

SOCIO-ECONOMIC AND ENVIRONMENTAL SITUATION AT SURROUNDING VILLAGES OF OLAM'S BLACK PEPPER PLANTATION

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| Abbreviation | |
|--------------|---|
| ANR | Assisted Natural Regeneration |
| APFNet | Asia-Pacific Network for Sustainable Forest Management and Rehabilitation |
| CEMA | Committee for Ethnic Minority Affairs |
| CV | Coefficient Variation (%) |
| D | Diameter at breast height of the tree (cm) |
| DDF | Dry dipterocarp forest |
| FAO | the Food and Agricultural Organization |
| Н | Height of the tree (m) |
| HH | Household |
| IPC | Income per capita (Million VND/person/month) |
| ITTO | International Tropical Timber Organization |
| IUCN | International Union for Conservation of Nature |
| n, N | Number of samples |
| NTFP | Non- Timber Forest Products |
| PCA | Principal Components Analysis |
| S | Standard deviation |
| | |

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1 INTRODUCTION

1.1 Rationale

Olam's Black Pepper Farm in Ia Le commune, Chu Puh district, Gia Lai province, Viet Nam, lies in a highly intensive production area. Perennial and annual crops are occupying almost all arable and accessible lands. Olam's pepper farm is surrounded by living and farming communities that are closely related to the landscape approach to sustainable pepper growing.

Olam has planted 275 ha of black pepper with total anticipated production of 1,650 MT / year; conducted the afforestation around 300 ha of mainly *Acacia hybrid* and being assigned by Gia Lai province to rehabilitate about 336 ha of degraded dipterocarp forests in two hills located in the East and West of Olam's pepper farms (Source: Olam office in Ia Le Commune, 2021)

Natural landscapes include dipterocarp forests, rivers, streams and swamps that have not been protected specifically. With the ecological characteristics of the area such as the vegetation previously distributed mainly as dipterocarp forest, many soil points are sand and rock with low organic matter content. Low forest coverage along with overexploitation of forest products results in low large tree density leading to frequent soil erosion throughout the landscape, thereby reducing soil nutrient, water quality. Therefore, the degraded dipterocarp forests here should have intensive silviculture techniques to rehabilitate.

The socio-economic trend is that the rural area organizes cultivation according to the model of scattered independent households, each household cultivates several hectares of agricultural commodity products, mainly cassava, cashew, pepper, maize, and beans, raises goats and cows. The agricultural land expansion of the surrounding communities is present both in Olam owned land and on the surrounding mountain slopes, at a high rate. As a result, some of the remaining natural spots in the nearby landscape are at stake and life expectancy is extremely low.

Olam is providing a possible way to improve the relationships among socio-economic and environmental factors for more sustainable development and responsible businesses. Thus, Olam has the targeted objectives:

- Environment, by enlarging the scope of action to the neighboring areas to protect remaining and rehabilitating natural forests and restore adjacent degraded lands. This will need a program on natural forest rehabilitation including restoring biodiversity, forest stands, protecting watershed and streams, sequestering carbon to mitigate climate change in the local region.
- Social, by engaging with local farmers within Olam's boundaries and on contiguous plots to build an agreed landscape management plan where the surrounding communities would benefit from Olam's support while ensuring the right implementation of landscape action plan.

To support this important mission, Olam is submitting a project entitled "Back Pepper Living Landscape" granted by Asia-Pacific Network for Sustainable (APFNet). The expectation of the project will place pepper into a landscape level approach that will positively impact on rehabilitating natural landscape and improving livelihoods of related local communities.

1.2 Objectives of the study

This study aims to provide the detailed, specific information on the livelihoods of surrounding communities to develop context-specific, sustainable long-term projects that are

relevant and motivated by the needs of the communities. This result can also be the basis for effectively measuring any changes or long-term impacts during and after project interventions.

This work is also expected to show the recommendations for communities, Olam and stakeholders for long term thematic and specific interventions.

2 APPROACH AND METHODOLOGY

2.1 Approach

There are the five forms of capital required for sustainable livelihood: i) Natural capital: land, forests, water; ii) Physical capital: social infrastructure such as roads, utilities, schools, hospitals, communication information, etc.; iii) Financial capital: cash income or saving; iv) Human capital: Health, nutritional level, educational standards, and skills; and v) Social capital: Social relationship including relations to formal organization (Thuan and Huy, 2005). Therefore, the study approaches the five forms of livelihood mentioned above to design questionnaires and discussions to collect information and feedback from local people.

To conduct group discussions and semi-structured interviews, the sample number of informants needs to be large enough by statistical standards. The representative samples of the households were selected randomly according to the different target groups. The questionnaires for interviews and discussions were designed around 5 fields of rural livelihoods to show a general and comprehensive picture of household and community life, and problems they are facing in efforts to escape poverty and towards sustainable livelihoods.

In addition, rapid forest inventory such as transects, sampling plots were conducted to supplement, clarify and cross-check information from representatives of households related to state of the art of surrounding natural forest resources.

2.2 Selection of villages and collection of background information at the village level

The residential area and cultivated land of the local people are concentrated to the southwest of Olam pepper farm, including the two closest villages, Ia Brel and Ia Jol, with the relationship in land and forest resource use with Olam.

Therefore, this study was conducted in two villages Ia Brel and Ia Jol, in Ia Le commune, Chu Puh district, Gia Lai province. Located at geographical coordinates N 13⁰25'30", E 108⁰11' 06" (Figure 1). These two villages are located 2 - 5 km from Olam pepper farm.



Figure 1. Location of Olam' pepper farm, two eastern and western hill forests and two related surrounding villages: Ia Brel and Ia Jol belong to Ia Le commune, Chu Puh district, Gia Lai province, Viet Nam (Source: Google Earth Pro)

At each village, a group discussion was conducted according to the open-ended questions of Form 1 in Annex 1, with participation of:

- At Ia Brel village: Two people of village head and deputy head
- At Ia Jol village: Four people of village head, deputy, women's union and farmer representatives.

The list of six representatives of the two villages involved into the discussions presented in Annex 3. The discussions focused on basic information at village level and concerned issues of the local people in the view of the key people. Main topics were as follows:

- Basic village information: Population, number of households, village history summary,
- Participatory sketching of village landscape
- Household situation: Education levels, HH economy classification, religion, ...
- Agriculture cultivation, livestock
- Forest and forest land contracted or owned.
- Infrastructures in the village
- Management of other natural sources: forest, biodiversity, wild animal
- Cooperation activities with Olam pepper farm
- Etc.

2.3 Collection of household information on their livelihoods and creation of a dataset of interviewed households

2.3.1 Selection of household representatives to interview and sample size (number of interviewees)

To collect household (HH) information on their livelihoods, the study interviewed mainly representatives of households in two selected villages: Ia Brel and Ia Jol and few farmers who have their farm closed to Olam's pepper farm and some workers of Olam farm.

The method of random sampling by subjects (proportion of household economy, ethnic composition, ...) was applied, in which representatives of households were female that reached at least one third.

- In Ia Brel village: The rate of poor households is extremely low (6.8%) and there are many ethnic groups but with no clear ethnic groups dominated; therefore, random sampling was used without target groups. In this village, 31 representatives of randomly selected households were interviewed.
- In Ia Jol village: The rate of poor households also is low (10.7%) and there are many ethnic groups, in which the Dao ethnic group dominates at 60% of total household in the village; thus, random sampling by ethnic groups was applied, with Dao ethnic group was 60% of the sample size, then the remaining 40% of the samples for other ethnic groups. In this village 29 representatives of randomly selected households were interviewed.

In addition, to supplement information from stakeholders, the study also interviewed 5 representatives of smallholder farmers who are cultivating around Olam farm and 02 workers of Olam farm.

Totally 67 interviewees were interviewed in this study, in which there were 60 representatives of households of the two selected villages, or 65 local farmers involved. List of informants presented in Annex 3.

The sample size (number of interviewees) was designed to reach the allowable error of 10%. After randomly sampling the interviewees, calculated the number of samples (interviewees) to make sure if there is a given error or not. Calculating the needed number of interviewed households based on variations in household's income per capita / month – a criteria for classifying household economy according to multi-dimensional poverty line (Prime Minister, 2015, 2021) (Huy, 2017; Huy and Long, 2019) (Table 1).

| ID | Statistics | Ia Brel village | Ia Jol village | Total |
|----|---|--------------------|-------------------|---------|
| 1 | n _{interviewed} (Sample number of households interviewed) | 31 | 29 | 60 |
| 2 | \overline{X} (Averaged income per capita, Mil. VND/month) | | | 2.194 |
| 3 | S (Standard deviation) | | | 2.630 |
| 4 | CV%: Coefficient variation | | | 119.845 |
| 5 | Min | | | 0.197 |
| 6 | Max | | | 19.667 |
| 8 | Ni, N (Total households in village i and grand total, respectively) | 147 | 93 | 240 |
| 9 | n _{required} (Sample number of households required to reach 10% allowed error for each village and in total) | 28 | 18 | 46 |

 Table 1. Summary statistics for income per capita/month of household and calculation of number sampling size

where:

$$n_{required in total} = \frac{(t^2 \times CV\%^2)}{E\%^2 + \frac{t^2 \times CV\%^2}{N}} = \frac{(2^2 \times 119.845\%^2)}{10\%^2 + \frac{2^2 \times 119.845\%^2}{240}} = 46$$
(1)

Where t = 2, E% is the allowable error in percent = 10%; N is total households; CV% is the coefficient variation in percent = $(100 \times S/\overline{X})$, S is standard deviation, \overline{X} is the averaged income per capita per month of households.

This result shows that the number of people interviewed in the two selected villages was 60, exceeding the required number of 46.

From there, the number of samples required to be interviewed by the village is calculated as follows:

$$n_{\text{required (Village)}} = n_{\text{required in total}} \times \text{Ni (Village)} / \text{N}$$
(2)

$$n_{\text{required (Ia Brel village)}} = 46 \times 147 / 240 = 28 \tag{3}$$

$$n_{\text{required (Ia Jol village)}} = 46 \times 93 / 240 = 18$$
(4)

The results showed that the number of interviewees in each village exceeded as required. In Ia Brel and Ia Jol village, the study interviewed 31 people, 29 people; meanwhile, according to the request of the allowed error were 28 people and 18 people, respectively.

The number of people and percentages interviewed by ethnic group, women in each village presented in Table 2. In which, the proportion of women interviewed was 49%, the Nung and Dao ethnic people participated the most - because these are the two dominant ethnic groups in the region.

| Location | Ethnic group | Female | Male | Total | Percent |
|------------------------------------|--------------|--------|------|-------|---------|
| Ia Brel village | H Mong | 2 | 9 | 11 | 35% |
| - | Dao | 1 | | 1 | 3% |
| | Nung | 4 | 7 | 11 | 35% |
| | Tay | 4 | 1 | 5 | 16% |
| | Kinh | 2 | 1 | 3 | 10% |
| Total | | 13 | 18 | 31 | 100% |
| Percent | | 42% | 58% | 100% | |
| | | | | | |
| Ia Jol village | Muong | 1 | 1 | 2 | 7% |
| | Dao | 11 | 8 | 19 | 66% |
| | Nung | 3 | 1 | 4 | 14% |
| | Kinh | 3 | 1 | 4 | 14% |
| Total | | 18 | 11 | 29 | 100% |
| Percent | | 62% | 38% | 100% | |
| Farmers around and workers of Olam | Nung | | 1 | 1 | 14% |
| | Kinh | 2 | 4 | 6 | 86% |
| Total | | 2 | 5 | 7 | 100% |
| Percent | | 29% | 71% | 100% | |
| | | | | | |
| All | Muong | 1 | 1 | 2 | 3% |
| | H Mong | 2 | 9 | 11 | 16% |
| | Dao | 12 | 8 | 20 | 30% |
| | Nung | 7 | 9 | 16 | 24% |
| | Tay | 4 | 1 | 5 | 7% |
| | Kinh | 7 | 6 | 13 | 19% |
| Grand total | | 33 | 34 | 67 | 100% |
| Percent | | 49% | 51% | 100% | |

Table 2. The number of people and percentages interviewed by ethnic group, women in eachselected village and in total

2.3.2 Collection of household information on livelihoods and establishment of a household dataset

Use method of semi- structured interview based on open- ended questionnaires in Form 2 of Annex 2 to collect household information on livelihoods.

Main contents and information in form 2 collected from interviews with household representatives are as follows:

- Household basic information: Ethnic group, number of family members, number of laborers, religion, etc.
- Well- being services for household: Education, health care, housing, sanitation, energy, electricity, fuel, etc.
- Participation in social organizations
- Farming practices: Owned land area, contracted land, land use right, main crops, yield and productivity for each main crop, purpose of crop (sale, consumption, or both), livestock, extension services, etc.

- Food security and nutrition
- Access to forest resources: Local forest management, the need from forest products such as wood for housing, barn, firewood, non-timber forest products (NTFPs), functions of the natural forest to livelihoods, etc.
- The meaning of biodiversity to HH livelihood: Intercropping and monocropping issues, hunting/gathering, using fire for land clearing, livelihood vs, loss/degraded biodiversity, etc.
- Soil issue: Flooding, using fertilizer and pesticides, soil problem, etc.
- Water sources: Water for farming, livestock, drinking water, domestic water, watershed monitoring, health issues relate to water sources, sewage system, etc.
- Economic and financial issues: Main income of HH, additional source of income, cash incomes form farm, livestock, wage, NTFPs, other, total income, expenditures of HH, access to savings and financing/loans, gender issue related to who makes decisions of spending money, investing cultivation in HH, etc.

Annex 4 shows some photos of discussion and interviews with representatives of households in two studied villages, Ia Brel and Ia Jol.

Based on interviewing 67 household representatives, a dataset on household livelihoods in the study area was created, including quantitative, qualitative variables, and descriptive variables. The qualitative variables were coded for statistical analysis purpose and units of variables presented in Annex 5.

2.4 Natural forest inventory

Two forest areas located in the east and the west hills from Olam pepper farm were surveyed as follows:

- For describing ecology and measuring forest variables: At each forest hill area, establishing two sample plots $300 \text{ m}^2 (10 \times 30 \text{ m})$ to record/collect data on ecological situation, remaining tree species, diameter at breast height (D, cm), height (H, m) of the tree, nearest distance tree to tree, and regeneration of the tree species including species name, height of regenerated tree.
- For recoding forest plants and wild animals: At each hill forest area, set up a transect line to record the presence of rare, endangered plants and existing wild animals.

There were also 2 Olam employees joined the study team to forest survey, their names are in Annex 3. The forms used for forest survey are presented in Annex 6.

2.5 Information and data analysis

2.5.1 Data, information analysis on socio- economic issues

Use the developed household livelihood dataset to proceed:

- Describing socio-economic and livelihood characteristics related to the households.
- Summarizing the statistics of the household livelihood variables (Huy, 2017)
- Some variables of household income and expenditure are calculated as follows:
 - Cash income is the income from the sale of crops, livestock, non-timber forest products (NTFPs) after deduction of production costs and together with salaries and wages (if any). Total cash income was calculated for each household in a year (Million VND / HH / year)

- Income includes cash income and any crops, livestock and NTFPs consumed by the household (not sold) converted to cash. Total income was calculated for each household in a year (Million VND / HH / year)
- Household expenditure by items such as food (rice, excluding farmers grow the rice, especially money to buy milk for families with children under 2 years old), education (tuition, other expenses), clothes, household appliance (such as televisions, refrigerators, smartphones, motorbikes, pumps, and other machines were calculated according to the depreciation rate of the equipment), electricity, drinking water (if any), communication (such for internet charges, smartphone charges), firewood, other energy (such as gas for cooking), health care. Total expenditure was calculated for each household in a year (Million VND / household / year)
- Balance of cash income and expenditure is total cash incomes minus total household expenditures in a year (Million VND / HH / year)
- Income per capita is total income divided by the number of household members and calculated per month (Mil. VND / person / month). It is one of important indicators to classify the poor, near-poor, average households of the Government (Prime Minister, 2015; Decision No. 59/2015 / QD-TTg)
- Household income level: Based on Income per capita per month indicator according to Decree No. 07/2021 / ND-CP (Prime Minister, 2021), this study categorized the Household income level and coded as follows:
 - ✓ 1: Below minimum income indicator with Income per capita < 1.5 Mil. VND/month
 - ✓ 2: At average income indicator with Income per capita from 1.5 –
 2.25 Mil. VND/month
 - ✓ 3: Above average income indicator with Income per capita > 2.25 Mil. VND/month
- Applying ANOVA to analyze and compare from one to multi factors relating to HH livelihoods, economy and using method of 95.0 percent LSD (Fisher's least significant difference (LSD) procedure) to identify homogenous groups (Huy, 2017)
- Principal Components Analysis (PCA): The purpose of the analysis is to obtain a small number of linear combinations of the numbers of variables which account for most of the variability in the data. Extract numbers of components that had eigenvalues greater than or equal to 1.0. Where the values of the variables in the equation are standardized by subtracting their means and dividing by their standard deviations (Abdi and Williams, 2010; Huy et al., 2020)

2.5.2 Analysis of forest, plant, wild animal data

Based on data collected on two transects to:

- Make a list of precious, rare, and endangered wild plant species that still exist in the studied forests.
- Make a list of wild animals that still appear in the studied forests.

Based on four sample plots data to:

- Make a list of dominant tree species in the studied forests.

- Set up the diameter distribution of trees layer and height distribution of regenerated trees layer.
- Develop a list of plant species used for assisted natural regeneration (ANR) and enrichment planting in tropical dry dipterocarp forest (DDF) after over exploitation.
- Develop a list of plant species in IUCN, VIET NAM Red List and Decree 06/2019/ND-CP existing or potential for tropical dry dipterocarp forest rehabilitation.
- Develop a list of wild animal species in IUCN, Viet Nam Red Book and Decree 06/2019/ND-CP potential for tropical dry dipterocarp forest rehabilitation.

