2 55-64, 1.5>65)	
Farmer education level index	index (0 none, 0.5 primary, 1 secondary, 1.5 high, 2 postgrade)	
Total hh habitants	N	
Women share in family members	%	
Childrens (0-15) share in family members	%	
Youth (15-35) share in family members	%	
Time walking from HH to plot	min	
Time motorbike from HH to market (for inputs)	min	
Total surface in 2023	ha	
Surface available per HH habitants	ha per person	
Surface available per tlu 2023 score	ha per tlu	
Irrigated surface share	%	
Irrigated surface in 2023	ha	
Total land owned in 2023	ha	
General land occupancy for farming activities (no includes others) 2023	%	
Land occupancy for main crops 2023	%	
Land occupancy for fodder 2023	%	
Land occupancy for vegetables 2023	%	
Production land destined for upland rice 2023 share	%	
Production land destined for paddy rice 2023 share	%	
Production land destined for maize 2023 share	%	
Production land destined for natural pasture 2023 share	%	
Production land destined for planted pasture 2023 share	%	
Production land destined for vegetables 2023 share	%	
TLU score for 2023	score	
TLU score for 2020	score	
TLU score difference between 2020/23	score	
Yearly share facing fodder shortage for animals	%	
Yearly share facing fodder shortage by cattle	%	
Yearly share facing fodder shortage by poultry	%	
Cows animals in 2023	n	
Pig animals in 2023	n	
Adult poultry animals in 2023	n	
Number of common land services to farm	n (mx 4)	
Total income generated at HH, in thousand Lak ($)	Lak ($) thousands	
Cropping income share	%	
Livestock income share	%	
Off-Farm activities income share	%	
Capital or recollection income share	%	
Number of crops at main season	n	
Crops share at main season	%	
Summatory of nutrients sources for all crops	n	
Total labor for cropping	Person day	
Average yield per season (main) for maize	Mg per ha	
Average yield per season (main) for paddy rice	Mg per ha	
Average yield per season (main) for upland rice	Mg per ha	
Total production at 2023 of maize	Mg	
Total production at 2023 of paddy rice	Mg	
Total production at 2023 of upland rice	Mg	
Sold share of maize	%	
Income from NTFPs or aquatics collection	Lak ($)	
Income from maize	Lak ($)	
Income from cattle	Lak ($)	
Total machines in possession related to cropping activities (other machines excluded)	n (max 11)	
Total use of services in possession relates to cropping activities (other machines excluded)	n (max 11)	
Personal use vehicles (motor and human force)	n (max 4)	
Average mechanization across subsystems crops	%	
Average mechanization for cropping activities, lowland rice	%	
Average mechanization for cropping activities, maize	%	
Average mechanization for cropping activities, upland rice	%	
Machinery requirement number of motives	n (max 5)	
Number of functions provided by trees at farm	n (max 6)	
Number of water constrains to access to irrigation	n (max 8)	
Number of watering sources	n (max 7)	
Number of irrigation types within HH	n (max 6)	
Amount of climatic events affecting main crops	n (max 5)	
Amount of climatic events affecting other crops	n (max 5)	
Amount of reasons for decline crops/animals at 2024	n (max 8)	
Amount of reasons to try a new crop or animal	n (max 8)	
Information obtained from Apps, share	%	
Information obtained from local network, share	%	
Food bought per year share, rice	%	

Variable	Unit	Description
Food bought per year share, meat	%	
Food bought per year share, fish	%	
Food bought per year share, fruit	%	
Food bought per year share, vegetables	%	
Months with copping practices in the last year	n	

NB: The information used for this analysis, has been anonymized as per CIMMYT-IREC protocols and can be accessed in the CKAN repository:

https://doi.org/10.25502/0APF-2230/D

Table 6.2 Variables included for analysis.

Unit	Variable	Mean	Median	St dev
index (0 18-24, 0.3 25-34, 0.6 35-44, 0.9 45-54, 1.2 55-64, 1.5>65)	Farmer age index	0.68	0.60	0.33
index (0 none, 0.5 primary, 1 secondary, 1.5 high, 2 postgrade)	Farmer education level index	0.68	0.50	0.51
n	Total hh habitants	6.44	6.00	2.43
%	Women share in family members	45.90	44.44	14.50
%	Childrens (0-15) share in family members	30.44	28.57	18.50
%	Youth (15-35) share in family members	43.91	42.86	18.43
min	Time walking from HH to plot	63.58	60.00	52.16
min	Time motorbike from HH to market (for inputs)	60.21	40.00	61.29
ha	Total surface in 2023	5.73	4.00	5.51
ha per person	Surface available per HH habitants	0.94	0.67	0.88
ha per tlu	Surface available per tlu 2023 score	1.13	0.69	1.99
%	Irrigated surface share	12.85	0.00	24.95
ha	Irrigated surface in 2023	0.50	0.00	1.04
ha	Total land owned in 2023	5.76	4.00	5.60
%	General land occupancy for farming activities (no includes others) 2023	100.00	100.00	0.00
%	Land occupancy for main crops 2023	55.71	52.12	28.44
%	Land occupancy for fodder 2023	34.34	33.33	28.31
%	Land occupancy for vegetables 2023	0.63	0.00	2.06
%	Production land destined for upland rice 2023 share	8.03	0.00	13.93
%	Production land destined for paddy rice 2023 share	11.53	0.00	17.02
%	Production land destined for maize 2023 share	37.32	34.10	30.06
%	Production land destined for natural pasture 2023 share	11.23	0.00	20.93
%	Production land destined for planted pasture 2023 share	20.68	13.29	23.24
%	Production land destined for vegetables 2023 share	0.57	0.00	1.79
score	TLU score for 2023	8.73	6.50	8.53
score	TLU score for 2020	5.66	4.38	5.88
score	TLU score difference between 2020/23	180.68	132.97	337.27
%	Yearly share facing fodder shortage for animals	39.36	33.33	21.71
%	Yearly share facing fodder shortage by cattle	31.08	33.33	14.13
%	Yearly share facing fodder shortage by poultry	7.36	0.00	13.03
n	Cows animals in 2023	11.53	9.00	11.52
n	Pig animals in 2023	1.05	0.00	1.91
n	Adult poultry animals in 2023	13.09	10.00	15.81
n (mx 4)	Number of common land services to farm	2.54	3.00	1.36
Lak ($) thousands	Total income generated at HH, in thousand Lak ($)	62,753.45	48,000.00	57,908.60
%	Cropping income share	75.40	90.91	31.17
%	Livestock income share	11.67	0.00	21.58
%	Off-Farm activities income share	5.19	0.00	13.55
%	Capital or recollection income share	7.41	0.00	20.67
n	Number of crops at main season	1.73	2.00	0.52
%	Crops share at main season	96.21	100.00	14.97
n	Summatory of nutrients sources for all crops	1.36	1.00	0.91
Person day	Total labor for cropping	134.31	108.00	96.83
Mg per ha	Average yield per season (main) for maize	3.76	4.00	2.81
Mg per ha	Average yield per season (main) for paddy rice	1.88	0.00	2.57
Mg per ha	Average yield per season (main) for upland rice	0.86	0.00	1.42
Mg	Total production at 2023 of maize	3.91	4.00	2.78
Mg	Total production at 2023 of paddy rice	1.98	0.00	2.56
Mg	Total production at 2023 of upland rice	0.86	0.00	1.42
%	Sold share of maize	74.83	100.00	40.83
Lak ($)	Income from NTFPs or aquatics collection	1,366,733.33	0.00	4,131,824.61
Lak ($)	Income from maize	31,937,166.67	23,500,000.00	35,390,428.78
Lak ($)	Income from cattle	7,307,400.00	0.00	17,233,457.00
n (max 11)	Total machines in possession related to cropping activities (other machines excluded)	1.48	1.00	1.41
n (max 11)	Total use of services in possession relates to cropping activities (other machines excluded)	1.97	2.00	1.23
n (max 4)	Personal use vehicles (motor and human force)	1.19	1.00	0.53
%	Average mechanization across subsystems crops	12.09	12.04	7.04
%	Average mechanization for cropping activities, lowland rice	20.17	0.00	27.50
%	Average mechanization for cropping activities, maize	45.94	66.67	33.63
%	Average mechanization for cropping activities, upland rice	20.67	0.00	30.00
n (max 5)	Machinery requirement number of motives	1.39	1.00	0.67
n (max 6)	Number of functions provided by trees at farm	2.30	2.00	1.60
n (max 8)	Number of water constrains to access to irrigation	1.96	2.00	1.40
n (max 7)	Number of watering sources	1.03	1.00	0.55
n (max 6)	Number of irrigation types within HH	0.87	1.00	0.50
n (max 5)	Amount of climatic events affecting main crops	1.34	1.50	0.91
n (max 5)	Amount of climatic events affecting other crops	0.61	0.00	0.88
n (max 8)	Amount of reasons for decline crops/animals at 2024	0.87	0.00	1.47
n (max 8)	Amount of reasons to try a new crop or animal	1.84	2.00	1.56
%	Information obtained from Apps, share	12.26	0.00	25.86
%	Information obtained from local network, share	82.20	100.00	28.03
%	Food bought per year share, rice	25.76	0.00	36.35
%	Food bought per year share, meat	39.89	40.00	23.68
%	Food bought per year share, fish	26.42	20.00	21.78
%	Food bought per year share, fruit	23.82	20.00	22.71
%	Food bought per year share, vegetables	17.17	10.00	21.33
n	Months with copping practices in the last year	2.98	2.00	3.02