3 RESULTS AND DISCUSSION

3.1 Background information on socio- economic environmental characteristics of the two studied villages

3.1.1 Natural environmental conditions of the studied area

The study area is in the terrain with an average altitude of 300 - 400 m. This is a flat plain, interspersed with mountains of 500 - 700 m high. The climate is adjacent to the low-lying Cheo Reo - Phu Tuc so the rainfall is low, about 1,200 - 1,600 mm / year. Droughts usually occur in the end of November to April next year; with dry and hot westerly winds at the beginning of the dry season, the temperature can be over 35^{0} C, the lowest humidity is below 50%. This area is affected by concentrated heavy rain, so it is easy to generate floods (CEMA, 2020).

The soil in the area consists of two groups of greyish-yellow soil on acid magma and alluvial soil. Soils with small red gravel have higher nutrient content and can be cultivated longer; while low- organic matter sandy soils, rapidly degenerating after a few years of monoculture. The soils layer is usually not thick, dry in the dry season, and waterlogged in the rainy season (CEMA, 2020; This study, 2021).

This is the ecoregion for the distribution of the tropical dry forests dominated by tree species of Dipterocarpaceae family (Dry dipterocarp forest - DDF). Common features are drought in the dry season, forest fires and waterlogging in the rainy season. The natural forest here was seriously degraded, the remaining wood layer has low canopy (< 20%), thin, small trees, poor quality trees. Forest biodiversity was degraded, most of wildlife was lost, forests have reduced their water regulation capacity in the basins (This study, 2021).

The main river here is Ea H Leo, it is also the boundary of the two provinces of Gia Lai and Dak Lak. Streams that originate in the mountains in the region flow into the Ea H Leo River. However, these streams are in deciduous dipterocarp forest areas, together with extreme degradation of the tree layer, they reduce the upstream regulatory function of the forest, shallow streams in the dry season and make flow strong in the rainy season (This study, 2021)

3.1.2 Socio-economic characteristics at village level

In this section, information, data is synthesized from the results of collecting and discussing with groups of key people in the two studied villages.

The ethnic minorities in the north began to migrate and gather here from 1998 to 2002, then from 2002 to 2008 the population increased to form a residential area, stable farming and in 2008 officially recognized the administrative units that are Ia Brel and Ia Jol villages.

The two villages now have many ethnic groups living together (Table 3), mainly ethnic minorities who have migrated from the North; In which, in Ia Jol village, the Dao ethnic dominates, while in Ia Brel, the Tay is slightly more than other ethnic groups.

| Id | Ethnic Group | Ia Brel Village | | Ia Jol Village | |
|----|--------------|-----------------|---------|----------------|---------|
| | | Number of HH | Percent | Number of HH | Percent |
| 1 | Muong | 2 | 1.4 | 3 | 2.9 |
| 2 | H Mong | 29 | 19.7 | | |
| 3 | Dao | 18 | 12.2 | 55 | 54.5 |
| 4 | Nung | 29 | 19.7 | 15 | 14.9 |
| 5 | Tay | 46 | 31.3 | 13 | 12.8 |
| 6 | Kinh | 14 | 9.5 | 15 | 14.9 |
| 7 | Others | 9 | 6.2 | | |
| | Total | 147 | 100.0 | 101 | 100.0 |

Table 3. Proportion of ethnic groups in the two studied villages

Source: The two village heads of Ia Brel and Ia Jol

The population in villages of Ia Brel and Ia Jol is 602 and 420 people with 147 and 101 households, respectively. Sketches made by key people showed that people in both villages live and cultivate alternately and along the inter-village road, about 4- 6 km from National road No. 14 and about 2- 5 km from Olam pepper farm (Figure 2).





According to data kept by the two village heads, the proportion of poor households according to the multidimensional poverty line (Prime Minister, 2015; Decision No. 59/2015/QD-TTg) was 6.8% and 9.9% in Ia Brel and Ia Jol, respectively (Table 4). Such a poverty rate is low, so these villages are categorized out of extremely difficult villages (The extremely difficult village has a poverty household rate of 35% or more (Prime Minister, 2016; Decision No. 50/2016/QD-TTg))

| Village | Household economy classification | | | | | | | | |
|---------|----------------------------------|---------|------|---------|---------|---------|-------|---------|--|
| | Poor | Percent | Near | Percent | Average | Percent | Total | Percent | |
| | HH | | poor | | HH | | | | |
| | | | HH | | | | | | |
| Ia Brel | 10 | 6.8% | 23 | 15.6% | 114 | 77.6% | 147 | 100.0% | |
| Ia Jol | 10 | 9.9% | 14 | 13.9% | 77 | 76.2% | 101 | 100.0% | |
| Total | 20 | 8.1% | 37 | 14.9% | 191 | 77.0% | 248 | 100.0% | |

Table 4. Household economy classified by Government in the two studied villages

Source: The two village heads of Ia Brel and Ia Jol

Regarding public infrastructure, both villages have village halls that are brick-built houses; about 20% of the main road is made of concrete in the inner village, the rest is dirt road; Each village has a kindergarten and a branch school at the primary level; There is no medical station in the village.

In both villages, there are crops that need watering such as pepper, coffee, and fruit trees. However, both villages do not have public irrigation systems to irrigate crops, so households invest themselves to water their crops from wells, ponds, lakes, and streams.

Most people buy and sell at the central market of Ia Le commune, 8-12 km from the village. The commune market is quite full of food and consumer goods; Just go to the center of Chu Pu district to buy agricultural machinery and electronics. The district center is about 20-25 km from the villages.

With efforts to produce pepper responsibly to the community, and towards attracting local communities to participate in production in a sustainable landscape, both villages have been supported by Olam pepper farm with infrastructure such as installing drinking water filtration system for Ia Brel village, upgrading primary schools in villages Ia Brel and Ia Jol, repairing community hall in Ia Jol village, installing some streetlights using solar energy roads in two villages (7-10 lights per village), cooperating with two villages to repair inner-village roads annually (Figure 3)



Community Hall of Ia Brel Village



Primary School at Ia Brel Village



Road connecting villages Ia Jol and Ia Brel



Streetlights using solar energy in Villages of Ia Jol and Ia Brel



Drinking water filtration system in Ia Brel Village

3.2 Information and estimated statistics related to household livelihoods

In this section, based on dataset created from household interviews, reflecting information, statistical data, estimates related to household livelihood development in the study area.

3.2.1 Statistics of household structure

Statistical data on the household structure for the two studied villages is presented in Table 5. The statistical results show that the family size of ethnic minority migrant communities is no longer too large, with an average of 4.6 people / HH. The number of children at school age is estimated at 446, and the number of children under 2 years of age that need special care is not much about 25 in both villages.

The number of male and female workers is quite balanced. Laborers in the families here are not only working on farm but also off-farm such as hired labor, working for Olam, for the rubber companies in the region. The number of non-farm workers is more than half of the workforce in the household. Half of HH members generate income for the family (Table 5).

Figure 3. Rural infrastructure in the two studied villages has been built or/and supported by Olam Pepper Farm

| | Count | Average | Standard | Coeff. of | Minimum | Maximum |
|-------------------------------------|-------|---------|-----------|-----------|---------|---------|
| | | | deviation | variation | | |
| Number of family members | 65 | 4.6 | 1.467 | 32.0% | 2 | 9 |
| Number of female laborers | 65 | 1.3 | 0.509 | 40.3% | 1 | 3 |
| Number of male laborers | 65 | 1.2 | 0.625 | 51.4% | 0 | 3 |
| Number of elders | 65 | 0.3 | 0.600 | 216.6% | 0 | 2 |
| Number of children | 65 | 1.8 | 1.156 | 65.3% | 0 | 5 |
| Number of children under 2 | 65 | 0.1 | 0.341 | 369.5% | 0 | 2 |
| Number of farm working | 65 | 2.1 | 0.897 | 42.9% | 0 | 4 |
| Number of off-farm working | 65 | 1.3 | 1.108 | 87.8% | 0 | 5 |
| Number of members generating income | 65 | 2.5 | 1.002 | 40.2% | 0 | 6 |

Table 5. Summary statistics of family structure of the household in the two studied villages

3.2.2 Household education

In terms of education, 10% of the population in Ia Brel village and 30% in Ia Jol village are illiterate. Since most of them have had to go through a long period of migration, they have organized farming to settle down and thus cannot go to school. At present, there are several young people going to college and university, about 2 - 5 people in two villages (Source: Head of the villages).

The results of the estimation of the percentage of household heads by educational level are shown in Figure 4. It shows that up to 26% of the household heads in the two villages are illiterate. About 30% of household heads have primary education. Thus, nearly 60% of household heads have low educational level. Such an education level of the household head has certainly limited the ability to access social information, markets, science and technology for economic and cultural development for the household. Meanwhile, education is the most important component to develop sustainable household livelihoods.





Both villages

Figure 4. Education levels of the head of household

Note: 9 (18.46%): the 9th grade in school with estimated 18.46% of HH numbers; If it is 0 that is illiterate



Figure 5. Number of children dropping out of school and percentage of households. Note: 0 (76.92) is 0 children dropping out of school with 76.92% of HH numbers

In both villages, 23% of households have 1-3 children dropping out of school including children never went to the school; up to 35% of households in Ia Brel village have 1-3 children dropping out of school, while in Ia Jol it was lower with 14% of households with an average of 1 child dropping out (Figure 5).

Thus, improved education should be made for both the elderly and children in the study area to ensure sustainable livelihood development.

3.2.3 Health insurance, social insurance, food security of the household

Between 2016 and 2020, according to Decision No. 50/2016 / QD-TTg (Prime Minister, 2016), the two studied villages have been categorized into the list of the extremely difficult villages belong to the communes in Ethnic Minority and Mountainous Areas, so health insurance was free for all family members. According to statistics, 93.8% of households have had this type of health insurance in recent years.

However, by 2021, the villages have escaped from the list of extremely difficult villages, so they will no longer receive the 100% health insurance subsidy as before; but people must pay $\frac{1}{2}$ of the health insurance fees. As a result, many households have not yet participated in this new health insurance.

Meanwhile, social insurance is even a new topic for urban residents who do not work for the state or private sector, so it is strange to farmers. Recently, the state introduced a program to buy voluntary social insurance among people. Its benefits are that people who do not work for the state or private companies with social insurance contributions, such as farmers, will receive 100% of their pension and health insurance upon retirement. In the studied villages, there are a few number of Village Heads, Village Vice Heads, Party Secretaries, Leaders of unions participating in voluntary social insurance; usually pay the minimum fee of 138,000 VND / month; meanwhile, almost no farmers are involved.

Up to 14/65 (21.5%) HH interviewed lack food in some years, usually 2 - 3 months; Often these are poor households, lacking basic livelihoods such as insufficient land, many sick family members, low education, etc. The solution of these households is often to borrow hot loans from the fertilizer and pesticide suppliers in the area. They pay high interest through agricultural products when they are harvested.

In terms of nutrition for children under 2 years old, through interviews, there is no major problem; Children are often given priority in nutrition despite being poor.

3.2.4 Drinking and domestic water of the household

Drinking water and domestic water are issues of concern in the study area; Because this is the area of natural water such as wells, lakes, rivers and streams that are often contaminated with lime and alum.

The drinking water sources of HH were categorized according to WHO/UNICEF (2018) presented in Table 6. Thanks to Olam's water filtration system, 74% of households in Ia Brel village and 21% of households in Ia Jol village have clean drinking water. Meanwhile, up to 25% of households do not have access to clean water, so they must buy bottled water to drink, usually those who are far from Olam's filtered water. 100% of Olam workers' families use dug water at their home for drinking; meanwhile Olam workers take drinking water from the piped water situtated inside the farm.

| Village/Object | Source of drinking water | | | | | |
|-----------------------|------------------------------|------|----------|-------|--|--|
| | Piped water (Olam) Dug water | | Packaged | Total | | |
| | | | water | | | |
| Ia Brel | 74% | 16% | 10% | 100% | | |
| Ia Jol | 21% | 34% | 45% | 100% | | |
| Surrounding Farmers | 20% | 60% | 20% | 100% | | |
| Olam Worker Famillies | 0% | 100% | 0% | 100% | | |
| Total | 45% | 30% | 25% | 100% | | |

Table 6. Categorizing drinking water sources of the households according to WHO/UNICEF (2018)

Note: % is Percentage of households

According to statistics, about 30% of households use self-filtered or unfiltered well water for drinking. Therefore, about 26/65 households interviewed (40% of households) suffer from intestinal disease, diarrhea every year or a few years, which may be due to unsanitary drinking water sources.

The domestic water source of the households is classified according to WHO / UNICEF (2018), shown in Table 7, which is mainly from two sources of dug water and pond. Dug water is often contaminated with lime, alum, and pond water is often not hygienic. Most households (97%) use dug water, 4.6% lack domestic water due to dry wells in the dry season.

| Village/Object | Source of domestic | Source of domestic water | | |
|---------------------|--------------------|--------------------------|------|--|
| | Dug water | Pond | | |
| Ia Brel | 97% | 3% | 100% | |
| Ia Jol | 97% | 3% | 100% | |
| Surrounding Farmers | 100% | 0% | 100% | |
| Olam Workers | 100% | 0% | 100% | |
| Total | 97% | 3% | 100% | |

Table 7. Categorizing domestic water sources of households according to WHO/UNICEF (2018)

Note: % is Percentage of households

3.2.5 Household housing

The statistical results show that about 60% of households have wooden houses, the rest are brick houses, some households have temporary houses (<5% of households) (Table 8). Wooden houses were mainly made more than 10 - 15 years ago, taking wood from surrounding natural forests; Currently, there is not much timber in the natural forests, and it is difficult to get wood, so many households have built brick houses. Particularly, some households cultivating around Olam farm have temporary houses (20% of households) and do not build permanent houses. They are farmers who migrated from other communes and districts build temporary houses on their farms around Olam's farm for annual crop cultivation. They stay there according to the seasonal schedule, and vacate these temporary houses to go their home when there is no field job.

| Village | Temporary | Wooden house | Brick house | Total |
|----------------------|-----------|--------------|-------------|--------|
| | house | | | |
| Ia Brel | 6.5% | 61.3% | 32.3% | 100.0% |
| Ia Jol | 0.0% | 62.1% | 37.9% | 100.0% |
| Surrounding farmers | 20.0% | 60.0% | 20.0% | 100.0% |
| Workers of Olam farm | 0.0% | 0.0% | 100.0% | 100.0% |
| Total | 4.5% | 59.7% | 35.8% | 100.0% |

Table 8. Percentage of households by housing type

3.2.6 Use of electricity and other energy

The national electricity grid was established in this area since 2011, people live along the inter-village axis, so most households use electricity; It is estimated that both villages have more than 93% of households using electricity from the grid. The number of households that do not have access to the electricity connection mainly in Ia Brel village accounts for about 13% of total households in which 10% use solar energy for the light. The households do not have grid electricity because they live on the fields far from the village and commune/village roads.

There is almost no public lighting system on rural roads, only a few solar-powered lights on the main road are installed by Olam in two villages.

3.2.7 Sanitation and sewage system of the household

Statistics on the percentage of households with toilets categorized according to WHO / UNICEF (2018) are presented in Table 9. It shows that about 27% of households have hygienic toilet (flush / pour flush); about 36% of household have relatively hygienic latrines (dry pit), the rest 36% do not have a facility (bush/field). Olam's workers are guaranteed to have hygienic toilets in the workplace.

In Ia Brel village, there are 62 households (42% of households), Ia Jol has 31 households (31% of households) that do not have a toilet (No facility / Bush / Field). Not making toilets here is more related to community living habits than not having enough money; In fact, it is observed that some households build large houses with good materials as the house in the urban but did not build toilets.

There are almost no public toilets in the village, only one dry pit latrine funded by Olam is built in the village hall area.

Like many rural mountainous areas in Vietnam, there is no domestic wastewater treatment system; Therefore, domestic wastewater has polluted rivers, streams, ponds and lakes in the area. Nearly 100% of households do not have sewage system.

| Village | Flush / pour | Dry pit | Composting | No facility / | Total |
|----------------------|--------------|----------|------------|---------------|-------|
| | flush | latrines | toilets | Bush/Field | |
| Ia Brel | 29% | 29% | 0% | 42% | 100% |
| Ia Jol | 17% | 48% | 3% | 31% | 100% |
| Surrounding farmers | 40% | 20% | 0% | 40% | 100% |
| Workers of Olam farm | 100% | 0% | 0% | 0% | 100% |
| Total | 27% | 36% | 1% | 36% | 100% |

Table 9. Percentage of households by toilet category according to WHO / UNICEF (2018)

3.2.8 Communication information

Modern communication technology has now reached remote villages, including fiberoptic Internet, Smartphone 3-4 G and Television. In the surveyed area, up to 10.7% of households connect to high-speed cable Internet, 78.5% of households use Smartphone 3-4 G to connect internet and 70-100% of households have television.

The connection to the internet, in addition to entertainment, also helps farmers to access socio-economic information, general science and technology. Farmers have in fact been on the internet to learn how to solve the production and life problems they face.

However, in terms of supporting agricultural and forestry production, information on the internet is limited, sometimes inaccurate, advertising from seeds, fertilizers, pesticides providers, ... makes farmers difficult to choose the correct information.

3.2.9 Social unions and household participation

Civil society organizations (CSO) that have not yet approached mountainous rural areas, so the activities are mainly from social unions such as the Farmers' Union, Women's Union, and Veterans Association.

Households participating in the Women's Union have some benefits such as supporting women to get loans from the Union, and women participating in social work. Joining Farmers' Association also helps households get more production information and technical advances. 65% of households have members who join these social unions.

Participation in social organizations and activities is an important component of household livelihoods, providing opportunities for farmers to have a voice, access to socio-economic development policies and reflect their aspirations.

However, these unions in practice have not brought real and effective benefits in rural mountainous development, improving household livelihoods, but mainly in administrative activities.

3.2.10 Household income level by income per capita

It is forecasted that when applying the new multidimensional poverty line in the period 2022 – 2025 (Prime Minister, 2021, Decree No. 07/2021 / ND-CP), the number of poor households will increase because indicators of the income per capita / month will be higher at 1.5 million VND. It is forecasted that the number of households that cannot reach this indicator will become poor households in the two villages at over 45 % (Table 10). Meanwhile, these two villages currently have poor households below 10% (Table 4) according to the current multidimensional poverty line with income per capita / month lower than 0.7 Million VND for the poor HH (Prime Minister, 2015; Decision No. 59/2015 / QD-TTg)

| HH income level based on income per capita per month in Mil. VND | | | | | | | | |
|--|----------------|------------------------|----------------|-------|--|--|--|--|
| Village | < 1.5 (Below | 1.5 – 2.25 (At average | > 2.25 (Above | Total | | | | |
| | minimum income | income indicator) | average income | | | | | |
| | indicator) | | indicator) | | | | | |
| Ia Brel | 45% | 26% | 29% | 100% | | | | |
| Ia Jol | 45% | 28% | 28% | 100% | | | | |
| Total | 45% | 27% | 28% | 100% | | | | |

Table 10. Rate of Household Income Levels based on Income Per Capita

3.3 Farming versus household livelihood

3.3.1 Agricultural land use right (Red Book) for households

100% of households in the two studied villages have not been granted agricultural land use rights (Red Book).

The first migrants reclaimed the forest for cultivation land, the latter continued to clear the forest or buy arable land from those who came first or from indigenous ethnic minorities. At present, the arable land of the residents here is almost stable, only a few households continue to clear the degraded forest and work on cultivation. Most of the HH do not have Red Book issued by the government as they are migrants and developed the land for farming in the last 15 to 20 years. Now the local commune government has taken initiative to issue the Red Book every year to the farmers after land survey. However at current agricultural land of HH is also now recognized but not officially; because according to the Land Law 2013 of Vietnam, in which HH who are using the land stably, have no disputes and are registered in the communal land book will be issued a Red Book.

Recently, Chu Puh district cadastral has measured the cultivated land of households to record and assign agricultural land use rights to households, but so far it has not been completed; In addition, some households also said that it is difficult for them to get the red book because the fee for issuing the certificate and measuring land is quite high compared to their income.

3.3.2 Land area and cultivated land area of household and factors affected to

The agricultural, cultivated, and contracted land areas of households in the study area are variable, CV% is between 120-140% (Table 11), meaning that there is a significant difference in assets across the land area among households; This is expected to affect household incomes and livelihoods, as land is an important factor in household livelihoods.

The average arable land per household is 2.0 hectares (Table 11) with the average number of people 4.6 people (Table 5), which is quite good compared to available land sources in the Central Highlands.

| | Count | Average | Standard | Coeff. of | Minimum | Maximum |
|------------------------------|-------|---------|-----------|-----------|---------|---------|
| | | (ha) | deviation | variation | | |
| Land area (ha/HH) | 67 | 2.20 | 2.746 | 124.7% | 0.0 | 17.0 |
| Cultivated land area (ha/HH) | 67 | 2.03 | 2.723 | 134.0% | 0.0 | 17.0 |
| Contracted land area (ha/HH) | 67 | 1.08 | 1.500 | 139.4% | 0.0 | 6.0 |

Table 11. Summary statistics of land area at household level

Therefore, using PCA to evaluate the factors (components) that were likely to affect the arable land of the household. There were 7 variables analyzed including: Land area, Cultivated land area, Contracted land area, Ethnic group, Number of family members, Number of farm working and Education level of the head of HH.

As a result, the first principal component (PC) had the equation: $PC = 0.521174 \times Land area + 0.496805 \times Cultivated land area 0.290094 \times Contracted land area + 0.415736 \times Ethnic group - 0.334403 \times Number of$ (5)

family members - $0.097032 \times Number$ of farm working + $0.321452 \times Education$ level of the head of HH

where the factors (components) with low weight (< 0.15) were considered as having no effect on the remaining factors (components) in the principal component model, they can be excluded. The greater the weight of a component (close to 1), the more important that factor plays a role in the whole components analyzed. If the weights of two variables have opposite signs (+ and -), then the two factors were inversely related, the increase in value of one factor will decrease the value of the other.

In the above equation, the variable of Number of farm working (the number of people of HH working in the field) with low weighs (weight = 0.097) had no significant impact on the other components of the equation. This shows that the household's land size was not influenced by the number of laborers in the field but by other factors.

As a result, remove the variable "Number of farm working" (Number of people working on farm) and run PCA again to get the first principal component had the equation and demonstrated in Figure 6:

 $PC = 0.535201 \times Land area + 0.511802 \times Cultivated land area -$ (6) $0.27169 \times Contracted land area + 0.41484 \times Ethnic group - 0.314514 \times Number$ of family members + 0.326791 \times Education level of the head of HH



Figure 6. Plot of component high weights of variables related to land area of households in the studied area

Note: The variables are in a circle are closely related to each other, the groups of variables in the opposite circles (with + and - weights) have inverse relationship.

The summary statistics of six variables in the selected principal component equation above presented in Table 12.

| | | | 5 | | | |
|---------------------|----------------|-----------------|--------------|-----------|-----------------|------------|
| Statistics | Number of | Education level | Ethnic group | Land area | Cultivated land | Contracted |
| | family members | of the head of | | (ha/HH) | area (ha/HH) | land area |
| | | HH | | | | (ha/HH) |
| Count | 67 | 67 | 67 | 67 | 67 | 67 |
| Average | 4.5 | 4.6 | 3.7 | 2.2 | 2.0 | 1.1 |
| Standard deviation | 1.457 | 3.476 | 1.428 | 2.746 | 2.723 | 1.499 |
| Coeff. of variation | 31.6% | 75.1% | 38.1% | 124.7% | 133.9% | 139.3% |
| Minimum | 2.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 9.0 | 12.0 | 6.0 | 17.0 | 17.0 | 6.0 |

Table 12. Summary statistics of components in principal component equation related to landarea of the households

Note: Education level of the head of HH and Ethnic Minority variables coded (Annex 5)

In the PCA equation shows:

- The variables Land area and Cultivated land area had close relationship with each other. This means that the more land a household has, the more cultivated land they use.
- The variables Education level of the head of HH and Ethnic group were also positively and closely related and positively related to the household's land area. This means that with a higher educational level of the household head, the household had access to more land. Cultivated land areas increased in the order of the Muong, H Mong, Dao, Nung, Tay and Kinh ethnic groups.
- Two variables Contracted land area and Number of family members had negative weights, so they had the opposite effect to land area. This means that households with little or no cultivable land such as newly migrant households or newly separated young households rent more land for cultivation. The number of people in the household is inversely to the cultivated land of the household, indicating that large households were more likely to work as hired labor or workers than working on farm.

An assessment was made on whether there was a difference in the average farmland area of the household among the two studied villages (Ia Brel and Ia Jol) and surrounding famers; and among households with different income levels. ANOVA results showed no difference between these two factors with P-Value> 0.05 (Table 13). This result showed that the household's land size was not affected by the household's income level, in other words, other households with income from farming also have other income such as hired labor, animal husbandry, etc.

| Table 13. | Analysis | of Variance | e for Land | l area | $(ha) b_{j}$ | y two | factors | of HH | Income | Level | and |
|-----------|----------|-------------|------------|--------|--------------|-------|---------|-------|--------|-------|-----|
| | | | | Villa | ige | | | | | | |

| | | • | | | |
|---------------------------|----------------|----|-------------|---------|---------|
| Source | Sum of Squares | Df | Mean Square | F-Ratio | P-Value |
| MAIN EFFECTS | | | | | |
| A: Household Income Level | 23.1938 | 2 | 11.5969 | 1.51 | 0.2284 |
| B: Village | 4.49462 | 3 | 1.49821 | 0.20 | 0.8991 |
| RESIDUAL | 467.626 | 61 | 7.666 | | |
| TOTAL (CORRECTED) | 497.772 | 66 | | | |

Meanwhile, the ANOVA analysis by ethnic group factor showed a significant influence on the size of the land hired by households to cultivate, P-Value = 0.0004.

The results of the grouping of ethnic groups with different farming land lease areas in Table 14 with homogenous groups are identified using columns of X's. Within each column, the levels containing X's form a group of means within which there are no statistically significant differences. There were 3 ethnic groups with differences in land lease: Group 1 including Muong (Code 1), Kinh (Code 6) and Tay (Code 5) hardly rent land; Group 2 includes the Nung (Code 4) and H Mong (Code 2) who rent out cultivated land on average from 1.0 to 1.2 ha / HH; The group of Dao ethnic group (Code 3) had the highest average land lease area, 2.1 ha / HH.

| Ethnic group (Code) | Count | LS Mean | LS Sigma | Homogeneous Groups |
|---------------------|-------|---------|----------|--------------------|
| | | (ha/HH) | | |
| 1 | 2 | 0.0 | 0.920902 | XX |
| 6 | 13 | 0.0 | 0.361208 | Х |
| 5 | 5 | 0.0 | 0.58243 | XX |
| 4 | 16 | 1.0 | 0.325588 | Х |
| 2 | 11 | 1.26364 | 0.392674 | XX |
| 3 | 20 | 2.11 | 0.291215 | Х |

Table 14. Multiple range tests for Contracted land area (ha) per HH by Ethnic group

Note: Method: 95.0 percent LSD (Fisher's least significant difference (LSD) procedure). Codes of Ethnic group presented in Annex 5

3.3.3 Main crops and its effect on the total income of the household

In the two research villages and small farmers around Olam pepper farm, there are the following crops: Cassava, Cashew, Pepper, Maize, Bean, Coffee, Rice, Jackfruit, Avocado, Mango, Tomato, Bitter gourd, *Santalum paniculatum* Hook. & Arn. (Đàn Hương), *Sterculia foetida* L. (Trôm) and Teak (*Tectona grandis* L.f.) (Tếch) (Figure 7). Most crops are for sale, only rice is used as food for the family.

The average crop area and its statistical summaries of the household in each village are shown in Table 15. From here, along with the number of households in each village, the total cultivated area of crops in two study villages is estimated (Table 16)

| | Cassava area | Cashew area | Pepper area | Maize area | Bean area |
|---------------------|--------------|-------------|-------------|------------|-----------|
| Ia Brel Village: | | | | | |
| Count | 31 | 31 | 31 | 31 | 31 |
| Average | 1.42903 | 0.76129 | 0.0290323 | 0.580645 | 0.148387 |
| Standard deviation | 1.86997 | 1.38316 | 0.100643 | 1.20012 | 0.294246 |
| Coeff. of variation | 130.856% | 181.686% | 346.66% | 206.687% | 198.296% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 8.0 | 6.0 | 0.5 | 4.5 | 1.0 |
| Ia Jol Village | | | | | |
| Count | 29 | 29 | 29 | 29 | 29 |
| Average | 2.43103 | 1.06207 | 0.296552 | 0.177586 | 0.0327586 |
| Standard deviation | 2.82414 | 2.55153 | 0.389581 | 0.328304 | 0.103748 |
| Coeff. of variation | 116.17% | 240.241% | 131.37% | 184.87% | 316.703% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 13.5 | 13.5 | 1.3 | 1.2 | 0.45 |

Table 15 Summary statistics of main crops area of the household

| | Cassava area | Cashew area | Pepper area | Maize area | Bean area |
|---------------------|--------------|-------------|-------------|------------|-----------|
| Count | 67 | 67 | 67 | 67 | 67 |
| Average | 1.89254 | 0.883582 | 0.155224 | 0.345522 | 0.0828358 |
| Standard deviation | 2.34988 | 1.95166 | 0.302657 | 0.866844 | 0.218561 |
| Coeff. of variation | 124.165% | 220.88% | 194.981% | 250.879% | 263.849% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 13.5 | 13.5 | 1.3 | 4.5 | 1.0 |

Note: Area of crops in ha/HH

Table 16. Estimated total crops area and the rate at the village level

| Crop | Ia Brel | | Ia Jol | | Both villages | |
|--------------------------------|-----------|------------|-----------|------------|---------------|------------|
| | Area (ha) | Percentage | Area (ha) | Percentage | Area (ha) | Percentage |
| Cassava | 210.07 | 46.3% | 245.53 | 55.7% | 455.60 | 51.0% |
| Cashew | 111.91 | 24.7% | 107.27 | 24.3% | 219.18 | 24.5% |
| Maize | 85.35 | 18.8% | 17.94 | 4.1% | 103.29 | 11.6% |
| Pepper | 4.27 | 0.9% | 29.95 | 6.8% | 34.22 | 3.8% |
| Bean | 21.81 | 4.8% | 3.31 | 0.8% | 25.12 | 2.8% |
| Rice | 11.38 | 2.5% | 9.75 | 2.2% | 21.13 | 2.4% |
| Coffee | 4.74 | 1.0% | 4.18 | 0.9% | 8.92 | 1.0% |
| Jackfruit | 2.37 | 0.5% | 5.22 | 1.2% | 7.59 | 0.8% |
| Avocado | 0.00 | 0.0% | 5.22 | 1.2% | 5.22 | 0.6% |
| Mango | 0.00 | 0.0% | 3.48 | 0.8% | 3.48 | 0.4% |
| Tomato | 0.95 | 0.2% | 0 | 0.0% | 0.95 | 0.1% |
| Bitter gourd | 0.47 | 0.1% | 0 | 0.0% | 0.47 | 0.1% |
| Santalum | 0.00 | 0.0% | 3.48 | 0.8% | 3.48 | 0.4% |
| <i>paniculatum</i> Hook. | | | | | | |
| & Arn. (Đàn | | | | | | |
| Hương) Stammulin fa stida I | 0.00 | 0.00/ | 2 40 | 0.90/ | 2 49 | 0.40/ |
| (Trôm) | 0.00 | 0.0% | 3.48 | 0.8% | 3.48 | 0.4% |
| Tectona grandis L.f. | 0.00 | 0.0% | 1.74 | 0.4% | 1.74 | 0.2% |
| (Teak) | | | | | | |
| Total | 453.33 | 100.0% | 440.57 | 100.0% | 893.87 | 100.0% |







Cashew



Pepper climbing Senna siamea



Jackfruit



Coffee







The main crops grown in the two villages are Cassava, Cashew, Maize, Pepper, Bean, the area of Rice and Coffee is not much. In addition, there are some households growing fruit trees such as Jackfruit, Avocado, Mango, Tomato and Bitter gourd. Some households have experimented with planting forest trees such as *Santalum paniculatum* Hook. & Arn. (Dan Huong), *Sterculia foetida* L. (Trom), *Tectona grandis* L.f. (Teak) (Table 16)

The PCA was conducted among the variable Total income of HH and variables of areas of crops and as a result, the first principal component had the equation below:

 $PC = 0.440732 \times Total \ income + 0.530088 \times Cassava \ area + 0.487846 \times Cashew$ $area + 0.312418 \times Pepper \ area - 0.263982 \times Maize \ area - 0.30782 \times Bean \ area + 0.0515393 \times Coffee \ area + 0.148549 \times Rice \ area$ (7)

In the PCA equation above, the variables of Coffee Area and Rice Area are of low weights, meaning that they had a negligible influence on the component model; In other words, the cultivation of coffee and rice is on a small scale and did not affect the household income.

As a result, remove the two variables of coffee area and rice area from the model, then the final principal component had the following equation and demonstrated in Figure 8:

 $PC = 0.433829 \times Total \ income + 0.540049 \times Cassava \ area + 0.49651 \times Cashew$ $area + 0.32169 \times Pepper \ area - 0.273645 \times Maize \ area - 0.308628 \times Bean \ area$ (8)



Figure 8. Plot of component weights of variables of total income of household with area of main crops

Note: The variables are in a circle are closely related to each other, the groups of variables in the opposite circles (with + and - weights) have inverse relationship.

The results indicated that Total Income of HH was positively and closely related to two main crops of Cassava and Cashew, while Pepper contributed a little but not much to the income of households in the studied area. Meanwhile, households that mainly cultivated Bean and Maize had lower incomes.

3.3.4 Soil, fertilizer, pesticides, herbicides and crop productivity

Most of the soil in the region has high content of sand and gravels, so the ability to accumulate organic nutrients is poor. In addition, hot weather causes the soil to dry out in the dry season, and the soil is often waterlogged in the rainy season. This is a characteristic of the soil in the distribution areas of the dipterocarp forest. Such soil makes it difficult to choose suitable crops and affects crop productivity. Therefore, there was no diversity in crops in the area, two main types of cash income crops were cassava and cashew.

However, almost 100% of households annually use chemical fertilizers, pesticides, herbicides, growth stimulants for crops; Few households apply organic fertilizers.

Many single chemical fertilizers and NPK are used mostly for different crops. The reason for continuous application of chemical fertilizers is due to the high sandy soil, low nutrient content soil that if farmers do not apply chemical fertilizers, there will be no yield, even for the plants that can grow in extreme poor soil conditions such as cassava and cashews.

A particularly serious problem is the widespread use of herbicides, that content mainly Paraquat and Glyphosate. The use of herbicides has brought labor efficiency to the farmer by reducing manual weeding. Biological herbicides method most farmers do not know.

The consequences of using herbicides are exceptionally large, first of all affecting the health of the sprayers, and in the long term, polluting surface and underground water sources and

soil. According to village leaders, toxic herbicides have been banned from sale, but through household interviews, farmers can still buy and use them on their farms.

Productivities of some major crops were estimated in Table 17. It showed that Cassava, Maize and Bean productivities in the region were moderate, while cashew and pepper were low. Productivities of the crops were related to the quality and suitability of the soil for the crop and the investment in farming by households.

| Object | Fresh | Fresh | Dried | Dried | Dried Bean |
|---------------------|---------|--------|--------|-------|------------|
| | Cassava | Cashew | Pepper | Maize | |
| Ia Brel | 12.61 | 0.22 | 1.27 | 4.61 | 0.84 |
| Ia Jol | 13.09 | 0.57 | 0.86 | 3.70 | 0.89 |
| Surrounding Farmers | 18.13 | 0.40 | 1.40 | | |
| Olam workers | 14.50 | | | | |
| Total | 13.36 | 0.41 | 0.97 | 4.23 | 0.86 |

Table 17. Averaged productivity of main crops in the studied area

Note: Productivity Unit: ton/ha/year

Meanwhile, the perennial cassava monoculture has made the soil degraded and led to a decrease in yield. The low yield of pepper was mainly due to lack of watering and poor growth. Cashew yield was low partly because a number of households have just planted and begun to harvest.