Table 6.3 Variable’s weights across components.

Variable	***Comp1***	***Comp2***	***Comp3***	***Comp4***	***Comp5***	***Comp6***	***Comp7***	***Comp8***	***Comp9***	***Comp 10***	***Comp11***	***Comp 12***	***Comp 13***	***Comp 14***	***Comp 15***
Farmer age index	0.18	-0.24	0.06	0.15	0.27	-0.13	-0.25	0.31	-0.18	0.33	-0.13	0.18	0.35	-0.18	0.1
Farmer education level index	-0.31	0.03	0.22	-0.14	-0.21	0.07	0.23	-0.35	0.1	-0.07	-0.04	-0.31	-0.32	0.08	-0.17
Total hh habitants	-0.13	-0.28	-0.23	0.07	0.09	0.2	0.08	0.41	-0.01	-0.13	-0.28	0.04	0.15	-0.11	0
Women share in family members	0.02	0	0.01	0.22	-0.15	-0.12	-0.02	0.09	0.19	-0.06	-0.08	-0.02	-0.02	0.29	0.47
Childrens (0-15) share in family members	-0.23	0.24	-0.04	-0.08	-0.35	0.08	0.25	-0.07	0.43	0.1	-0.19	-0.01	0.12	0.3	-0.21
Youth (15-35) share in family members	-0.23	0.12	-0.03	-0.02	0.05	-0.07	-0.48	-0.01	-0.28	-0.22	0.21	0.02	-0.43	-0.1	0.32
Time walking from HH to plot	-0.45	0.02	0.15	-0.11	0.28	0.12	0.33	-0.1	0.06	0.07	-0.25	0.2	-0.05	-0.13	-0.11
Time motorbike from HH to market (for inputs)	-0.47	0.38	-0.11	0.16	0.25	-0.17	0.29	0.12	-0.06	-0.08	0.21	0.02	-0.15	-0.05	-0.03
Total surface in 2023	-0.58	-0.48	-0.05	0.12	-0.17	0.22	0.01	0	-0.09	-0.03	0.01	0.22	-0.11	0.04	0.18
Surface available per tlu 2023 score	-0.16	0.21	0.11	-0.23	-0.08	0.22	0.15	-0.01	-0.01	0.26	-0.09	-0.01	-0.08	0.27	0.41
Irrigated surface share	0.17	0.15	0.53	0.32	0.09	0.06	0.04	0.14	-0.14	-0.37	0.1	-0.15	-0.03	0.04	-0.13
Land occupancy for main crops 2023	0.41	0.59	-0.07	0.4	0.01	0.2	-0.08	0.06	0.18	-0.08	-0.24	-0.2	-0.03	-0.12	0.09
Land occupancy for vegetables 2023	-0.15	0.03	0.2	-0.18	0.16	0.13	-0.29	0.3	0.36	-0.07	0.03	0.08	-0.02	0.21	0.09
Production land destined for paddy rice 2023 share	0.5	-0.21	0.19	0.42	0.24	0.07	-0.05	-0.27	0.12	-0.01	-0.05	-0.22	0.01	-0.03	0.01
Production land destined for maize 2023 share	-0.14	0.83	-0.02	0.23	-0.18	0	-0.1	0.11	0.07	-0.02	-0.15	-0.05	-0.03	-0.11	0.07
Production land destined for natural pasture 2023 share	-0.13	-0.39	0.39	-0.24	-0.13	0.12	-0.12	-0.38	-0.37	-0.13	-0.17	0.24	0.11	0.06	0.09
Production land destined for planted pasture 2023 share	-0.17	-0.46	-0.14	0.08	-0.15	-0.28	0.18	0.32	0.17	0.17	0.48	-0.05	0.08	0.03	-0.06
TLU score for 2023	0.03	-0.67	-0.29	0.3	-0.19	0.07	0.09	0.16	-0.08	-0.19	-0.12	-0.03	-0.11	-0.01	-0.04
TLU score for 2020	-0.28	-0.57	-0.01	0.4	-0.19	-0.01	0.04	0.09	-0.13	-0.06	-0.16	-0.14	-0.17	0.05	-0.03
TLU score difference between 2020/23	0.05	0.04	0.02	-0.11	-0.01	-0.31	0.02	-0.28	0.27	-0.33	-0.08	0.45	0.17	0.01	0.17
Yearly share facing fodder shortage for animals	-0.52	-0.35	-0.06	-0.05	-0.09	0.39	-0.03	-0.2	0.13	0.07	0.16	0.08	0.16	-0.08	0.06
Adult poultry animals in 2023	-0.59	-0.27	0.28	-0.13	-0.15	0.13	-0.07	-0.11	0.15	0.08	0.04	-0.02	-0.02	-0.21	-0.04
Number of common land services to farm	0.26	-0.09	-0.34	-0.14	0.49	0.09	0.1	-0.1	0.19	-0.06	-0.24	0.06	-0.12	-0.12	-0.09
Total income generated at HH, in thousand Lak ($)	-0.36	-0.42	-0.21	0.16	-0.08	0.09	0.17	0.28	0.07	-0.35	-0.24	0.06	-0.07	-0.1	0.07
Cropping income share	0.01	0.37	-0.57	0.23	-0.1	0.52	-0.05	-0.11	-0.1	-0.06	0.11	-0.03	0.16	0.01	-0.03