Some fruit trees planted by some households in the area have had good growth and yield such as avocado, Thai Land jackfruits from seeds or grafted. Teak grows fast on suitable soil such as low sand ratio, gravel soil.

Total yield per year of main crops at village level were predicted based on estimated total area and averaged productivity of each main crops at village level presented in Table 18.

| Village | Fresh Cassava | Fresh Cashew | Dried Pepper | Dried Maize | Dried Bean |
|---------|---------------|--------------|--------------|-------------|------------|
| Ia Brel | 2,649 | 25 | 5 | 393 | 18 |
| Ia Jol | 3,214 | 61 | 26 | 66 | 3 |
| Total | 5,863 | 86 | 31 | 460 | 21 |

Table 18. Total yield of main crops in the studied villages

Note: Yield Unit: ton/year/village

3.3.5 Livestock and Vet versus household income level

Domestic animals in the study area include goats, cows, pigs, chickens and ducks. The summary statistics for each type of livestock per HH are shown in

Table 19. Goats and cows for sale were nearly 100%, pigs were usually 30% for HH consumption and 70% for sale; 70% of chickens and ducks for HH consumption, 30% for sale. CV% rate of each type of livestock is very large (> 260%), indicating a large difference in husbandry among households; Some households do not breed livestock, others raise a lot, and also grow grass to raise goats and cows.

| | Number of |
|---------------------|-----------|-----------|-----------|-----------|-----------|
| | Goats | Cows | Pigs | Chickens | Ducks |
| Ia Brel village | | | | | |
| Count | 31 | 31 | 31 | 31 | 31 |
| Average | 2.32258 | 0.806452 | 0.193548 | 23.7097 | 2.90323 |
| Standard deviation | 7.34115 | 1.57944 | 0.601074 | 41.9318 | 10.0643 |
| Coeff. of variation | 316.077% | 195.85% | 310.555% | 176.855% | 346.66% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 30.0 | 6.0 | 3.0 | 200.0 | 50.0 |
| Ia Jol village | | | | | |
| Count | 29 | 29 | 29 | 29 | 29 |
| Average | 2.44828 | 0.275862 | 0.482759 | 19.0345 | 1.58621 |
| Standard deviation | 4.30603 | 0.996299 | 1.68228 | 37.3998 | 4.93904 |
| Coeff. of variation | 175.88% | 361.158% | 348.471% | 196.485% | 311.374% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 16.0 | 5.0 | 7.0 | 200.0 | 20.0 |
| All | | | | | |
| Count | 67 | 67 | 67 | 67 | 67 |
| Average | 2.13433 | 0.492537 | 0.298507 | 20.9254 | 2.1791 |
| Standard deviation | 5.73637 | 1.28362 | 1.18084 | 39.0677 | 7.62557 |
| Coeff. of variation | 268.767% | 260.613% | 395.583% | 186.7% | 349.94% |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Maximum | 30.0 | 6.0 | 7.0 | 200.0 | 50.0 |

Table 19 Summary statistics of numbers of livestock at household level

Based on averaged numbers of livestock from HH interviews, total numbers of livestock were estimated in the two studied villages presented in Table 20.

| Livestock | Ia Brel village | Ia Jol village | Both villages |
|-----------|-----------------|----------------|---------------|
| Goat | 341 | 247 | 589 |
| Cow | 119 | 28 | 146 |
| Pig | 28 | 49 | 77 |
| Chicken | 3485 | 1922 | 5408 |
| Duck | 427 | 160 | 587 |

Table 20. Estimated total numbers of livestock in the two studied villages

Note: Data of total numbers of livestock in the village and both

Therefore, the main husbandry here is goats and cows (Table 20). Many households also raise chickens a lot to provide food for them.

Livestock here also had access to new breeds of cows and goats, some households grew grass to raise cows, grew acacia trees for climbing pepper and feed acacia leaves for goats. Cow and goat manure was also used to fertilize crops.
Veterinary services of the government programs at district and commune levels carry out national vaccination programs for livestock. In animal husbandry, most households use private veterinary services in Ia Le (Gia Lai) and Ea HLeo communes (Dak Lak) to buy medicine for livestock, vaccination, crossbreeding, etc.

3.3.6 Water source for farming

There were 32/67 (48%) interviewed HH required water sources for farming. Crops that require watering include pepper, coffee, fruit trees, rice, bean, maize, grass for raising and raising duck.

Households mainly used water from ponds (31%), from wells (13%) for irrigation (Table 21); In fact, few households use water from streams to irrigate crops, as streams dry up in the dry season. Up to 100% and 74% of HH in Ia Brel and Ia Jol villages, respectively who use irrigation lack water especially for pepper and fruit trees in the dry season due to dried-up water sources.

| | Source of water for farming | | | | | |
|---------------------|-----------------------------|------|------|--------|-------|--|
| Village | No need | Well | Pond | Stream | Total | |
| Ia Brel | 74% | 6% | 13% | 6% | 100% | |
| Ia Jol | 34% | 21% | 45% | 0% | 100% | |
| Surrounding Farmers | 20% | 0% | 80% | 0% | 100% | |
| Olam Worker | 50% | 50% | 0% | 0% | 100% | |
| Famillies | | | | | | |
| Total | 52% | 13% | 31% | 3% | 100% | |

Table 21. Household percentage per water sources for watering crops in the studied area

3.3.7 Fire used for farming

Using fire in cultivation here was quite common, 52% of the households interviewed used fire in cultivation, mainly to clear the fields of cassava and cashew branches every year.

Using fire to clear the fields was positive to replenish coal ash as a micro-fertilizer for crops, destroy pathogens and weeds. However, the consequences of burning were often greater, first it emitted CO_2 – a greenhouse gas, polluted the air, then killed useful organisms and microorganisms and made soil harden.

3.3.8 Monoculture versus multi-crop and intercropping

The cultivation in this area is mainly monoculture, with cassava or cashew, or pepper. The limitations of monoculture are obvious, farmers are often at risk of depending on one agricultural product; Pests, diseases, and soil degradation happen strongly, so farmers have to use more fertilizers and chemicals, thereby polluting agricultural products, polluting the environment, and harming the health of the community.

However, about 37% of the interviewed households applied some simple models of agroforestry and crops rotation; an example of agroforestry is cassava intercropping in a cashew field for the first 2-3 years (Figure 9), a model of mango - cassava, cashew - bean - corn. There were also a number of pepper growing models with a variety of wood trees for pepper climbing, such as *Acacia* sp. and its leaves also for fodder, teak (*Tectona grandis* L.f.) trees, and *Senna siamea* (Lam.) H.S.Irwin & Barneby (Muong den) or rotation of maize – beans. These models are forecasted to have a certain potential to bring about economic and environmental benefits,

but not many households have applied them, because the effectiveness is unclear of either the model is still newly planted or has not been fully evaluated.



Figure 9. Model of intercropping cashew and cassava on sandy soil

Monoculture cultivation and the application of many chemical fertilizers, pesticides, herbicides, fire, lack of water for irrigation on nutrient-poor sandy soil have greatly affected public health, the environment, and suffered market risks; Therefore, continuing research to develop suitable agroforestry models that will play an important role in reducing chemical, improving soil, keeping soil moisture, and diversifying farming products should be a direction that needs attention for the region.

3.4 Agriculture and forestry extension services for the household

Agricultural and forestry extension services in the region are ineffective; Up to 51/67 (76%) of the interviewed households did not receive or participate in the state extension services. Most households self-learn and learn from each other to develop cultivation and husbandry.

Some households received agricultural extension such as training on planting fruit trees, growing pepper, new maize varieties, raising goats and cows ... organized by the commune farmers' union, the agricultural division and agriculture extension station of Chu Puh district. Some commercial company provided instructions for the use of fertilizers and pesticides.

However, there are also opinions that agricultural extension activities were not useful, such as training in selecting crops by soil types, but nothing new, not as quality as training on pepper cultivation techniques. The commune rangers also advised villagers for forest plantation, but this was not applicable.

In general, the State's agricultural extension activities for farmers in the region have not made sense, have not helped farmers improve farming and husbandry clearly; especially when this is an area with extreme climatic and soil conditions.

3.5 Local watershed management versus household livelihoods

The cultivated and inhabited area of the two studied villages together with the Olam Pepper Farm is located in the landscape of a small basin that flows water into the Ea HLeo River (the boundary between Dak Lak and Gia Lai provinces). This local catchment has a length of streams originating from the hillsides and extending around 5-8 km, flowing through the cultivated area, home gardens of two villages and Olam farms, and into the Ea Hleo River. This watershed system provides domestic water and irrigation for local people and for the reservoirs of the OLam pepper farm.

Hydrological characteristics of the dipterocarp forest ecoregion are often less water or drought in the dry season. At present, the remaining forest cover in the watershed area is low, strongly degraded, the density and forest canopy are low. In particular, deforestation along the upstream corridor increased the drought, almost unable to keep surface water in the dry season, and at the same time the groundwater level also decreased.

According to the HH interview results, the households' wells were dry, or less water in the dry season, not enough water for domestic use and irrigation for the crops. In addition, the lack of forest cover in the basin is expected to fill the irrigation lakes of the Olam pepper farm. At the same time, in the rainy season, forests in the basin and along streams were not covered enough to keep and filter water, so the stream flowed strongly, causing inundation for the cultivated areas of the two villages, the roads of village, Olam farm below; Water was mixed with alluvial soil, so the quality was poor.

In terms of watershed resources management in this locality, official environmental agencies were hardly interested; Most of rivers and streams were polluted due to waste, chemicals of fertilizers, pesticides, herbicides discharged from cultivated areas into streams. Therefore, the natural surface water and groundwater resources of this area are predicted to be quite chemically polluted.

3.6 Management of biodiversity, forest resources and impacts on existing degraded forests

3.6.1 Management of the natural forests around Olam pepper farm

This is an ecological area distributing DDF on a large, flat plateau. The topography is more favorable for farming than other steep hilly areas in the Central Highlands, although the soil and climate are quite harsh; Therefore, many ethnic minority communities in the North migrated here, cleared forests for cultivation land, cut wood for houses, barns, firewood, and burned coal. The rate of forest cover in the area decreased sharply in the period 1998 - 2005; The remaining natural forest is strongly degraded dipterocarp forest, which is distributed mainly to the east of Olam pepper farm, in the mountains.

The forest here has no forest owners, currently, the People's Committee of Ia Le commune is managing on behalf of the state. And there are two forested hills to the east and west of Olam pepper farm with about 336 hectares that the Department of Agriculture and Rural Development of Gia Lai Province agrees to assign to Olam to implement a voluntary, non-profit reforestation project (Figure 10).

The policy of forest allocation to ethnic minorities in the Central Highlands has been implemented mainly from 2000-2005, but in this area the ethnic minorities in the north came later and were mainly interested in cultivated land for livelihood stabilization. Therefore, there was hardly any policy implementation on forestland allocation to these migrant communities (Hung et al., 2020; Huy, 2019)

Interviews showed that most of the people here do not know who the real forest owner is; 94% of the interviewed households do not know the forest owners around the village and Olam Pepper Farm. They believe that no one is managing and protecting these forests, so people are free to take timber, collect firewood, burn coal, and cut forests for farming land. Recently, some households of Ia Brel village have applied to receive forest land on Chu Mang mountain for afforestation, reforestation to combine livestock (Source: village leader Ia Brel)



Figure 10. Map of Landscape of Olam Pepper Farm and surrounding forest hills

In addition to the previous extraordinarily strong impacts on the natural forests from the mass migration in search of new life; Now that no one seems to manage and protect the remaining forests, so the impacts on the forest are still going on. It is predicted that if this continued, the forests around the village Ia Brel and Olam farm would be gone in a few years.

On the two forest hills east and west of Olam farm (Figure 10) that Gia Lai province assigned Olam to implement a project of voluntarily forest rehabilitation; still affected. In the eastern forest hill, there are several wooden houses and a few hectares of cassava and cashew, charcoal kilns. In the western forest hill, there is a log hut and several hectares of cassava, where local people are free to cut timber (Figure 11).



Housing and growing cashew and cassava on the eastern forest hill of Olam farm



Illegal burning wood for charcoal on the eastern forest hill of Olam farm



Illegal logging on the western forest hill of Olam farm

Figure 11. Farming, charcoal making, and illegal logging still occur on degraded forest hills to the east and west of Olam farm.

3.6.2 *Current use of wood, firewood, collection of NTFPs, and hunting of wild animals in the studied villages*

About 10 years ago, the communities of the two studied villages used a lot of natural forest products. Most households used timber for house construction, so up to now 60% of households still maintain their wooden houses (Table 8). Nowadays, large trees from the forest for house construction are almost no longer present in the nearby forests. In addition, the cutting of trees for growing pepper took place strongly, the tree dominant species of the dipterocarp forest that is preferred for the pillar for pepper climbing is *Shorea obtusa* Wall, has been almost gone. Wildlife hunting was also popular before 2012, now there are almost no animals to hunt. In the past, NTFPs were also exploited a lot such as rishi mushrooms (*Ganoderma* lucidum (Leyss ex. Fr.) Karst.), bamboo shoots and honey. Currently, there are not many rishi mushrooms, but honey and bamboo shoots are still collected by some households for own consumption and sale.

The current available forest products of the degraded natural forest in the area are mainly honey, bamboo shoots and firewood.

Currently, in Ia Brel village, the proportion of households using firewood is 35%, higher than that in Ia Jol is 14% (Figure 12). The settlement of Ia Brel village is closer to the forest and uses more firewood, including coal. However, interviews showed that because the remaining forests are quite far from 5 to 10 km, most of the households use firewood in the field from cashew branches, dried cassava stems, and rubber branches.



Both villages

Figure 12. Percentage of households using fuels for cooking Note: 1: Firewood, 2: Firewood and gas; 3: Gas

Currently, 18% of households collect forest honey for sale and about 37% of households collect bamboo shoots for food. Table 22 shows summary statistics on average amount of honey and bamboo shoots harvested by the household per year. The volume of these two types of NTPFs collected was not much. ANOVA was performed to test the effect of two variables of the amount of honey and bamboo shoots on total household income in the year (Table 23). As a result, it figured out that these two types of NTFPs had a negligible effect (P-Value> 0.05) on total household income for the year. NTFPs have just provided food for households and for sale a little.

 Table 22. Summary statistics of forest honey and bamboo shoots collected by households in the two studied villages

 Forest honey (liter/HH/year)

 Bamboo shoots (kg/HH/year)

| | Forest honey (liter/HH/y | ear) Bamboo shoots (kg/HH/year) |
|---------------------|--------------------------|---------------------------------|
| Ia Brel village | | |
| Count | 31 | 31 |
| Average | 1.14516 | 5.06452 |
| Standard deviation | 2.72395 | 14.064 |
| Coeff. of variation | 237.866% | 277.697% |
| Minimum | 0.0 | 0.0 |
| Maximum | 10.0 | 60.0 |
| Ia Jol village | | |

| | Forest honey (liter/HH/year) | Bamboo shoots (kg/HH/year) |
|---------------------|------------------------------|----------------------------|
| Count | 29 | 29 |
| Average | 0.0862069 | 15.0 |
| Standard deviation | 0.329203 | 23.566 |
| Coeff. of variation | 381.875% | 157.107% |
| Minimum | 0.0 | 0.0 |
| Maximum | 1.5 | 100.0 |
| Both villages | | |
| Count | 65 | 65 |
| Average | 0.584615 | 11.2615 |
| Standard deviation | 1.9537 | 20.6006 |
| Coeff. of variation | 334.186% | 182.929% |
| Minimum | 0.0 | 0.0 |
| Maximum | 10.0 | 100.0 |

 Table 23. Analysis of Variance for Total income of the household effected by Forest honey and
 Bamboo shoots

| Source | Sum of Squares | Df | Mean Square | F-Ratio | P-Value |
|-------------------|----------------|----|-------------|---------|---------|
| MAIN EFFECTS | | | | | |
| A: Forest honey | 27024.2 | 6 | 4504.04 | 0.72 | 0.6392 |
| B: Bamboo shoots | 51429.4 | 10 | 5142.94 | 0.82 | 0.6143 |
| RESIDUAL | 302323. | 48 | 6298.39 | | |
| TOTAL (CORRECTED) | 375807. | 64 | | | |

3.6.3 Current forest state around the OLAM pepper farm and consequences of loss and degradation of natural dipterocarp forest on household livelihoods and environment

The forests here have been severely destroyed over the past 20 years by ethnic minority groups who migrated from the north to collect cultivated land, and form villages like today. The remaining forests are scattered on hills, mountain ranges, and strongly degraded. Forest canopy and density of trees are low, dispersion pattern of spatial distribution is clumped. Most of the large and precious trees were lost due to the cutting of timber for house construction and pillars for pepper climbing. Forest animals are almost gone. Dipterocarp forest soil is not thick, with a high rate of gravel and floating rocks (Figure 13). Some woody forests are mixed with bamboo forest (*Gigantochloa nigrociliata* (Buse) Kurz.) with averaged culm diameter around 3 cm, averaged culm height at 6 m and culm density estimated approximately are 12,400 culm/ha (Source: Sample plot of this study).





Degraded dipterocarp forest stands with low density, low canopy, small trees and dispersion pattern is clumped



Bamboo forest (*Gigantochloa nigrociliata* (Buse) Kurz.)

Soil in dipterocarp forest has high rate of stones, rocks

Figure 13. Photos of current forest state around the Olam Pepper farm

The current large mammal species no longer exist due to the loss of habitat, the remaining ones are mainly some birds and small mammals such as wild mice, squirrels, and civets (Table 24). This survey confirmed that there still exist six species of wood plant and one herbaceous plant which are rare and endangered species in red list, including small size trees, bad shape (

Table 25).

Table 24. List of wild animals existing in two transects in the eastern and western forest hills ofOlam pepper farm

| - | | | | | | | |
|----|-----------------|-----------------------|----------------|----------|------------|------------------|------------|
| | Species name in | Species name in Latin | | Class | Trace type | Estimated | Estimated |
| Id | Vietnamese | | | | | number of | number of |
| | | | | | | individuals | herds (if |
| | | | | | | (if | possible) |
| | | | | | | (ii possible) | possiole). |
| | | | | | | possible) | |
| | En (Nhạn rừng) | Artamus fuscus | Vieillot, 1817 | Aves | Visibility | 13 | 2 |
| 1. | | | | | | | |
| | Bìm bịp nhỏ | Centropus | (Gmelin, | Aves | Visibility | 1 | |
| 2. | | bengalensis | 1788) | | | | |
| | Chích chòe lửa | Copsychus | (Scopoli, | Aves | Chatter | 1 | |
| 3. | | malabaricus | 1786) | | | | |
| | Chuột núi | Leopoldamys sabanus | (Thomas, | Mammalia | Leftovers | 1 | |
| 4. | | | 1887) | | | | |
| | Sóc vằn lưng | Menetes berdmorei | (Blyth, 1849) | Mammalia | Visibility | 1 | |
| 5. | | | | | | | |
| | Vàng anh | Oriolus xanthornus | (Linnaeus, | Aves | Chatter | 1 | |
| 6. | | | 1758) | | | | |

| | Species name in | Species name in Latin | | Class | Trace type | Estimated | Estimated |
|-------|----------------------|------------------------|--------------|----------|------------|-------------|------------|
| Id | Vietnamese | | | | | number of | number of |
| | | | | | | individuals | herds (if |
| | | | | | | (if | possible). |
| | | | | | | possible) | |
| | Chích bông nâu | Orthotomus ruficeps | (Lesson, | Aves | Visibility | 1 | |
| 7. | | | 1830) | | | | |
| | Cu rốc Đông Dương | Psilopogon | (Robinson & | Aves | Chatter | 3 | |
| 8. | | annamensis | Kloss, 1919) | | | | |
| | Chào mào đít vàng | Pycnonotus flavescens | Blyth, 1845 | Aves | Visibility | 2 | |
| 9. | | | | | | | |
| | Cu gáy | Streptopelia chinensis | (Scopoli, | Aves | Visibility | 1 | |
| 10. | | | 1786) | | | | |
| | Cầy sp. | Viverridae | | Mammalia | Feces | 1 | |
| 11. | | | | | | | |
| Sourc | ce: This study, 2021 | | | | | | |

Table 25. List of forest plant species in IUCN, Viet Nam Red List and Decree 06/2019/ND-CP existing in two transects in the easter and western forest hills of Olam pepper farm

| Id | Species name in | Species name in | | Living | IUCN | Viet | Decree |
|----|-----------------|--------------------|----------|-------------|----------|---------|----------|
| | Vietnamese | Latin | | form | 2020 | Nam Red | 06/2019/ |
| | | | | | Red List | Book | NÐ-CP |
| | | | | | | 2007 | |
| 1 | Cẩm lai | Dalbergia oliveri | Prain | Woody | EN | EN | IIA |
| | | | | | | | |
| 2 | Giáng hương quả | Pterocarpus | Kurz | Woody | EN | EN | IIA |
| | to | macrocarpus | | | | | |
| | ~ . ~ | ~ | | | | | |
| 3 | Gụ mật, Gõ mật. | Sindora siamensis | Mıq. | Woody | | EN | IIA |
| 4 | Sến mật, Cà | Shorea roxburghii | G.Don | Woody | VU | | |
| | đoong, Sến mủ | 0 | | 2 | | | |
| | , | | | | | | |
| 5 | Sơn huyết, Sơn | Gluta laccifera | Ding Hou | Woody | | VU | |
| | đào | | | | | | |
| 6 | Trắc | Dalbergia | Pierre | Woody | | EN | IIA |
| | | cochinchinensis | | 5 | | | |
| 7 | Tuế lá chả | Cycas micholitzii | Dyor | Harbacaous | VII | | ΠΛ |
| / | | Ο γεας πιεποιτιζιί | Dyci | Tierbaccous | ٧U | | шл |

Source: This study, 2021

Note: IUCN: Red List: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Near Threatened: NT Vietnam Red Book: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Lower risk: LR; Conservation dependent: CD; Near Threatened: NT; Least concern: LC; Data deficient: DD; Not evaluated: NE. Decree 06/2019: Consisting of two groups of species IA: Strict protection or IIA: Limited exploitation and trading

The current diameter distribution with diameter at breast height (D, cm) > 5 cm was a reverse J-shaped diameter distribution (Figure 14), which was estimated to have a density of 858 trees / ha, concentrated in trees with small sizes with D < 15 cm, most of the trees have poor

quality, shape and clumped dispersion pattern, low forest canopy from 10-30%. The tree layer has dominant species with density ratio (N%) > 5% with 3 species, > 3% with 11 species, mainly the species belong to Dipterocarpaceae family (Table 26).



Figure 14. Diameter distribution of tree layer with diameter at breast height (D) greater than or equal to 5 cm in the easter and western forest hills of Olam pepper farm

| Id | Vietnamese species | Latin species name | | N (Number | N % |
|-----|--------------------|-------------------------|---------------------|--------------|---------|
| | name | | | of trees/ha) | |
| 1. | Cẩm liên | Pentacme siamensis | (Miq.) Kurz | 75 | 8.82% |
| 2. | Căm xe | Xylia xylocarpa | (Roxb.) Taub. | 67 | 7.84% |
| 3. | Trâm vối | Syzygium cumini | (L.) Skeels | 50 | 5.88% |
| 4. | Côm | Elaeocarpus kontumensis | Gagnep. | 42 | 4.90% |
| 5. | Cò ke | Microcos tomentosa | Sm. | 42 | 4.90% |
| 6. | Gáo vàng | Nauclea orientalis | (L.) L. | 42 | 4.90% |
| 7. | Sến mủ | Shorea roxburghii | G.Don | 42 | 4.90% |
| 8. | Cà chít | Shorea obtusa | Wall. | 42 | 4.90% |
| 9. | Cóc rừng | Spondias pinnata | (L. f.) Kurz | 42 | 4.90% |
| 10. | Trâm trắng | Syzygium lanceolatum | (Lam.) Wight & Arn. | 33 | 3.92% |
| 11. | Chiêu liêu đen | Terminalia chebula | Retz. | 33 | 3.92% |
| 12. | Loài khác | Other 31 species | | 342 | 40.20% |
| | | Total | | 850 | 100.00% |
| 0 | | 1 2021 | | | |

Table 26. List of dominant tree species with density rate N% > 3 % in the easter and westernforest hills of Olam pepper farm

Source: Sample plots of this study, 2021

Current regenerated trees layer with D < 5 cm and H \ge 0.5 m was estimated to have 5,650 plants per ha, concentrated at class of H < 2 m (Figure 15), clumped dispersion pattern. List of dominated regenerated tree species according to density rate (n %) greater than 3% including 9 species, some of them belong to Dipterocarpaceae family (Table 27).

| Table 27. List of dominant regenerated tree species with density rate $n \% > 3 \%$ in the easter |
|---|
| and western forest hills of Olam pepper farm |

| Id | Vietnamese species name | Latin species name | | n (Number of regenerated trees /ha) | n % |
|-----|----------------------------|------------------------------------|-------------------------------------|---|--------|
| 1. | Sóng rắn | Albizia lebbeck | (L.) Benth. | 750 | 13.3% |
| 2. | Thầu tấu | Aporosa octandra var. malesiana | Schot | 650 | 11.5% |
| 3. | Thành ngạnh | Cratoxylum formosum | (Jacq.) Benth. & Hook.f. ex Dyer | 400 | 7.1% |
| 4. | Trắc | Dalbergia cochinchinensis | Pierre | 400 | 7.1% |
| 5. | Cà chít | Shorea roxburghii | Wall. | 350 | 6.2% |
| 6. | Mật nhân | Eurycoma longifolia | Jack | 300 | 5.3% |
| 7. | Bứa | Garcinia gummi-gutta | (L.) Roxb. | 200 | 3.5% |
| 8. | Nhãn rừng | Lepisanthes rubiginosa | (Roxb.) Leenh. | 200 | 3.5% |
| 9. | Trâm vối | Syzygium cumini | (L.) Skeels | 200 | 3.5% |
| 10. | Loài khác | Other | | 2200 | 38.9% |
| | Total | | | 5650 | 100.0% |

Source: Sample plots of this study, 2021



Maximum H (m)

Figure 15. Height (H) distribution of regenerated tree layer with diameter at breast height less than 5 cm and the height of regenerated trees greater than or equal to 0.5 m in the easter and western forest hills of Olam pepper farm

Consequences of degraded forest and deforestation in this area are visible, including:

- Forest products including timber, and NTFPs are almost gone, local people can only collect a little bit of wild honey, bamboo shoots, and a little firewood in strongly degraded forests. Meanwhile, the livelihoods of most ethnic minority communities have always been linked to the use of diversified forest products.
- The climate in the region changes markedly, the dry season is hotter, and the wind is stronger. As a result, many crops lose fruit and reduce their yield. Rainy season has more concentrated rainfall causing waterlogging and flooding that make crops failure. At the same time, deforestation and coal burning have increased CO₂ emissions causing climate change.
- In the local watershed basin, streams are dry, the water level of wells in the region decreases.
- Biodiversity is lost or seriously degraded, causing ecological and biological imbalance in the area, making it easy for pests and diseases to grow and damage crops.

3.7 Household economy versus livelihoods

- 3.7.1 Income sources and balance of cash income and expenditure of the household Income of households in the region include 2 main sources:
 - There are 61/67 (91%) interviewed HH have income from farm
 - There are 45/67 (67%) interviewed HH have income from off farm as hired labor, worker for Olam, works for rubber companies in the region or in other provinces like Binh Duong.

From the source of income, local people now not only earn income from farming but also from other sources such as off-farming. Especially since Olam's establishment of pepper farm, it has attracted many local workers, thereby increasing household income in the region.

Results of ANOVA figured out that two factors of villages and ethnic groups did not affect Total Income of HH with P-Value > 0.05. As a result, the summary statistics of cash income from different sources, total cash income, total income of HH were calculated for both villages together (Table 28).

| | Count | Average (Mil. VND/HH/year) | Standard deviation | Coeff. of variation | Minimum | Maximum |
|-----------------------------------|-------|-------------------------------|--------------------|---------------------|---------|---------|
| Cash income from farm | 65 | 43.2 | 63.326 | 146.46% | -2.0 | 443.0 |
| Cash income from livestock | 65 | 3.5 | 8.419 | 238.49% | 0.0 | 45.0 |
| Cash income from wage & salary | 65 | 55.0 | 61.221 | 111.24% | 0.0 | 264.0 |
| Cash income from NTFPs | 65 | 0.1 | 0.447 | 436.99% | 0.0 | 2.7 |
| Cash income from others | 65 | 0.5 | 2.450 | 530.83% | 0.0 | 17.0 |
| Total cash income | 65 | 102.1 | 77.196 | 75.57% | 4.2 | 466.0 |
| Total income | 65 | 108.7 | 76.629 | 70.53% | 11.4 | 472.0 |

Table 28. Summary statistics for income sources of the household in the two studied villages

Note: Value in table is Million VND/HH/year

The two studied villages are all engaged in agriculture, but the averaged cash income of the household was most from wages, accounting for 54% of the total cash income of the household, while the cash income from agriculture only accounts for 42%; Cash income from livestock was low, only 4% of total cash income of households; NTFP cash income almost was negligible (Figure 16)



Figure 16. Estimated percentage of households per cash income sources

ANOVA for Total Income of HH effected by Household Income Level presented P-Value <0.05; In other words, different Household Income Levels had significantly different total income (Table 29).

| Household Income Level | Count | LS Mean | LS Sigma | Homogeneous Groups |
|-----------------------------------|-------|-----------------|----------|--------------------|
| | | (Averaged total | | |
| | | income, Mil. | | |
| | | VND/HH/year) | | |
| 1: Below minimum income indicator | 27 | 62.1184 | 11.1106 | Х |
| 2: At average income indicator | 17 | 111.811 | 14.2625 | Х |
| 3: Above average income indicator | 21 | 180.891 | 12.4916 | Х |
| | | | | |

Table 29. Multiple Range Tests for Total Income by Household Income Level

Note: Method: 95.0 percent LSD

Total household expenditure was not affected by three factors such as the difference of the Villages, Ethnic groups and Household Income Levels from the ANOVA results, with P-Value > 0.05. As a result, summary statistics were computed by expenditure categories and total household expenditure for both villages together in Table 30

Table 30. Summary statistics of expenditure categories and household expenditures for both studied villages

| | Count | Average | Standard | Coeff. | Minimum | Maximum |
|--------------------------------|-------|--------------|-----------|-----------|---------|---------|
| | | (Million | deviation | of | | |
| | | VND/HH/year) | | variation | | |
| Expenditure for food | 65 | 26.2 | 19.122 | 72.95% | 2.3 | 81.4 |
| Expenditure for education | 65 | 4.8 | 6.982 | 145.83% | 0.0 | 32.5 |
| Expenditure for clothes | 65 | 4.5 | 2.898 | 64.04% | 0.7 | 15.0 |
| Expenditure for home appliance | 65 | 4.9 | 2.719 | 55.54% | 0.0 | 12.3 |

| | Count | Average | Standard | Coeff. | Minimum | Maximum |
|--------------------------------|-------|--------------|-----------|-----------|---------|---------|
| | | (Million | deviation | of | | |
| | | VND/HH/year) | | variation | | |
| Expenditure for electricity | 65 | 2.4 | 1.971 | 80.71% | 0.0 | 9.6 |
| Expenditure for drinking water | 65 | 0.5 | 0.848 | 168.68% | 0.0 | 4.8 |
| Expenditure for communication | 65 | 2.8 | 2.175 | 76.76% | 0.0 | 12.0 |
| Expenditure for firewood | 65 | 0.1 | 0.203 | 405.58% | 0.0 | 1.0 |
| Expenditure for gas | 65 | 0.9 | 0.769 | 85.31% | 0.0 | 4.2 |
| Expenditure for health care | 65 | 6.3 | 12.029 | 191.45% | 0.0 | 79.2 |
| Total expenditures | 65 | 53.4 | 26.125 | 48.91% | 17.3 | 142.9 |

Note: Value in table is Million VND/HH/year



Figure 17. Averaged expenditure categories of the household in percent in the two studied villages

Figure 17 shows that household was spending the most on food (49% of total expenditures), followed by health care (12%) and education (9%), and the rest < 9%.

ANOVA was used for balance of cash income and expenditure of the household by four factors such Household Income Level, Who makes decision on the expenditures of the HH, Ethnic group and Education level of the head of the HH. As a result, two factors Household Income Level and Who makes decision clearly affected the balance of cash income and expenditure with P-Values < 0.05; meanwhile, the two factors Ethnic group and Education level of the head of HH did not have a significant effect with P-Values > 0.05 (Table 31)

Table 32 and

Table 33 shows the difference of Balance of cash income and expenditure of the HH according to two influencing factors as follows:

- For the Household Income Level factor, two distinct groups were formed: 1) Below income indicator: This group had the worst cash balance, 2) Including Average income indicator and Above average income indicator: This group had the best cash balance.
- _ For Who makes decision on the expenditures of the HH, the two different groups were formed: 1) Both man and woman and Man/ husband: This group had the worst cash balance, 2) Woman, wife: This group had the best cash balance.

Interestingly, this finding shows that if a woman or wife decided to spend in the family, the balance of cash was the highest compared to the man/husband and both man and woman or husband and wife decided. Unfortunately, the decision-making women accounts for only 22% of number of households in the two studied villages (Figure 18).

| | household by fou | ır fact | ors | | U | |
|------------|----------------------|---------|-------------|---------|---------|--|
| ce | Sum of Squares | Df | Mean Square | F-Ratio | P-Value | |
| IN EFFECTS | | | | | | |

Table 31. Analysis of Variance for Balance of cash income and expenditure of the

| Source | Sum of Squares | Df | Mean Square | F-Ratio | P-Value |
|--------------------------------------|----------------|----|-------------|---------|---------|
| MAIN EFFECTS | | | | | |
| A: Household Income Level | 97028.2 | 2 | 48514.1 | 12.31 | 0.0001 |
| B: Who makes decision | 27963.1 | 2 | 13981.6 | 3.55 | 0.0370 |
| C: Ethnic group | 19017.0 | 5 | 3803.39 | 0.97 | 0.4490 |
| D: Education level of the head of HH | 60644.9 | 10 | 6064.49 | 1.54 | 0.1570 |
| RESIDUAL | 177278. | 45 | 3939.5 | | |
| TOTAL (CORRECTED) | 395843. | 64 | | | |

Table 32. Least Squares Means for Balance of cash income and expenditure of the household with 95.0 Percent Confidence Intervals

| Factors | Count | Mean (Mil. | Stnd. | Lower | Upper |
|------------------------------------|-------|--------------|---------|----------|---------|
| | | VND/HH/year) | Error | Limit | Limit |
| Household Income Levels | | | | | |
| 1: Below income indicator | 27 | 1.63551 | 17.282 | -33.1723 | 36.4433 |
| 2: Average income indicator | 17 | 62.8912 | 20.1888 | 22.2288 | 103.553 |
| 3: Above average income indicator | 21 | 105.179 | 19.4679 | 65.9687 | 144.39 |
| Who makes decision on expenditures | | | | | |
| of HH | | | | | |
| 1: Man, husband | 22 | 49.2886 | 19.0776 | 10.8642 | 87.713 |
| 2: Woman, wife | 14 | 94.0465 | 22.919 | 47.8851 | 140.208 |
| 3: Both man and woman | 29 | 26.3708 | 16.7718 | -7.40948 | 60.1511 |

| Table 33. Multiple Range | Tests for Balance | e of cash income c | and expenditure | by Household |
|--------------------------|-------------------|--------------------|-------------------|--------------|
| Income Level and | d Who makes deci | ision on expenditu | ires of the house | chold. |

| Household Income level | Count | LS Mean (Mil. | LS Sigma | Homogeneous Groups |
|-----------------------------------|-------|---------------|----------|--------------------|
| | | VND/HH/year | •) | |
| 1: Below income indicator | 27 | 1.63551 | 17.282 | Х |
| 2: Average income indicator | 17 | 62.8912 | 20.1888 | X |
| 3: Above average income indicator | 21 | 105.179 | 19.4679 | Х |
| Who makes decision | | | | |
| 3: Both man and woman | 29 | 26.3708 | 16.7718 | Х |
| 1: Man, husband | 22 | 49.2886 | 19.0776 | XX |
| 2: Woman, wife | 14 | 94.0465 | 22.919 | Х |

Note: Method: 95.0 percent LSD





Note: 1: Man, husband; 2: Woman, wife; 3: Both man and woman

3.7.2 Factors affecting household economy and livelihoods

The PCA was used to assess the factors (components) that are likely to affect Income per capita - an important indicator of the multidimensional poverty line to classify household economies.