Livestock income share	-0.28	-0.44	0.22	0.04	-0.3	-0.46	0.02	-0.01	-0.19	0.04	-0.07	-0.12	0.08	0.08	0
Off-Farm activities income share	0.09	0.02	0.38	0.02	0.1	-0.27	0.09	-0.01	0.4	-0.4	0	0.32	-0.02	0.03	0.06
Capital or recollection income share	0.18	-0.1	0.37	-0.4	0.41	-0.13	0.02	0.21	0.08	0.31	-0.09	-0.01	-0.3	-0.09	0
Number of crops at main season	-0.32	-0.09	-0.37	0.39	0.36	-0.06	0.18	-0.11	-0.07	0.17	-0.11	0.15	-0.13	0.4	0
Summatory of nutrients sources for all crops	-0.6	0.1	0.09	-0.07	0.35	0	0.09	-0.04	-0.25	-0.22	0	-0.15	0.13	0.22	-0.04
Total labor for cropping	-0.73	-0.09	-0.18	0.14	0.24	0.06	0.15	0.09	-0.01	0.09	0.11	-0.06	-0.08	0.07	0.13
Average yield per season (main) for maize	-0.45	0.36	0.12	0.27	0	-0.26	0.14	-0.08	-0.24	0.11	-0.16	-0.01	0.18	-0.09	0.05
Average yield per season (main) for paddy rice	0.34	-0.36	0.17	0.54	0.18	-0.09	0.08	-0.03	0.15	0.17	0.01	-0.06	-0.11	0.2	0.04
Average yield per season (main) for upland rice	-0.3	0.23	-0.44	-0.3	0.26	-0.06	-0.12	-0.02	-0.26	-0.03	-0.01	0.24	-0.21	0.21	-0.26
Sold share of maize	-0.52	0.5	0.01	0.26	-0.11	-0.31	0.06	-0.12	-0.02	0.22	-0.1	0.08	0.08	-0.08	0.11
Income from maize	-0.68	0.23	-0.18	0.19	0.04	0.15	0.02	0.11	0.08	-0.1	-0.06	0.05	-0.03	-0.27	0.06
Total machines in possession related to cropping activities (other machines excluded)	-0.44	-0.33	0.45	0.15	0.12	-0.16	0.09	-0.01	0.1	0	-0.08	-0.14	0.05	-0.25	-0.09
Total use of services in possession relates to cropping activities (other machines excluded)	-0.02	-0.18	0.22	0.09	0.3	0.28	-0.24	-0.08	-0.05	0.11	-0.23	-0.1	0.24	0.22	0.02
Average mechanization across subsystems crops	-0.48	-0.03	-0.09	-0.01	0.04	-0.14	-0.48	0.18	0.09	-0.14	-0.09	-0.06	0.11	0.31	-0.31
Average mechanization for cropping activities, maize	-0.58	0.37	0	0.08	-0.18	-0.31	-0.38	0.07	0.02	-0.01	-0.21	-0.1	0.1	0.06	-0.14
Machinery requirement number of motives	0.16	0.06	-0.09	0.41	-0.03	0.1	0.16	0.03	-0.03	0.04	0.34	0.39	0.19	0.01	-0.18
Number of functions provided by trees at farm	-0.51	-0.19	-0.18	-0.24	-0.04	0.01	-0.38	0.09	0.24	0.12	-0.05	0.02	-0.06	-0.16	-0.11
Number of water constrains to access to irrigation	0.04	-0.2	0.15	0.44	-0.06	0.07	-0.32	-0.45	0.03	0.07	0	0.18	-0.11	-0.06	-0.21
Number of irrigation types within HH	-0.06	-0.08	0.26	0.56	0.22	0.09	-0.36	-0.03	0.19	0.07	0.15	0.12	-0.14	0.05	-0.04
Amount of climatic events affecting main crops	-0.51	0.33	-0.03	0.27	0.23	-0.17	0.03	-0.27	0.06	0.01	0.17	-0.03	0.02	-0.1	0.04
Amount of climatic events affecting other crops	-0.57	-0.03	0.09	-0.1	0.06	0.25	-0.13	-0.07	0.27	0.07	0.28	-0.12	0.1	0	0.12
Amount of reasons to try a new crop or animal	-0.53	0.01	0.57	-0.05	0.23	0.21	0.1	0.06	0	-0.01	-0.03	-0.09	0.08	-0.04	0.03
Food bought per year share, fish	0.02	0.24	0.5	0.17	-0.28	0.23	0.08	0.15	-0.13	0.25	-0.15	0.34	-0.21	-0.01	-0.1
Food bought per year share, vegetables	-0.01	0.37	0.48	0.11	-0.28	0.19	0.01	0.38	-0.05	0.09	0.02	0.23	-0.22	0.1	-0.14
Months with copping practices in the last year	-0.01	0.24	0.58	-0.09	0.14	0.21	0.12	0.19	-0.2	-0.26	0.23	-0.03	0.24	0.11	-0.03