There were 18 variables analyzed including: Income of per capita, Ethnic group, Number of family members, Education level of the head of HH, Cultivated land area, Contracted land area, Cassava area, Cashew area, Pepper area, Maize area, Bean area, Number of Goats, Number of Cows, Forest honey, Bamboo shoots, Intercropping, Access to loans and Who makes decision As a result, the first principal component had the equation:

PC = 0.352706*Income of per capita + 0.28519*Ethnic group - 0.26227*Number of family members + 0.185785*Education level of the head of HH + 0.371265*Cultivated land area - 0.109626*Contracted land area + 0.334827*Cassava area + 0.372984*Cashew area + 0.174511*Pepper area - 0.224309*Maize area - 0.241295*Bean area + 0.176619*Number of Goats - 0.0825396*Number of Cows - 0.200988*Forest honey - 0.113275*Bambooshoots + 0.180413*Intercropping + 0.140902*Access to loans + 0.0851649*Who makes decisions (9)

where the factors (components) with low weight (< 0.15) were considered to have no effect on the remaining factors (components) in the principal component model, can be excluded. The greater the weight of a component (close to 1), the more important that factor plays a role in the whole components analyzed. If the weights of two variables have opposite signs (+ and -), then the two factors were inversely related, the increase in value of one factor will decrease the value of the other.

In the above equation, the variables such Contracted land area, Number of Cows, Bamboo shoots, Access to loans, Who makes decision had weights less than 0.15. The results show:

- The household's area of leased land for cultivation changes does not affect Income per capita (IPC)
- Raising cows and harvesting bamboo were negligible for IPC
- Up to 43/65 (66%) of the interviewed households accessed the loan from 20 to 80 million VND for production in 2 5 years from Government Social Policy Bank with interest rate of 8.4% 12% / year; or from Women Union. However, this PCA result shows that loan was not meaningful to the IPC.
- The Who makes decision variable affected Balance of cash income and expenditure as analysis above but did not affect IPC!

This shows that these variables had an insignificant effect on IPC of the HH. As a result, remove these variables from the model and run PCA again to get the first principal component had the equation and demonstrated in Figure 19.

PC = 0.384195*Income of per capita + 0.267406*Ethnic group - 0.25827*Number of family members + 0.177903*Education level of the head of h + 0.393617*Cultivated land area + 0.377136*Cassava area + 0.3917*Cashew area + 0.190339*Pepper area - 0.209637*Maize area - 0.228213*Bean area + 0.162744*Number of Goats - 0.192248*Forest honey + 0.190361*Intercropping (10)



Figure 19. Plot of component weights of Income Per Capita with factors of household livelihood Note: The variables are in a circle are closely related to each other, the groups of variables in the opposite circles (with + and - weights) have inverse relationship.

The PCA results in Figure 19 form 3 groups of variables that are closely related as follows:

- The IPC is positively and closely related to the variables related to the cultivated land area and the area of major crops such as cassava and cashew.
- IPC increased but weak when pepper area increased, households applied intercropping, education level of household head increased, goat production increased, and codes of ethnic composition increased.
- IPC is inversely related to the group of variables: Maize area, Bean area, Forest honey, Number of family members; This means that households who grew more than maize and beans had lower income than households grew cassava, cashew, and pepper; Households collecting wild honey had less income than households concentrating on farms; and large households significantly reduced IPC

This result shows that in order to significantly improve the IPC, there is a need to improve the variables that are viable in the region, namely, support to increase pepper cultivation, implement intercropping or agroforestry, and increase raising goat.

4 RECOMMENDATIONS FOR SUSTAINABLE FARMING LANDSCAPE AND LIVELIHOODS

4.1 Improving household living standards

From the survey results on five forms of capital required for sustainable livelihood and according to the basic social services of the Government's multidimensional poverty line in the period 2022 - 2025 (Decree No) 07/2021 / ND-CP); The following issues are suggested at the household level for improving household living standards:

i) Employment

Although this is an agricultural production area, the climate is harsh, the soil here is poor with nutrients, crops have low productivity; Therefore, off-farm employment plays an important role, contributing up to 54% of total cash income of households (Figure 16). In part, thanks to Olam pepper farm, it has attracted many local workers. Therefore, in the coming time, if Olam has a training plan and a strategy plan to attract more local workers into the company's production in a long-term and stable way, it will be creating favorable conditions for household income improvement.

ii) Medicine, health care

By 2021, ethnic minority households in the two studied villages will no longer receive 100% health insurance subsidies from the state as the villages escaped from the list of extremely difficult villages, whereas many households still have low-income levels. If calculated according to the new poverty line in the period 2021 - 2025, there will be 45% households with a per capita income below the minimum income indicator; thus, support for this disadvantage group has Health Insurance is a must-do of the local government.

iii) Education

In both the studied villages, the households with number of children dropping out of school is 1-3, which accounts for 23% of the households. Therefore, it is important to have plans and solutions to help children go to school, improve school infrastructure, and the quality of teachers is important.

From the assessment shows that the education level of the household head had an important influence on the household's livelihood. Up to 26% of the household heads in the two villages are illiterate and 29% of household heads reach only primary education level. Therefore, media providing socio-economic information, scientific and technical information of the farm should be done to support households to improve their qualifications and access to society.

iv) Household housing

In Ia Brel village, about 6.5% of households (about 10 households) only have temporary housing, it would be better if social organizations or Olam Farm will be interested in helping them improve their housing.

v) Drinking water, domestic water, and sanitation

Well water and surface water of rivers and streams in the area are contaminated with lime and alum and cannot drink. Currently, Ia Brel village has 26% and Ia Jol village has 79% of households having to drink contaminated well water or must buy bottled water. Olam has had experience in providing a water filtration system for Ia Brel village, thus, if possible, it is advisable to support such the same system in Ia Jol village.

97% of households in the area mainly use well water for domestic purposes. However, this is a dry area, so wells often lack water in the dry season. Establishment of pumped wells to supply domestic water for groups of households is a need to concern of social organizations.

Up to 36% of households in the two villages do not have toilets, even though they may have the means to do so. Therefore, it is necessary to carry out campaigns and environmental education for generations of households to improve this important issue in household living standard.

vi) Intra-village traffic

Currently, in the two studied villages, there are concrete roads in the main axis, the branch roads are all dirt roads. Inner-village road improvement is needed, it can be the local HH and the government working together or support from Olam

4.2 Improving farming system

i) Red Book of agricultural land

100% of households here have not been issued a Red Book of agricultural land, so the commune authorities need to pay attention to promote this. In addition, the fee for issuing Red Book is also quite high compared to the income of poor households. For this reason, subsidizing poor households to access the Red Book is a must for voluntary social organizations, or Olam.

ii) Irrigation water for household farming

There are 48% of HHs required water sources for growing crops such as pepper, coffee, fruit trees, or livestock such raising pig, duck, etc. They mainly use water from dug ponds or wells, which are usually dry during the dry season. Therefore, setting up a pump well system for each residential cluster for their farming is the concern of the community and the local authority or Olam.

iii) Improving crop and livestock composition

As a result, it showed that increasing pepper cultivation and goat raising will significantly improve income per capita of HH. Therefore, it is important to improve the irrigation system and support the poor to grow pepper in the right land. In addition, promoting the households to raise goats, and use goat fertilizer for crops will improve the household economy in the area.

iv) Limiting and terminating the use of herbicides

Currently 100% of HH use herbicides in cultivation. Advocacy campaigns need to be implemented to change this toxic farming practice; In addition, it is necessary to have research on biological weed-killing measures to support the community in replacing herbicides

v) Promoting agroforestry practice and research

Promoting agroforestry is important for this region, as it solves most of the difficult farming problems (ICRAF; Landicho et al., 2019) here such as:

- Improving poor soil nutrients through legume systems and intercropped short and long-term crops systems.
- Improve cassava or cashew monoculture that make soil degraded, gradually lower productivity.
- Diversification of crop products helps to reduce risks from market fluctuations in agricultural prices, farmers do not depend too much on one crop product such as casava or cashew.
- Improve the regulation of surface and underground water sources
- Improved living environment, atmosphere
- Helps absorb CO₂ to mitigate climate change (Lang and Huy, 2019)

In fact, there are up to 37% of the interviewed households applied some simple models of agroforestry and crop rotation such as:

- Pepper + Teak, Pepper + *Senna siamea* (Lam.) H.S.Irwin & Barneby (Muồng đen), Pepper + *Leucaena leucocephala* (Lam.) de Wit (Keo dậu)
- Maize, beans + Teak
- Cashew + Cassava
- Cassava + (*Sterculia foetida* L.) (Trôm)

The forest species adapted in the area should be included in agroforestry models are Teak (*Tectona grandis* Lf), Trom (*Sterculia foetida* L.), Muong den (*Senna siamea* (Lam.) HSIrwin & Barneby), Keo dau (*Leucaena leucocephala* (Lam.) de Wit), and Jackfruit. It is necessary to encourage the application of these species to intercrop with short-term crops such as cassava, maize, and beans.

The further studies required to develop agroforestry models for this area with extreme site conditions are:

- Researching on selecting indigenous, multi-purpose and fast-growing tree species for inclusion in agroforestry
- Research to establish agroforestry models that are monitored and evaluated for a long time.

These studies should be conducted by Institutes, Universities in the Central Highlands, in collaboration with Olam to implement and guide farmers.

vi) Communication information on farming

In the surveyed area, up to 11 % of households connect to high-speed cable Internet, around 80% of households use Smartphone 3-4 G to connect internet.

Today the way of agricultural and forestry extension should also be changed, not too much one-way training, providing many printed materials; The extension system should provide more reliable information on the internet since most HHs have access to the internet. Therefore, the development of local websites for extension system at the provincial, district and commune level is convenient and useful for farmers.

Olam can also assist local people in clean pepper production and high technology. Olam should open a website to introduce pepper production from seeding to harvest and preservation of pepper. This will provide a meaningful support to this area, when the area under pepper cultivation is small, while pepper is a completely meaningful source of income.

4.3 Improving local watershed

The need is to restore vegetation in the local watershed to limit erosion, sedimentation, improve water quality, as well as retain water in the dry season. The required actions are:

- Protect streams and reservoirs with natural vegetation along rivers and streams and along around reservoirs as a buffer zone. Vegetation strips can be established on each side from 5 to 10 meters for streams and 10 to 20 meters around the reservoir.
- Extend the ability to protect runoff to watershed through rehabilitation of natural forests

Benefits for both Olam farm in protecting the reservoirs yet and providing natural clean water to the community downstream.

4.4 Rehabilitating forest, biodiversity and landscape

4.4.1 The purpose of restoring the natural forest ecosystem in the area

The study area is located in an extreme ecological region, thus the loss of forest on a large scale will cause environmental risks and impacts on the livelihoods of the community. Restoration of degraded dipterocarp forest in the two forest hills in the west and east of Olam Farm is expected to bring benefits:

- In terms of climate, it will help to improve the climate such as reducing heat, drought and strong winds in the dry season. In addition, rehabilitated forests will increase the capacity of carbon accumulation to mitigate regional climate change.
- Flow regulation, anti-erosion, sedimentation, purification of water sources for use and irrigation for Olam farm and the community of the two studied villages.
- Restoring biodiversity will help limit pests and diseases in the area
- Gradually provide essential forest products such as wood, firewood, NTFPs for the local community's life.
- Restoration and conservation of rare and precious fauna and flora species of the dipterocarp forest ecosystem.

4.4.2 Approach for forest rehabilitation

Natural forests rehabilitation today and in the future requires a new approach (Huy and Hien, 2021):

- *Multi-purpose and multi-product forest rehabilitation:* Forest rehabilitation is *not only aimed at the purpose of logging as tradition*, but also aimed towards *multi-purpose and multi-product*. Woody trees help to restore forest ecology, but not only for timber, sometimes without timber, but also for other product purposes such as

fruit, resin, leaf, bark for many needs of food, pharmaceutical products, flavorings, raw materials for manufacturing industries, ...

- *Restoration of forest ecology associated with forest environment services:* The forest rehabilitation is not only for producing and creating forest products, but also for making an important contribution to the protection of ecological environment, such as watershed protection and regulation, soil erosion protection, soil improvement, carbon sequestration for climate change mitigation, biodiversity conservation. In this direction, it is possible to restore fast-growing native plants that function as upstream protection, carbon rapid accumulation, and food, leaves, fruits provision for animals to restore the wildlife and biodiversity.
- 4.4.3 Silviculture measures for rehabilitating degraded dipterocarp forests There are three important silviculture measures for forest rehabilitation:

i) Assisted Natural Regeneration - ANR

ANR is a silvicultural measure to enhance the restoration of degraded forests by maximizing the regeneration capacity, ecological succession, protecting and nurturing mother trees and regenerated trees inherent in the area. ANR is to speed up, instead of waiting for natural processes, it supports the seeding, germination. It also assists the growth of natural regeneration by eliminating or reducing barriers to natural forest regeneration such as the elimination of competition from valueless weeds, lianas, shrubs and impacts such as fire, grazing. Furthermore, ANR helps improve the value and quality of young forests, regenerated trees that meet the purpose of forest management.

With the ANR, forests develop faster than let them grow naturally (Circular No. 29/2018/TT-BNNPTNT (MARD, 2018a); FAO, 2020). In addition, ANR is a simple, low-cost forest rehabilitation method that can effectively convert damaged forest areas with degraded vegetation into more productive forests (Shono et al., 2007).

ii) Assisted natural regeneration with additional planting

This is an extended measure of the ANR, including additional planting some species of purpose plants in areas with lack of regenerated trees to promote forest formation within a defined time limit and to increase the value and ecological function of the natural forest environment (Circular No. 29/2018/TT-BNNPTNT (MARD, 2018a); FAO, 2020).

iii) Enrichment planting

Enrichment planting is used to assist rehabilitation of degraded forests through planting more of purpose trees in canopy gaps or on cutting rows. Enriching planting while keeping natural purpose trees in forests and additionally planting for forests that have degradation, poor value, degradation in ecological function, and lack of regeneration capacity; the used plants are fast-growing valuable and meet the goal of forest management. Enrichment planting is aimed at improving the productivity and quality of degraded forests and meeting the demand for forest products as well as promoting the ecological and environmental functions of natural forests (Circular No. 29/2018 / TT-BNNPTNT (MARD, 2018a); ITTO, 2002).

Species are selected for rehabilitation based on the criteria as follows (ITTO 2002; Appanah, 1998; Longman and Wilso, 1995; and Circular No. 30/2018/TT-BNNPTNT MARD, 2018b):

- Native plants
- Prioritize multi-purpose trees
- Capable of supplying timber
- Fast growth in height and diameter growth > 1.5 cm year⁻¹
- Flowering regularly
- Straight trunk shape
- Small canopy
- No/ less pestilent insect
- Wide ecological amplitude

Among the criteria for selecting plant species to restore the natural forest, native trees are the first priority and compulsory. Since native trees have grown themselves in the ecological conditions of the forest objects that need to be restored in the past, there is no need for research to test the adaptation, only selecting based on the needs and purposes of forest rehabilitation (FAO, 2015).

Tree species selected for forest rehabilitation should be multi-purpose trees (Figure 20), providing a variety of products with economic value, easy to grow, rapid growth in height to surpass the shrub layer and compete for light, regular flowering, no/ less pestilent insect, ... (Huy and Hien, 2021)



Figure 20. Illustration of multi-purpose indigenous trees: Food, medicine, aromatic compound, fodder, wood fuel, timber, etc. (Huy and Hien, 2021)

Table 34 is a list of plant species that meet the criteria of selection to restore dipterocarp forests, with priority given to native species, suitable for ecology, rapid growth, and multi-purpose.

| Id | Species in Vietnamese | Species in Latin | Purpose | Products | Living form | Sources |
|----|----------------------------|---|---------|--|----------------|---|
| 1 | Bầu nâu/ Trái mắm | Aegle marmelos (L.) Corrêa | М | Fruit, leaves, essential oil, resin, timber | Woody | Useful tropical plants |
| 2 | Bồ ngót rừng | <i>Melientha suavis</i> Pierre | М | Timber, leaves, flower, seed | Woody | Useful tropical plants |
| 3 | Bời lời nhớt | <i>Litsea glutinosa</i> (Lour.) C.B.Rob. | М | Timber, bark | Woody | Useful tropical plants |
| 4 | Cóc chuột | <i>Lannea</i> coromandelica (Houtt.) Merr. | М | Timber, leaves, bark | Woody | Useful tropical plants, Hop (2002) |
| 5 | Cóc rừng | <i>Spondias pinnata</i> (L. f.) Kurz | М | Timber, fruit, leaves | Woody | Useful tropical plants |
| 6 | Dẻ anh | <i>Castanopsis</i> <i>piriformis</i> Hickel & A Camus | М | Fruit, timber | Woody | Useful tropical plants, Thang (2016) |
| 7 | Gáo trắng | <i>Neolamarckia cadamba</i> (Roxb.) Bosser | М | Timber, fruit, bark, leaves | Woody | ITTO (2002), Useful tropical plants, WFO |
| 8 | Gòn đỏ, gạo đỏ, Pơ lang | Bombax ceiba L. | М | Timber, fruit, leaves flower, root, resin, bark | Woody | Useful tropical plants, Jain and Verma (2012), WFO |
| 9 | Gòn gai | <i>Bombax anceps</i> Pierre | М | Timber, bark, fruit | Woody | Useful tropical plants |
| 10 | Kơ nia, cầy | <i>Irvingia</i> <i>malayana</i> Oliv. ex A.W.Benn. | М | Timber, fruit, seed | Woody | GIZ, WWF |
| 11 | Lõi thọ | <i>Gmelina arborea</i> Roxb. | М | Timber, flower, fruit, root, resin | Woody | Useful tropical plants |
| 12 | Me | Tamarindus indica L. | М | Timber, fruit | Woody | VAFS, Useful tropical plants, |
| 13 | Quao khộp | Heterophragma sulfureum Kurz | М | Timber, root | Woody | Htun (2016) |
| 14 | Sóng rắn/ Bồ kết tây | <i>Albizia lebbeck</i> (L.) Benth. | М | Timber, bark, flower, leaves | Woody | Useful tropical plants |
| 15 | Sữa, Mò cua | Alstonia scholaris (L.) R. Br. | M | Timber, resin, bark, flower | Woody | VAFS, Useful tropical plants, |

Table 34. List of plant species used for assisted natural regeneration and enrichment planting in
tropical dry dipterocarp forest after over exploitation

| Id | Species in Vietnamese | Species in Latin | Purpose | Products | Living form | Sources |
|----|---------------------------------|---|---------|---|----------------|--|
| 16 | Tếch | <i>Tectona grandis</i> L.f. | М | Timber, leaves, root, bark, flower, seed | Woody | ITTO (2002), Huy et al. (2018), VAFS |
| 17 | Thành ngạnh đỏ ngọn | Cratoxylum formosum (Jacq.) Benth. & Hook.f. ex Dyer | М | Timber, leaves, bark, resin | Woody | ITTO (2002), Useful tropical plants |
| 18 | Trám lá đỏ | <i>Canarium</i> subulatum Guillaumin | М | Timber, fruit | Woody | Useful tropical plants |
| 19 | Trâm mốc, Vối rừng, Trâm vối | <i>Syzygium cumini</i> (L.) Skeels | М | Timber, fruit, leaves, bark | Woody | GIZ, WWF |
| 20 | Tre gai | Bambusa blumeana Schult.f. | NTFP | Bamboo culm, Bamboo shoot | Bamboo | VAFS, Useful tropical plants, |
| 21 | Trôm hôi | Sterculia foetida L. | М | Resin, timber | Woody | MARD, TT 30/2018; Useful tropical plants |
| 22 | Vỏ dụt | Hymenodictyon orixense (Roxb.) Mabb. | М | Timber, bark | Woody | Useful tropical plants |
| 23 | Xoan chịu hạn | Azadirachta indica A.Juss. | М | Timber, fruit, leaves, flower, seed, bark | Woody | ITTO (2002), Useful tropical plants |

Note: Purpose: T: Timber, M: Multiple purpose, NTFPs: Non-Timber Forest Products Source: Huy and Hien (2021)

The forest rehabilitation here needs to be divided into two phases:

- In the first period, about 3-5 years, silviculture measures such as ANR, or ANR with additional planting or enrichment planting would be applied for forest restoration. Supplementary plants need to be ecologically suitable, fast growing, multi-purpose (Table 34), to promote rapid restoration of forest ecological functions.
- The second phase will promote the recovery of the biodiversity of rare and precious plant and animal species according to the list of Table 35 and Table 36. These rare species of flora and fauna or will recover by themselves through restored forest ecology or some potential plant species could be added during this period.

| Id | Species in Vietnamese | Species in Latin | | Living form | IUCN 2020 | Viet Nam Red Book 2007 | Decree 06/2019 / NĐ- CP | Existing or Potential for rehabilitation |
|----|------------------------------|-------------------------------------|-------------|----------------|--------------|------------------------------------|----------------------------------|--|
| 1 | Cẩm lai | Dalbergia oliveri | Prain | Woody | EN | EN | IIA | Existing |
| 2 | Dầu lông, Dầu trai | Dipterocarpus intricatus | Dyer | Woody | EN | | | Potential |
| 3 | Giáng hương quả to | Pterocarpus macrocarpus | Kurz | Woody | EN | EN | IIA | Existing |
| 4 | Gụ mật, Gõ mật. | Sindora siamensis | Miq. | Woody | | EN | IIA | Existing |
| 5 | Kiền kiền | Hopea pierrei | Hance | Woody | VU | EN | IA | Potential |
| 6 | Sến mật, Cà đoong, Sến mủ | Shorea roxburghii | G.Don | Woody | VU | | | Existing |
| 7 | Sơn huyết, Sơn đào | Gluta laccifera | Ding Hou | Woody | | VU | | Existing |
| 8 | Trắc | Dalbergia cochinchinensis | Pierre | Woody | | EN | IIA | Existing |
| 9 | Tuế lá chẻ | Cycas micholitzii | Dyer | Herbaceou s | VU | | IIA | Existing |
| 10 | Vên vên | Anisoptera costata | Korth. | Woody | EN | EN | | Potential |
| 11 | Các loài lan | Species in Orchidaceae family | | Herbaceou s | | | IIA | Potential |

 Table 35. List of plant species in IUCN, Viet Nam Red List and Decree 06/2019/ND-CP existing or potential for tropical dry dipterocarp forest rehabilitation

Source: This study and Huy and Hien (2021).

Note: Existing: The species are existing in the studied forests surrounding OLAM fåm; Potential: The species are potential for assisted natural regeneration of enrichment planting in the studied forests surrounding OLAM farm IUCN: Red List: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Near Threatened: NT Vietnam Red Book: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Lower risk: LR; Conservation dependent: CD; Near Threatened: NT; Least concern: LC; Data deficient: DD; Not evaluated: NE. Decree 06/2019: Consisting of two groups of species IA or IIA

| Id | Species in Vietnamese | Species in Latin | | Class | CITES | IUCN 2020 | Viet Nam Red Book 2007 | Decree 06/2019/ NĐ-CP | Existing or Potential for rehabilitation |
|----|--------------------------|--|-----------------|----------|-------|--------------|------------------------------------|-----------------------------|--|
| 1 | Cầy vòi hương | Paradoxurus hermaphroditus | Pallas, 1777 | Mammalia | III | | NA | IIB | Potential |
| 2 | Kỳ đà vân | Varanus nebulosus (Varanus bengalensis) | Gray, 1831 | Reptilia | | | EN | IIB | Potential |
| 3 | Rắn hổ mang chúa | Ophiophagus hannah | | Reptilia | Π | VU | CR | IB | Potential |
| 4 | Rùa núi vàng | Indotestudo elongata | Blyth, 1835 | Reptilia | II | CR | EN | IIB | Potential |

 Table 36. List of wild animal species in IUCN, Viet Nam Red Book and Decree 06/2019/ND-CP

 potential for tropical dry dipterocarp forest rehabilitation

Source: This study

Note: IUCN: Red List: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Near Threatened: NT; Vietnam Red Book: Critically Endangered: CR; Endangered: EN; Vulnerable: VU; Lower risk: LR; Conservation dependent: CD; Near Threatened: NT; Least concern: LC; Data deficient: DD; Not evaluated: NE. Decree 06/2019: Consisting of two groups of species IB: Strict protection or IIB: Limited exploitation and trading CITES: Annex I, II or III.

Class: Mammalia; Aves; Reptilia; and Amphibia.

Teak, a multi-purpose tree with high economic values, is suitable for the ecology of dipterocarp forest, which was studied by Huy et al. (2018) to enrich degraded dipterocarp forests in the Central Highand of Viet Nam. Here is a summary of an introduction to ANR with additional planting or enrichment planting of teak in degraded dipterocarp forest. This silviculture measure is predicted to be successful in applying to two degraded dipterocarp forests in the east and west of Olam pepper farm in Ia Le commune.

Introduction of teak for ANR with additional planting or enrichment planting in degraded DDF

1. Tree description, uses:

Teak is a large woody tree that reaches a height of more than 30 m, and the diameter reaches 60- 80 cm. With growing demand teak for timber along with processing technology development, teak can be traded in small logs 20-25 cm in diameter over a period of 15 years. Teak also is a multi-purpose tree: Using timber, leaves, roots, bark, flowers, seeds

- Timber has high economic value in domestic and international markets. The wood has a core of golden brown, durable, and beautiful grain.
- Leaves used for dyeing foods, fabrics; as a diuretic, slimming agent, stimulant, detoxifier and diarrhea agent, cure tuberculosis, respiratory infections such as laryngitis, bronchitis, lung.
- Root oil extract for eczema, ringworm, and inflammatory diseases.
- The bark is used as an astringent and for treating bronchitis.

- Flower is used as a diuretic, treating diabetes mellitus, bronchitis and urinary disorders.
- The seeds are used as diuretics. Oil extracted from the seeds makes hair growth medicine.

2. Ecological requirements and techniques for planting teak in degraded DDF:

Teak is used to rehabilitate the degraded DDF ecosystem, increase economic value due to high value of teak and to restore the ecological functions of the DDF, also increase forest carbon accumulation thanks to its relatively rapid growth.

| | Ecological requ | irements for planting teak in DDF |
|-----|--|---|
| Id | Ecological indicators | Required to be able to plant teak |
| 1. | Average annual rainfall | 500-5.000 mm/ year |
| 2. | Lighting intensity. | High light intensity. |
| | Temperature | Average annual temperature from 27- 36°C |
| 3. | Light requirement | From 70% to full light |
| 4. | Number of dry months | 3- 5 months |
| 5. | Altitude above sea level | < 1.000 m |
| 6. | Soil type | Many types of soil from limestone, shale, gneiss, shale, basalt |
| 7. | Thick layer of soil | Depth 30- 50 cm for small timber (roots \leq 30 cm) Depth up to 50 cm for large timber (roots \leq 50 cm) |
| 8. | Drainage | The soil must be well drained. No waterlogging |
| 9. | Physical properties of the soil: | Suitable to soil mixed with gravel about 50%, clay, a bit |
| | gravel, mixed stone, sand | heavy soil. |
| | | Not suitable to soil mixed with sandy or clay of over |
| | | 30% |
| 10. | Soil pH _{H2O} | 6.5-7.5 |
| 11. | Calcium content | High |
| 12. | Content of NPK of soil | Medium to high |
| 13. | Forest fire | Withstands fire, shoot regeneration after fire |
| 14. | Plant physiology: Deciduous, stopped growing in the dry season | Withstands dry season thanks to deciduous trees and stops growing for 3 to 5 months |
| 15. | DDF species indicative for planting teak | Dipterocarpus tuberculatus Roxb., Terminalia chebula Retz., or Xylia xylocarpa (Roxb.) Taub., or Pentacme |
| | | siamensis (Miq.) Kurz, a grass species (cò lào (Chromolaena odorata (L.) R.M.King & H.Rob.)) indicate a good site for teak. |

Teak planted in the DDF has a harvest time of 15 years for small timber (20-25 cm in diameter); and 30 years for large timber (over 40 cm in diameter).

Technique to enrich degraded DDF with teak:

- Teak is planted in canopy gaps of the DDF, the gaps with diameter > 6 m can be planted with at least one teak seedling.
- Larger canopy gaps can be planted with more trees. Teak planted in the DDF in canopy gaps with distances 3 m apart and 3 m away from the DDF trees
- The density of teak planting depends on the density of the remaining DDF timber trees, ranging from 200 to 500 trees/ ha depending on the area of canopy gaps.



Sketch of planting teak in canopy gaps of degraded DDF



Image of teak in the enrichment of DDF in Dak Lak

Note: In place of good suitability level at the age of 6 years, planted teak reach 10- 12 cm in diameter (Huy et al., 2018)

Sources:

- Huy, B., Tri, P.C., Triet, T. 2018. Assessment of enrichment planting of teak (Tectona grandis L.f.) in degraded dry deciduous dipterocarp forest in the Central Highlands, Viet Nam, Southern Forests: a Journal of Forest Science, 80:1, 75-84.
- *ITTO* (International Tropical Timber Organization), 2002. *ITTO* guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. 86 pp.
- Useful tropical plants: http://tropical.theferns.info/

- 4.4.4 *Regulations to involve local communities into forest landscape rehabilitation* Forest restoration requires the participation of local communities for two reasons:
 - Only local people provide labor for reforestation and can effectively protect forests, turning them from deforestation to reforestation and protection.
 - The rehabilitated forest will be the livelihood of ethnic minority communities with high dependence on forests.

Organizing for communities of two studied villages to participate in forest restoration:

- Focus on Ia Brel village participation as it is close to the forests that need rehabilitation, while Ia Jol village may be less. Up to 77% of households wishing to participate in forest rehabilitation and receive benefits.
- Promote households participation in works such as planting, tending and protecting the regenerated forests.
- Use the experience and indigenous knowledge of the ethnic minorities to collect seeds of indigenous tree species to sow, create seedlings for forest restoration.
- Attract households that are invading cultivation in these two forest hills to restore forests, stop cutting forests for cultivation.

Set up forest management mechanism and benefit sharing:

- Consensus is needed on forest rehabilitation and benefit sharing in the two villages. Establishment of a forest management regulation with the participation of the two villages that should be approved by Ia Le Commune.
- Assign each area to each household to plant, take care of and protect the restored forest.

5 CONCLUSION

i) Key socio-economic and environmental findings in Ia Brel and Ia Jol villages

These two villages are mainly ethnic minorities came from the North with more than 6 different ethnic groups migrating in 1998 and forming village administrative units since 2008.

The current poverty rate is less than 10%, which are villages that have been removed from the list of difficult villages. However, it is predicted that the number of poor households will increase up to 45% in 2022 when applying the multi-dimensional poverty line in the period 2022 - 2025 of the Government. There are still about 21.5% of households in short of food for several months of the year.

The educational level of the elderly is extremely low, up to 27% of the household head cannot read and write; and up to 23% of households have children dropping out of school including children never went to the school.

In recent years, ethnic minority households have had health insurance sponsored by the state, but after escaping from difficult villages, this funding is only half left.

45% of households use clean drinking water from Olam's water filtration system, the rest use drinking water from wells contaminated with lime and alum. About 4.5% of households have temporary houses. Most households use the grid electricity, reached 93% of total HH in both villages; The households do not have access to the electricity connection mainly in Ia Brel village accounts for about 13% of total households. Up to 36% of households do not have toilets. Most households use the internet and the 3-4 G network of smartphones.

Agricultural land has not been issued a red book. In average, each household has about 2 ha of cultivated land. Land area varies by ethnic group, education level of the head of household, number of family members. The main crops here are cassava, cashew, maize, beans, pepper, and they are the main source of cash income for the household.

Use of chemical fertilizers, pesticides and herbicides is widespread, posing a risk to human health and the surrounding environment.

Cassava, maize and bean productivities in the region are moderate, while cashew and pepper were low. Soil is degraded due to perennial casava and cashew monoculture. However, there are also 37% of households applied some simple models of agroforestry and crop rotation.

The main husbandry is goats, cows, pigs, which are mainly for sale and chickens and ducks are for both sale and own consumption. Goats have the potential to improve household income.

48% of households need to use irrigation water for farming, in which up to 100% and 74% of households in Ia Brel and Ia Jol villages, respectively lack water in the dry season due to dried-up water sources.

76% of households did not receive or participate in the state extension services.

Local forests are poorly managed, remaining degraded forests are still being cut down for cultivation, timber, and wood burning for coal. The forests in local watershed, along rivers and streams were almost destroyed, reducing the protection function of watersheds and natural water sources. NTFPs almost disappeared, only a few households still collected honey, bamboo shoots, and firewood. The forests still retain the genetic resources of some red-listed plant species, but the remaining forests are highly degraded with clumped dispersion pattern and low canopy (from 10-30%).

The household's cash income is from two main sources: hired labor (54%) and agriculture production (42%). Household was spending the most on food (49% of total expenditures), followed by health care (12%) and education (9%), and the rest < 9%. Two factors of Household Income Level and Who makes decision on the expenditures of the HH significantly affected the balance of cash income an expenditure of HH. In which, woman / wife helps to the balance of household's cash income and expenditure best.

The key factors that affected significantly household economy were the cultivated land area, the area of main crops such as cassava, cashew, pepper, applying intercropping, raising goat, the level of education of the household head and the ethnic group.

ii) Recommendations for sustainable farming landscape and livelihoods

- Improving household living standards such as creating employment; providing health insurance; improving education; constructing poor households housing; improving drinking water, domestic water, and sanitation and constructing intra-village traffic.
- Improving farming system such as issuing Red Book of agricultural land; developing irrigation water for household farming groups; improving crop and livestock composition; limiting and terminating the use of herbicides and promoting agroforestry practice and research; improving communication information on farming
- Improving local watershed functions.
- Rehabilitating forest, biodiversity, and landscape by applying Assisted Natural Regeneration (ANR), ANR with additional planting, enrichment planting and setting up regulations to involve local communities into forest landscape rehabilitation.

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6 Annexes

6.1 Annex 1: Form 1 - Collecting basic information at village level

Method: Group discussion with the key people of each selected village

Introducing objectives of the survey to the group

Undertake a socio-economic survey at the surrounding communities to understand their livelihood needs and how Olam can use its assets, infrastructure, and skills to assist. It is also to support for developing long-term sustainable projects that are relevant and driven by the needs and well-being of the related communities.