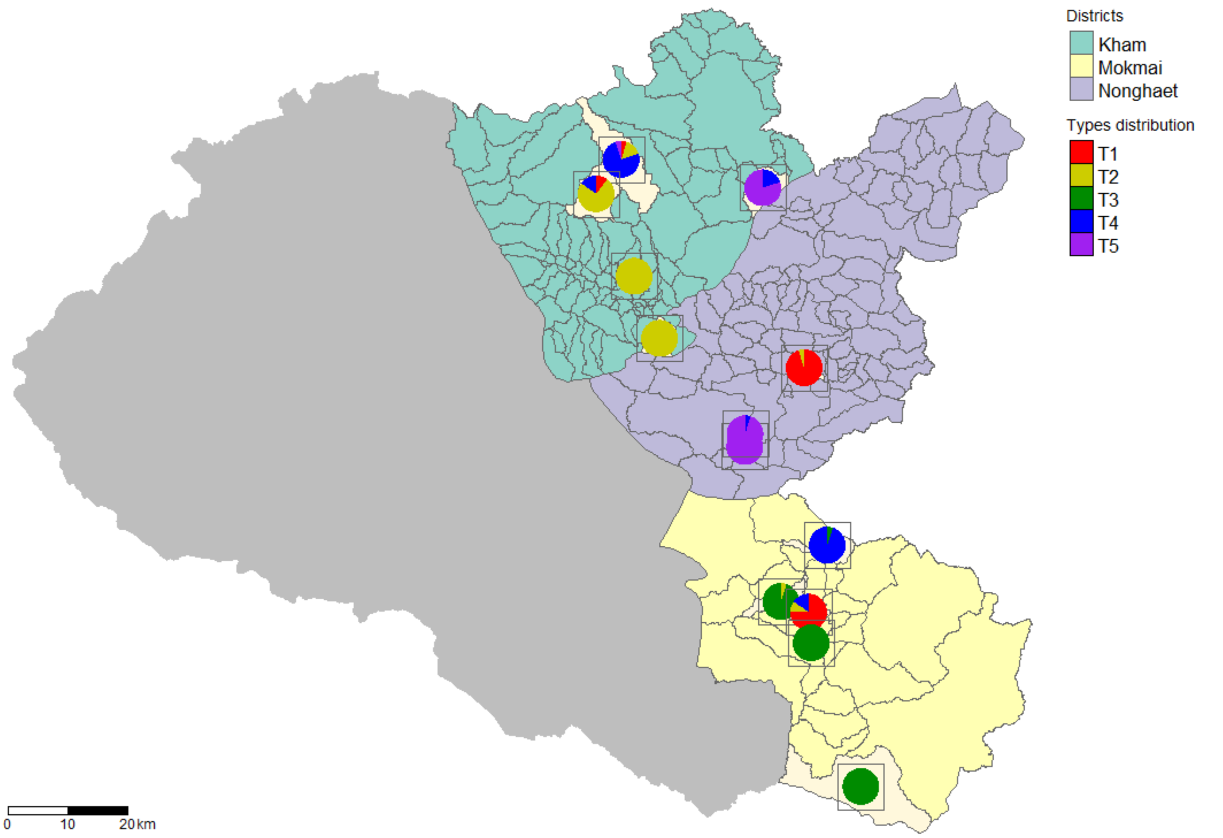

Figure 6.1 Farm type distribution across the survey locations in Kham, Moke and Nonghet districts at Xiengkhouang Province. **T1** – Agroclimatic resilience livestock-cropping farms; **T2** – High-intensity paddy-rice cropping systems with food insecurity; **T3** – Vulnerable paddy-rice smallholdings; **T4** – Climate-adapted maize-paddy smallholders units, and **T5** – Integrated food security ventures.

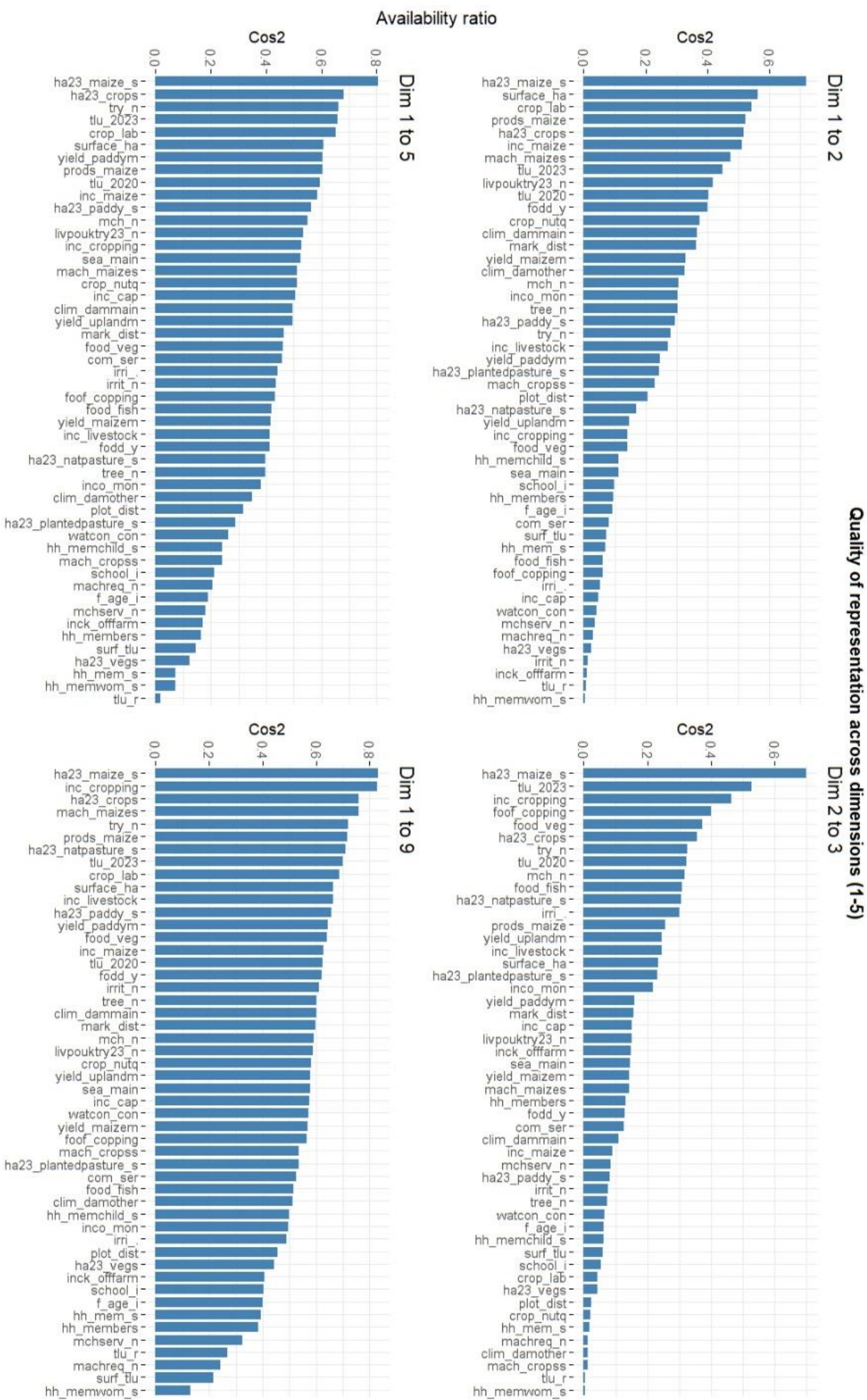

Figure 6.2 Relative contribution per variable across selected dimensionalities.

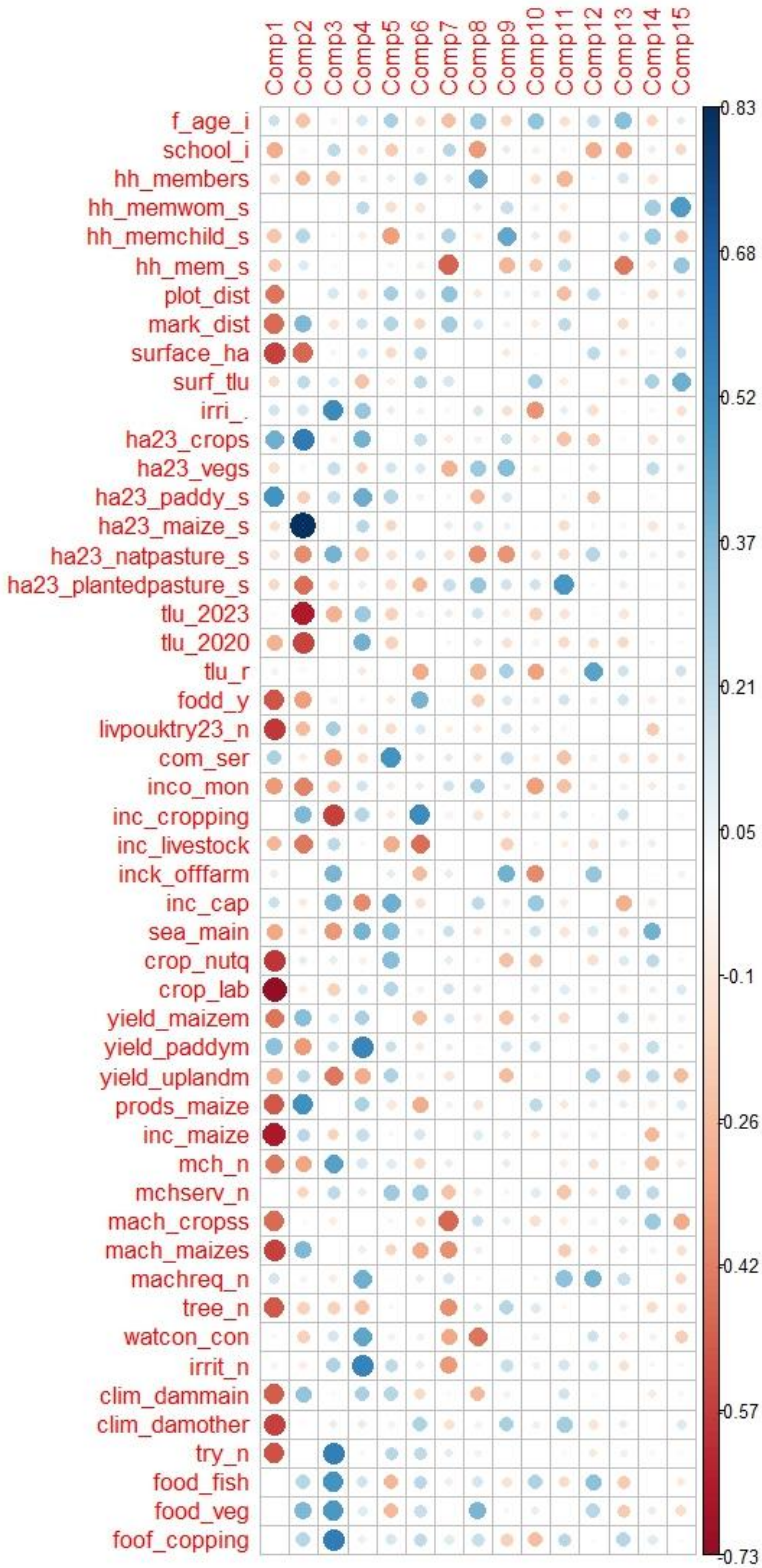

Figure 6.3 Correlation Pearson’s matrix for variables VS general dimensionalities.

Table 6.4: Bonferroni test result to show significant differences between farm type definitory variables.

variables	***T1***	***T2***	***T3***	***T4***	***T5***
Farmer age index	a	a	a	ab	b
Farmer education level index	a	a	b	a	a
Total hh habitants	ab	b	a	ab	ab
Women share in family members	a	a	a	a	a
Childrens (0-15) share in family members	bc	c	c	a	ab
Youth (15-35) share in family members	a	ab	b	a	a
Time walking from HH to plot	b	b	c	b	a
Time motorbike from HH to market (for inputs)	c	b	d	b	a
Total surface in 2023	a	c	bc	b	a
Surface available per tlu 2023 score	ab	b	c	ab	a
Irrigated surface share	b	a	cd	d	bc
Land occupancy for main crops 2023	c	a	a	ab	b
Land occupancy for vegetables 2023	b	bc	c	bc	a
Production land destined for paddy rice 2023 share	b	a	a	c	c
Production land destined for maize 2023 share	c	b	c	a	ab
Production land destined for natural pasture 2023 share	a	b	c	c	c
Production land destined for planted pasture 2023 share	a	c	ab	bc	a
TLU score for 2023	ab	c	a	c	b
TLU score for 2020	a	b	b	b	a
TLU score difference between 2020/23	a	a	a	a	a
Yearly share facing fodder shortage for animals	b	c	b	c	a
Adult poultry animals in 2023	a	b	c	b	a
Number of common land services to farm	c	b	a	b	b
Total income generated at HH, in thousand Lak ($)	a	b	b	b	a
Cropping income share	c	c	a	b	b
Livestock income share	a	bc	c	b	b
Off-Farm activities income share	bc	a	c	bc	b
Capital or recollection income share	a	a	b	a	ab
Number of crops at main season	bc	c	b	bc	a
Summatory of nutrients sources for all crops	b	b	c	b	a
Total labor for cropping	b	d	d	c	a
Average yield per season (main) for maize	a	b	c	ab	a
Average yield per season (main) for paddy rice	b	ab	a	c	c
Average yield per season (main) for upland rice	b	b	b	a	a
Sold share of maize	ab	b	c	ab	a
Income from maize	bc	c	d	b	a
Total machines in possession related to cropping activities (other machines excluded)	a	b	c	c	b
Total use of services in possession relates to cropping activities (other machines excluded)	ab	a	ab	b	ab
Average mechanization across subsystems crops	a	b	b	a	a
Average mechanization for cropping activities, maize	b	c	d	a	b
Machinery requirement number of motives	bc	b	a	c	ab
Number of functions provided by trees at farm	a	b	b	a	a
Number of water constrains to access to irrigation	a	a	a	b	ab
Number of irrigation types within HH	ab	a	b	c	ab
Amount of climatic events affecting main crops	b	b	c	b	a
Amount of climatic events affecting other crops	b	b	c	b	a
Amount of reasons to try a new crop or animal	b	a	d	c	a
Food bought per year share, fish	ab	a	b	b	b
Food bought per year share, vegetables	b	a	b	b	ab
Months with copping practices in the last year	b	a	c	b	b

Note: each variable compares the media's types assigning a letter, in which similar letters imply no-statistical difference between types. The green colour highlights statistical difference between types.

Table 6.5 Chi-square test for variables.

Variable	***Chisq***	***Df***	***p.chisq***
Farmer age index	23.63	4	0.000
Farmer education level index	41.48	4	0.000
Total hh habitants	11.28	4	0.024
Women share in family members	1.98	4	0.739
Childrens (0-15) share in family members	32.22	4	0.000
Youth (15-35) share in family members	26.05	4	0.000
Time walking from HH to plot	65.37	4	0.000
Time motorbike from HH to market (for inputs)	146.48	4	0.000
Total surface in 2023	124.64	4	0.000
Surface available per tlu 2023 score	90.23	4	0.000
Irrigated surface share	121.44	4	0.000
Land occupancy for main crops 2023	81.66	4	0.000
Land occupancy for vegetables 2023	47.45	4	0.000
Production land destined for paddy rice 2023 share	119.21	4	0.000
Production land destined for maize 2023 share	92.93	4	0.000
Production land destined for natural pasture 2023 share	64.03	4	0.000
Production land destined for planted pasture 2023 share	45.54	4	0.000
TLU score for 2023	94.20	4	0.000
TLU score for 2020	75.80	4	0.000
TLU score difference between 2020/23	5.85	4	0.210
Yearly share facing fodder shortage for animals	100.82	4	0.000
Adult poultry animals in 2023	155.65	4	0.000
Number of common land services to farm	58.48	4	0.000
Total income generated at HH, in thousand Lak ($)	58.46	4	0.000
Cropping income share	96.38	4	0.000
Livestock income share	91.03	4	0.000
Off-Farm activities income share	82.12	4	0.000
Capital or recollection income share	20.85	4	0.000
Number of crops at main season	41.12	4	0.000
Summatory of nutrients sources for all crops	117.12	4	0.000
Total labor for cropping	142.90	4	0.000
Average yield per season (main) for maize	76.80	4	0.000
Average yield per season (main) for paddy rice	90.17	4	0.000
Average yield per season (main) for upland rice	86.93	4	0.000
Sold share of maize	54.86	4	0.000
Income from maize	154.37	4	0.000
Total machines in possession related to cropping activities (other machines excluded)	103.43	4	0.000
Total use of services in possession relates to cropping activities (other machines excluded)	21.82	4	0.000
Average mechanization across subsystems crops	62.58	4	0.000
Average mechanization for cropping activities, maize	145.29	4	0.000
Machinery requirement number of motives	34.25	4	0.000
Number of functions provided by trees at farm	69.47	4	0.000
Number of water constrains to access to irrigation	27.35	4	0.000
Number of irrigation types within HH	42.89	4	0.000
Amount of climatic events affecting main crops	87.77	4	0.000
Amount of climatic events affecting other crops	91.19	4	0.000
Amount of reasons to try a new crop or animal	145.66	4	0.000
Food bought per year share, fish	21.35	4	0.000
Food bought per year share, vegetables	31.18	4	0.000
Months with copping practices in the last year	99.75	4	0.000

Table 6.6 Calendar equivalent.

Month number	**Gregorian calendar**	**Laotian script**	**English transliteration**	**Season**
1	January	ມັງກອນ	Măŋ Kōng	Second
2	February	ກຸມພາ	Kumphā	Second
3	March	ມີນາ	Mīnā	Main
4	April	ເມສາ	Mēsā	Main
5	May	ພຶດສະພາ	Phutsaphā	Main
6	June	ມິຖຸນາ	Mithunā	Main
7	July	ກໍລະກົດ	Kōlākōt	Main
8	August	ສິງຫາ	Singha	Second
9	September	ກັນຍາ	Kānñā	Second
10	October	ຕຸລາ	Tūlā	Second
11	November	ພະຈິກ	Phachik	Second
12	December	ທັນວາ	Thanwā	Second

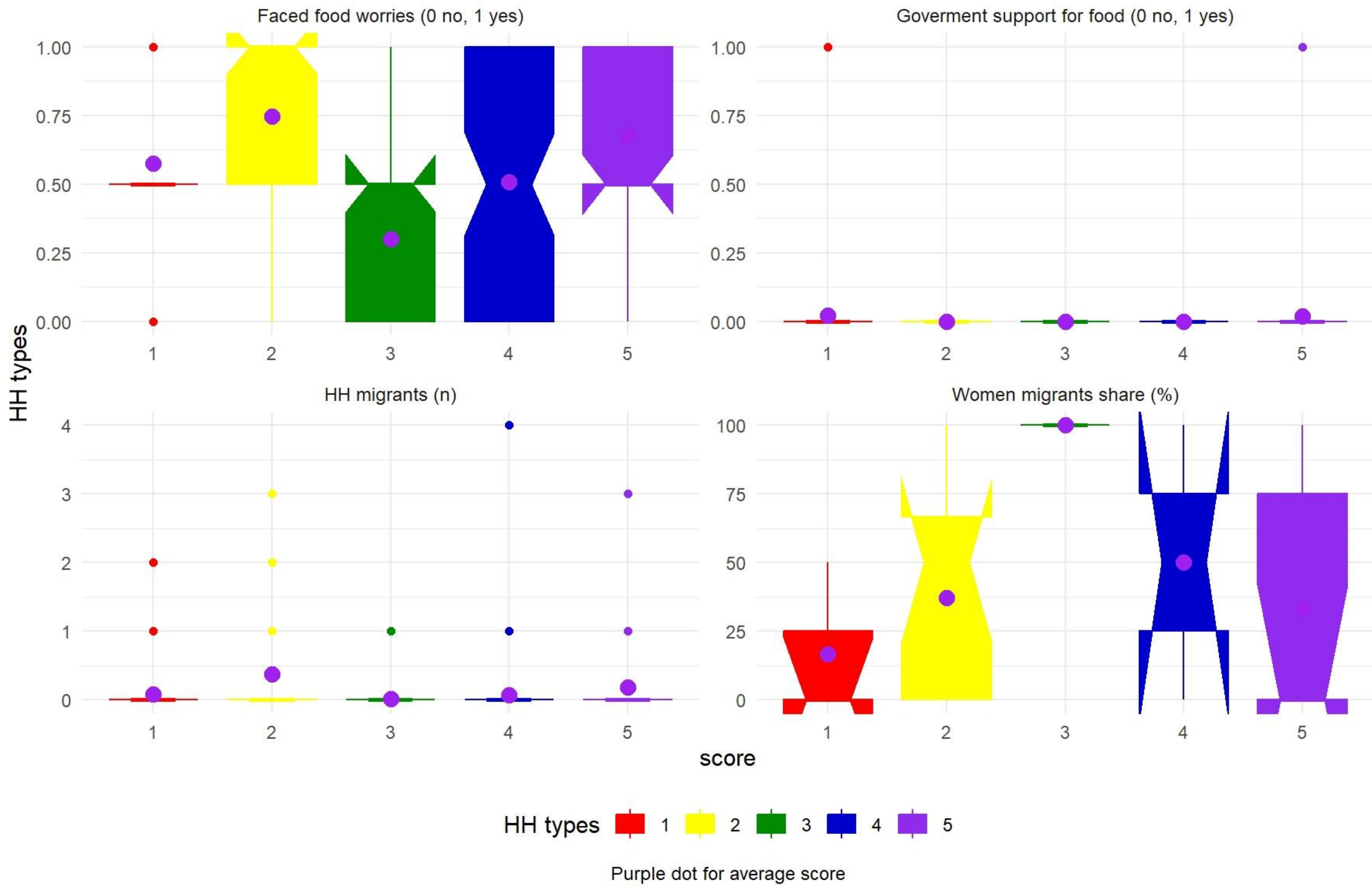

Figure 6.4 Family characteristics, Kham, Moke and Nonghet districts in Xiengkhouang Province.

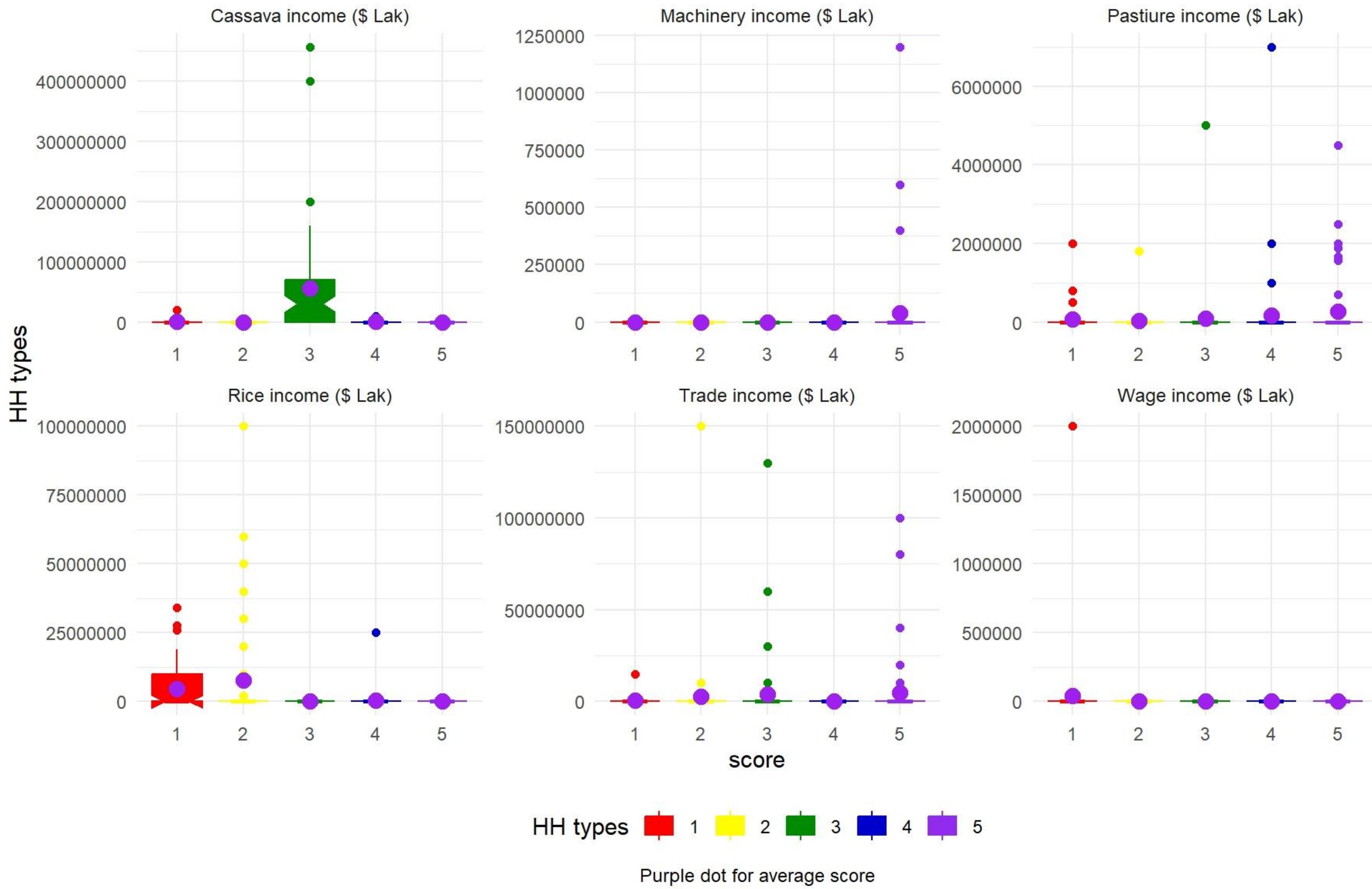

Figure 6.5 Income characteristics, Kham, Moke and Nonghet districts in Xiengkhouang Province.

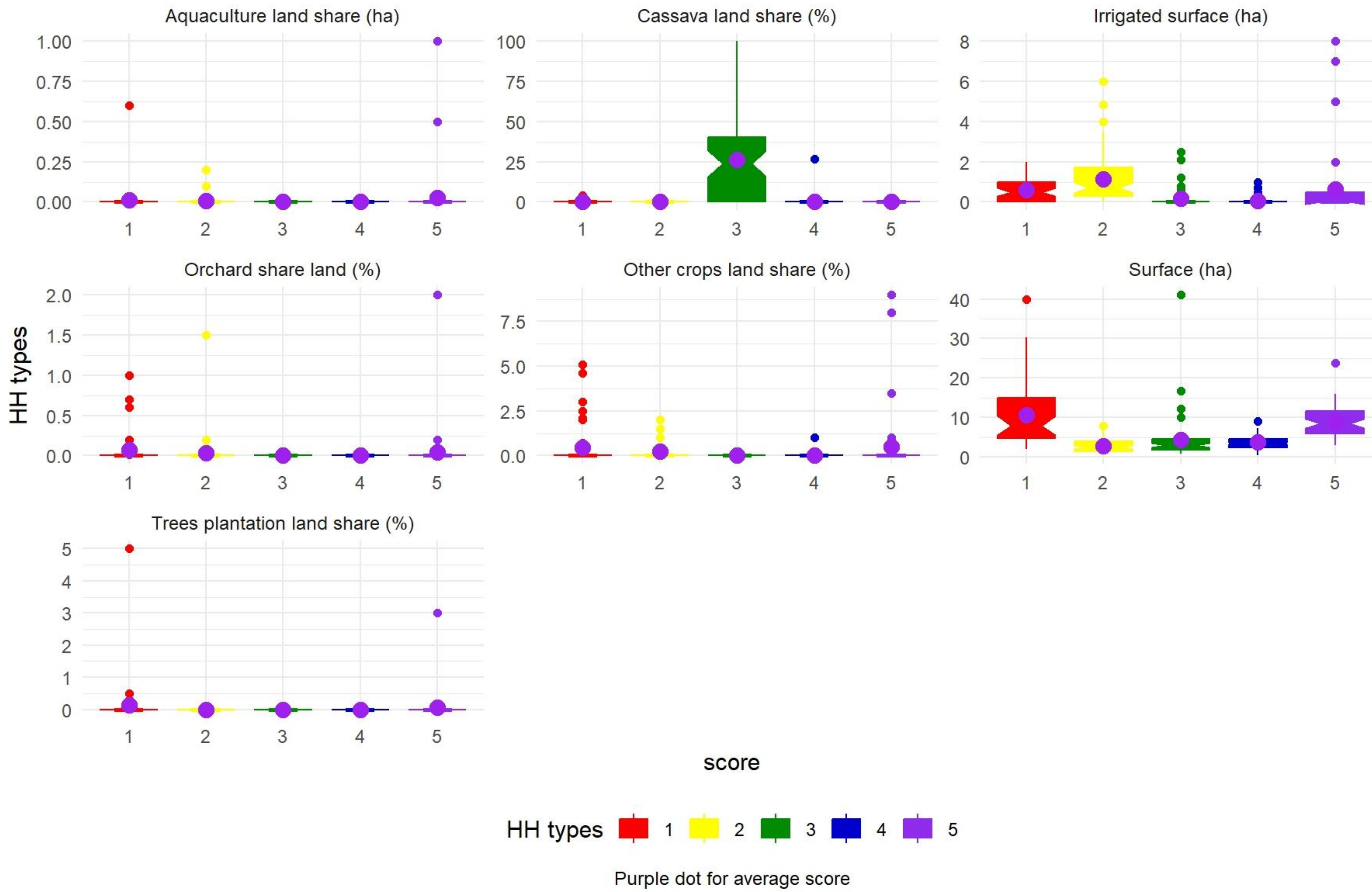

Figure 6.6 Land characteristics, Kham, Moke and Nonghet districts in Xiengkhouang Province.

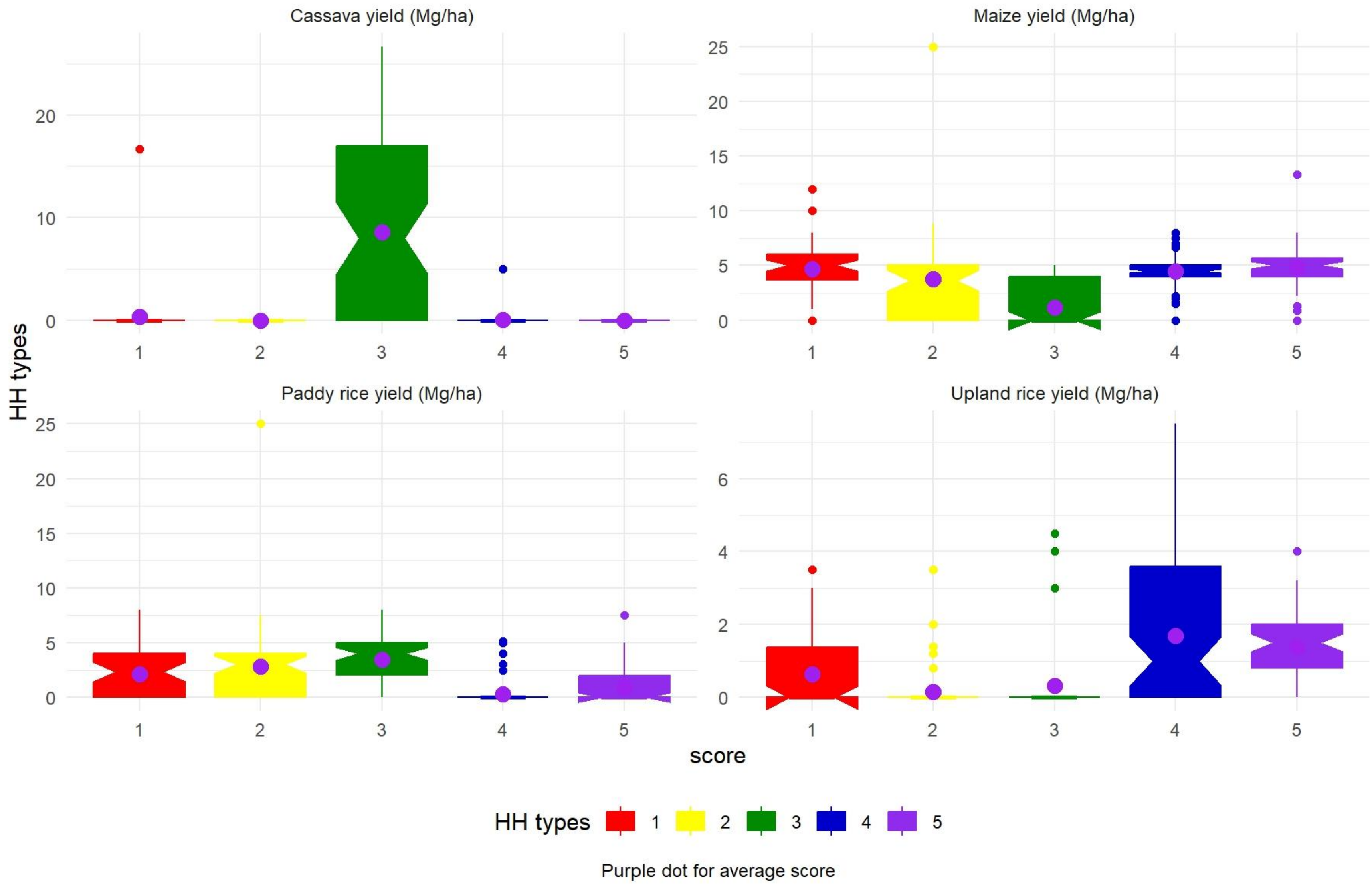

Figure 6.7 Production characteristics, Kham, Moke and Nonghet districts in Xiengkhouang Province.

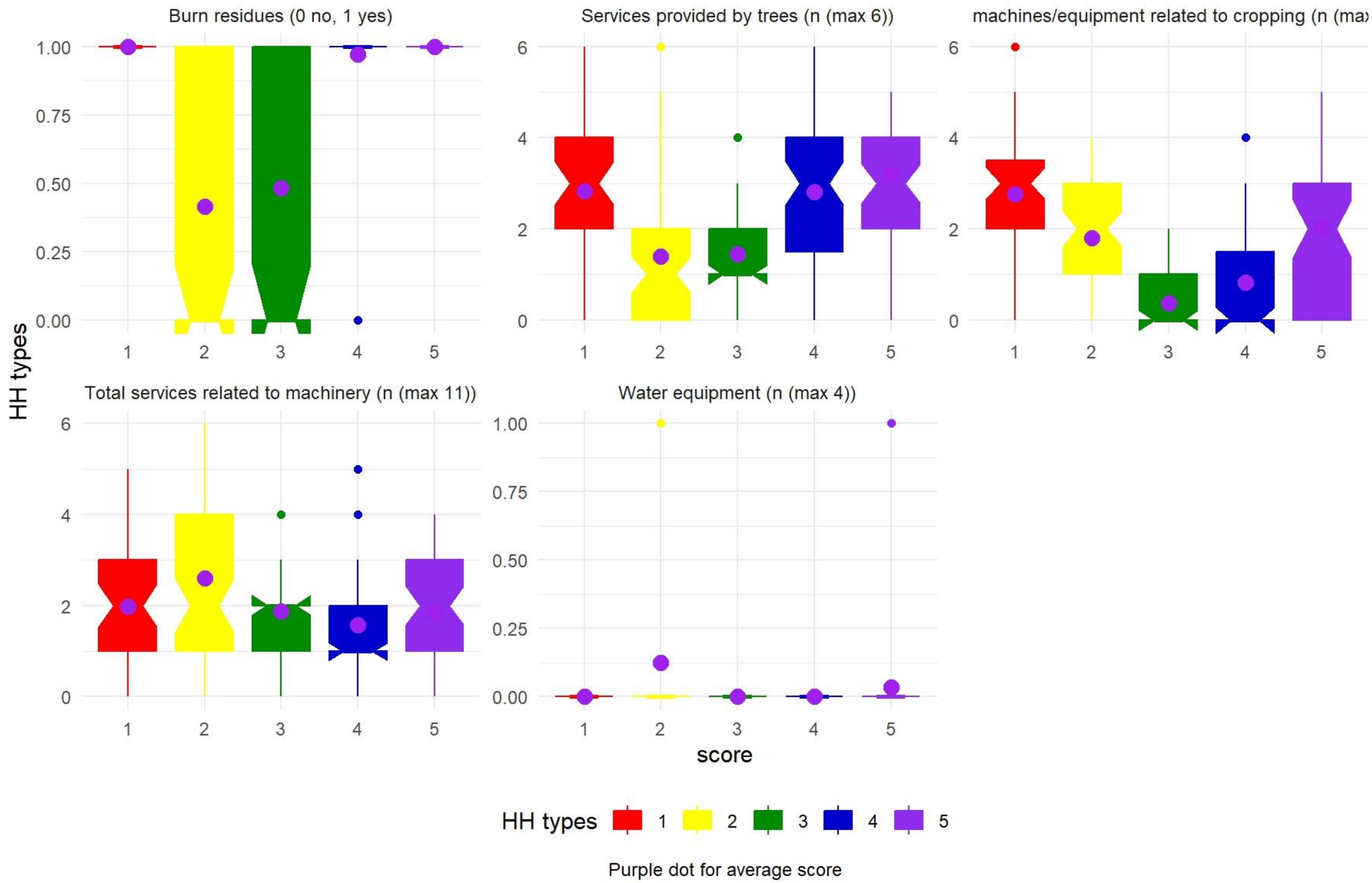

Figure 6.8 System characteristics, Kham, Moke and Nonghet districts in Xiengkhouang Province.

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IITA Transforming African Agriculture

ICARDA Science for resilient livelihoods in dry areas

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

IRRI International Rice Research Institute

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