Informant's information

| ID | Full name | Sex | Ethnic group | Position | Location | Phone number |
|---|---|---|--|----------|---------------|-----------------|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 3 | | | | | | |
| 1. Vi | llage information: | | | | | |
| - Vill | age name: | | | | | |
| - UTI | M Coordinates: X: | | Y: | | Altitude (m): | |
| | | | | | | |
| 2. Po | pulation: | | | | | |
| 3. To | otal of households: | | in which: | | | |
| Ethni | c groups: | | | | | |
| 4. Vi | llage history summ | ary: | | | | |
| 5. Pa | rticipatory sketchi | ng of villag | ge landscape | | | |
| 6. Ec | lucational level: (if | applicable) |) | | | |
| - Nun - Nun - Nun - Nun 7. H e | nber of people at Un nber of people at Hig nber of people at Pri nber of illiterate peo Dusehold economy | iversity lev gh school le mary schoo ple: classificatio | vel: evel: bl level: on: | | | |
| - Nun - Nun - Nun 8. Nu | nber of poor househonder of near poor ho nber of near poor ho nber of escaped from 1mber of household | olds: useholds: 1 poverty: I s belongs 1 | to what religi | on: | | |

9. Agriculture cultivation:

- Total cultivated area (ha): in which: divided by crop (specify if crop is for sale, for consumption, or for both):

- Technology, techniques, fertilizers, pesticides applied
- Extension services for agriculture:
- Problem (land, technology, pollution, ...):
- Expectation/Recommendation:

10. Livestock: What kind and quantity (specify if for sale, for consumption or for both)

- Technology, techniques, fodder applied:
- Vet services:
- Problem:
- Expectation/Recommendation:

11. Forest and forest land contracted or owned (if applicable) or accessed to:

- Where:
- Area (ha):
- Forest products collected:
- Problem:
- Expectation/Recommendation:

12. Infrastructures in the village:

- Describe village meeting hall:
- Describe housing of HH in village:
- Describe toilet facilities of HH in the village? Number of HHs who have toilet?
- Describe warehouses / crop storage facilities in village:
- Describe electricity in the village:
- Describe road in village:
- Describe school at different levels:
- Describe medical services at village:
- Describe drinking water for HH in village. Number of HHs who have access to clean drinking water? and where, how far, how long to take it?
- Describe irrigation water in village:
- Describe communication: Internet, phone, TV in village. Number of HHs who have access to internet?
- Problems:
- Expectation/Recommendation?
- **13. Market:** How far is the nearest local traditional market? Does the local market provide enough things? otherwise, need to go to any market or food shop, how far away?

14. Management of other natural sources: forest, biodiversity, wild animal

- Where, What and How:

- Problem

- Expectation/Recommendation?

15. Cooperation activities with Olam Pepper Farm

- What kind of supports the village has received from Olam pepper farm? What kinds are useful and not?

What activities the village has worked together with Olam pepper farm? and what are results?What expectations will the village require from Olam

- What contribution will the village associate with Olam pepper to manage sustainable living landscape

- Other problem?

- Recommendation?

6.2 Annex 2: Form 2 - Questionnaire for semi-structure individual interview

Method: Semi-structure interview

Introducing objectives of the survey to the interviewee:

Undertake a socio-economic survey of the surrounding communities to understand their livelihood needs and how Olam can use its assets, infrastructure, and skills to assist. It is also to support for developing long-term sustainable projects that are relevant and driven by the needs and well-being of the related communities.

Name of interviewee:Sex:Age:Objects: a) Local community, b) Smallholder Farmers, c) Informally employed on smallholderfarms and d) OLAM Plantation Workers (permanent & contracted):

Name of Interviewer: Time/Place of interview: Residence (Village, Commune, District, Province):

1. Household (HH) basic information

- 1.1. Ethnic group:
- 1.2. Classification of household economy:
- 1.3. Number of family members:
- 1.4. Number of female laborers (Over 18 60):
- 1.5. Number of male laborers (Over 18 60):
- 1.6. Number of elders (Over 60):
- 1.7. Number of children (Between 2 18):
- 1.8. Number of children (under 2):
- 1.9. Number of family members working in the field:

1.10. Number of family members working for Government, NGO, CSO, private company, informally employed and the position:

- 1.11. How many family members generate income in your household?
- 1.12. Religion:

2. Well- being services for household

- 2.1. Education level of head of the household and why:
- 2.2. Number of children is going/not to school, college, university and why:
- 2.3. To what extent do you have access to health and welfare service providers? For children, women, elders? Who are the main service providers?
- 2.4. Do your family have TV, Internet, Smart phone?
- 2.5. What kind of your house? (The house is built of brick, of concrete, number of floors; wooden house, temporary house):
- 2.6. Your family use electricity? What are your energy sources for household purposes, light?
- 2.7. What kind of toilet facility do member of your household usually use? (Categorize the response according to WHO/UNICEF as below)
 - Flush / pour flush
 - Dry pit latrines
 - Composting toilets
 - Bucket
 - No facility / Bush/Field

Other

_

2.8. What do you use as fuel for your household?

3. Participation in social organizations

- 3.1. Do your family members participate in any social organization? if yes, please indicate which organization? and yourself or/and who:
- 3.2. What are purposes and benefits to join these social organization?

4. Farming practices

- 4.1. What is the size of your own land (ha)?
- 4.2. How much of your land do you use for farming (ha)?
- 4.3. What is the size of the farm that you work on (informally employed)? (Object c):
- 4.4. Do you have any contract of land use? How large (ha)? and What is the length of the contract?
- 4.5. Do you have enough land for your family farming? What is your expectation on the land size for your family? Please explain and what is your expectation:
- 4.6. What are the main crops you are planting? and what size for each? and what are the yields for each the crop? Are the crops for primarily for consumption, for sale, or for both? Please fill out table below:

| Id | Сгор | Area (ha) | Total yield | Productivity ton/ha | Purpose (% for sale, consumption, both) |
|----|------|-----------|-------------|------------------------|--|
| | | | | | |

| Total | | | |
|-------|--|--|---|
| | | | - |

- 4.7. Are you satisfied with productivity? If yes, please describe or if not, what are your suggestions for improvement?
- 4.8. Is there any problem of land use right (red book) in your family? If yes or no, please describe it and what are your suggestions to solve these problems:
- 4.9. What is your family's main livestock, quantity for each? Are the livestock for sale, consumption, or both? Is there any problem? If yes or no please describe. How to solve the problem?
- 4.10. What are Vet services for your family? Is there any problem? If yes or no please describe What are your suggestions to improve it?
- 4.11. Have you received any agriculture extension, training in new technology of seed, seedling, cultivation, agrochemicals, fertilizers use, livestock? If yes, please indicate what extension services you have received? Who are providers of extension? What is your satisfaction level and your recommendation? Please fill out table below:

| Id | Kind of extension, contents of training | Who is provider? | Timing | Satisfaction level (Excellent, Good, Average, Poor) | Recommendations |
|----|--|---------------------|--------|--|-----------------|
| Iu | contents of training | provider? | Tining | level (Excellent, Good, Average | Recommendations |
| | | | | Poor) | |

5. Food security and nutrition

- 5.1. Status of enough foods in the family: Do your family has enough foods in recent years or lacks food? If not enough, how long it has been insufficient (number of days, months). What are reasons for lack of foods for your family?
- 5.2. For any children in the household under two years old, what are they fed? (list the most common foods). Are there enough foods for them? and why?

6. Access to forest resources

- 6.1. Do you know who manages and owns the surrounding forests?
- 6.2. Do you have your own forests or contracted? If yes, when, where and how large is it?
- 6.3. What materials are your house made of? If it was made of wood, where, when was it?
- 6.4. Do you use firewood for cooking? if yes, where, when do you get it from? How far away from your home/how long does it take to get to the collection area (one way?)
- 6.5. What materials are a barn for raising animals made of? If it was made of wood, where and when was it?
- 6.6. Do you collect any NTFPs (for vegetables, medicine, commercial products) from the surrounding forests? if yes, please indicate what are main NTPFs your family collect, estimated volume collected annually using table below? and when?

| ID | Main kind of NTFP | Harvested | Purpose (% for sale, | Remarks | |
|----|-------------------|---------------|----------------------|---------|--|
| | | volume / year | consumption, both) | | |

- 6.7. What did these forests look like 10 15 years ago? Why are these current forests being degraded, cleared? What are your greatest forest management problems / concerns now? In the future? How to solve these?
- 6.8. Are the surrounding forests important to you? and What, Why and How? What does the forest look like do you want? and what are expectations from forest sources of your family?
- 6.9. Do you want to involve into the process of forest rehabilitation? and Why, What, and How?

7. The meaning of biodiversity to HH livelihood

- 7.1. Do you practice intercropping? What are your models?
- 7.2. What are the problems in your farm related to the mono/multi crops? and how to solve it?
- 7.3. Does hunting/ gathering occur near/on your farm/plantation? If yes, which animal (for Object b, c, d):
- 7.4. Do you rely on meat from hunting/gathering from the surrounding forests? (for Object a). If yes, which animal and quantity?

- 7.5. Where have you cleared land recently? Why? How? Has there been an increase or decrease in the use of fires for clearing vegetation?
- 7.6. Do you think there is any problem with your livelihood related to the loss, degradation of biodiversity?
- 7.7. Do you think it is important to have a variety of different plants and animals, wildlife in the landscape? and which are important, why and how restore them?

8. Soil issue

- 8.1. How often do flooding events occur? and what effects?
- 8.2. Have you been affected by flooding in the past? How has this impacted you? (for Object a, b, d)
- 8.3. How often and how much do you apply fertilizer/ pesticides to your crops per year? and what is happening?
- 8.4. How to improve fertilizer and pesticide use?
- 8.5. Do you have soil problems e.g., soil loss, lack of nutrients, poor production? What are the problems? What are the causes? and what do you think to improve this (for Object a, b, d)

9. Water sources

- 9.1. What are your HH's farming, livestock activities that require the most water?
- 9.2. Where do you get your water for your farm, livestock from? How to get water sources?
- 9.3. What is the main source of drinking and domestic water for members of your household? How is the quality and quantity? (Categorize the response according to WHO/UNICEF as below).
 - Piped water
 - Dug water
 - Water from spring
 - Rainwater collection
 - Delivered water
 - Water kiosk
 - Packaged water
 - Surface water (River, stream, dam, lake, pond, canal, irrigation channel)
 - Other
- 9.4. How far are the water sources for drinking from your house? How long does it take to get there (one way)
- 9.5. Is the quality of the surrounding stream water monitored? Please explain, describe:
- 9.6. Did you or anyone in your household experience health issues characterized by stomach

pain or diarrhea? If yes, how often, how severe was it? If yes, did it affect children?

- 9.7. What type of sewage system do you have?
- 9.8. Whilst at work, do you have toilet facilities? (for Object c and d)
- 9.9. What are your greatest water problems / concerns now? In the future? (e.g., quantity, quality, access, water systems, waste water, flood protection, drinking water...) Why are these concerns? What are your suggestions to improve these?

10. Economic and financial issues

- 10.1 What are your main sources of income?
- 10.2 Do you have an additional source of income? If yes, please describe it:

10.3 What is your income and cash income for each source per year? Interview and fill out table below:

| I d | Sources of main income of HH | Total yield/ year | Yield / year for sale | Unit prize | Revenue (Mil. VND/year) | Cost for production (Mil. VND/year) | Income after deduction of cost (Mil. VND/year) | Cash income (Mil. VND/year) |
|--------|---------------------------------------|-------------------------|-----------------------------|---------------|-------------------------------|--|--|-----------------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 = 3*5 | 7 | 8 = 6 - 7 | 9 = 4*5 - 7 |
| 1 | From farm | | | | | | | |
| 2 | From main | | | | | | | |
| | livestock | | | | | | | |
| | | | | | | | | |
| 3 | From wage, | | | | | | | |
| | salary | | | | | | | |
| | | | | | | | | |
| 4 | From | | | | | | | |
| | NTFPs | | | | | | | |
| | | | | | | | | |
| 5 | Other | | | | | | | |
| | Total (Mil. | | | | | | | |
| | VND/ year) | | | | | | | |
| | | | | | | | | |

10.4 What are your household expenditures? Interview and fill out table below

| Id | Kind of main expenditure | Quantity | Unit Cost | Total |
|----|----------------------------------|----------|-----------|------------------|
| | | | | (Mil. VND/ year) |
| 1 | For food | | | |
| | Rice | | | |
| | Meat, vegetable, | | | |
| | Milk for children | | | |
| 2 | For education | | | |
| | | | | |
| 3 | For clothes | | | |
| | | | | |
| 4 | For home appliance (List of main | | | |
| | items) | | | |
| | | | | |
| 5 | For electricity | | | |
| 6 | For drinking water | | | |

| 7 | For communication: internet, phone |
|----|------------------------------------|
| 8 | For firewood |
| 9 | For energy: Cooking, bathing |
| 10 | Health care |
| | Total |

- 10.5 Do you have access to savings and financing/loans? For loans: Where, how much, how often? and the loan for what purpose? (Include and specify any type of financial service: mobile money, bank accounts, savings and loans associations etc.)
- 10.6 Who makes decisions around how you spend money in your household?
 - Only, mainly husband/male household head
 - Shared decision-making between male and female household heads
 - Only, mainly wife/ female household head
 - Other:

| ID | Full name | Sex | Position | Location/ Institution | Time |
|----|-------------------|--------|-------------------------------------|----------------------------------|-----------|
| 1 | Hoàng Thị Liên | Female | Head of village | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 2 | Nông Thị Thu Hạnh | Female | Women union, deputy head of village | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 3 | Nông Thị Thới | Female | Women union | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 4 | Bàn Phụ Nguyện | Male | Deputy head of village | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 5 | Đặng Chòi Vặng | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 6 | Triệu Tiến Hồng | Male | Head of village | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/27/2021 |
| 7 | Nguyễn Thị Sa | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 8 | Nông Trung Việt | Male | Veteran, elderly | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 9 | Triệu Thị Liêm | Female | Elderly | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 10 | Nộng Thị Nậu | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 11 | Phùng Văn Ón | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 12 | Hoàng Thị Biện | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 13 | Lương Thị Mọ | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 14 | Phan A Chứ | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 15 | Lăng Văn Thướng | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 16 | Vàng Sao Sùng | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 17 | Hoàng Văn Vàng | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 18 | Lý Seo Dàu | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 19 | Ma Sơ Tú | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 20 | Ma Thị Duyên | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 21 | Ma Seo Chinh | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 22 | Sùng Thị Pái | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/28/2021 |
| 23 | Nông Thị Thảo | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 24 | Đường Thị Hiền | Female | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 25 | Phan Văn Hành | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 26 | Phan Văn Hợp | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 27 | Ly Seo Sỷ | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 28 | Nguyễn Thị Nhung | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |

6.3 Annex 3: List of Informants

| ID | Full name | Sex | Position | Location/Institution | Time |
|----|------------------|--------|-----------------------------|----------------------------------|-----------|
| 29 | Phùng Văn Khợ | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 30 | Phan Văn Chùng | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 31 | Lộc Văn Trọng | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 32 | Ma Chạnh Hồ | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 33 | Triệu Thị Tư | Female | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 34 | Ma Seo Diu | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 35 | Nguyễn Văn Quảng | Male | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 36 | Nông Thị Tuyết | Female | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 37 | Lê Thị Tươi | Female | Representative of | Ia Brel, Ia Le, Chu Puh, Gia Lai | 1/29/2021 |
| 38 | Đặng Thị Lan | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 39 | Triệu Mong Muốn | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 40 | Triệu Văn Tòng | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 41 | Triệu Chiều Vặng | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 42 | Bàng Phụ Nguyện | Male | Deputy head of village | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 43 | Lý Kiềm Chiêu | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 44 | Đặng Chòi Sểnh | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 45 | Triệu Văn Nam | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 46 | Lý Mùi Khe | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 47 | Lý Mùi Phẩy | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 48 | Phạm Văn Dung | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 49 | Triệu Hồng Lẫy | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 50 | Triệu Văn Năm | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 51 | Triệu Văn Sau | Male | Representative of | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 52 | Nguyễn Văn Lợi | Male | Representative of | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 53 | Lê Thị Tám | Female | Representative of | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/30/2021 |
| 54 | Chíu Thị Sơn | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |

| ID | Full name | Sex | Position | Location/ Institution | Time |
|----|-----------------|--------|-----------------------------|---------------------------------------|-----------|
| 55 | Triệu Mùi Nái | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 56 | Nguyễn Thị Thắm | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 57 | Lê Thị Đức | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 58 | Bàng Mùi Phới | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 59 | Bàng Mùi Khe | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 60 | Lý Thị Chuyền | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 61 | Triệu Tài Múi | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 62 | Lý Kiềm Quyên | Male | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 63 | Nông Thị Lạc | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 64 | Đỗ Thị Huế | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 65 | Lý Thị Trang | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 66 | Đặng Mùi Kiều | Female | Representative of household | Ia Jol, Ia Le, Chu Puh, Gia Lai | 1/31/2021 |
| 67 | Hầu Thị Mai | Female | Worker of Olam | Phu Binh, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 68 | Nguyễn Cường | Male | Worker of Olam | Phu Hoa, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 69 | Bùi Thanh Quang | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 70 | Đặng Thị Tuỳ | Female | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 71 | Nông Văn Bách | Male | Representative of household | Ea Hleo commune, Ea H Leo, Dak Lak | 2/1/2021 |
| 72 | Nguyễn Tấn Phút | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 73 | Nguyễn Tấn Tài | Male | Representative of household | Ia Brel, Ia Le, Chu Puh, Gia Lai | 2/1/2021 |
| 74 | Dương Văn Hà | Male | Safe Guard of Olam | Olam Pepper Farm | 2/1/2021 |
| 75 | Hồ Tỷ Tuấn Anh | Male | Staff of Olam | Olam Pepper Farm | 2/1/2021 |

6.4 Annex 4. Some photos of interview and discussion with local people in studied villages













6.5 Annex 5: Coding variables and units

| ID | Factors | Code | | | | | | | | |
|----|----------------------------------|--------------|--------------|--------------|-------------|---------------|-------------|----------|---------------|-------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | Health Insurance | No | Yes | | | | | | | |
| 2 | Kind of house | Temporary | Wooden | Brick house | | | | | | |
| | | house | House | | | | | | | |
| 3 | Electricity | No | Yes | | | | | | | |
| 4 | Other energy sources | Oil lamp | No | Solar power | | | | | | |
| 5 | Kind of toilet | Flush / pour | Dry pit | Composting | Bucket: | No facility / | Other | | | |
| | | flush | latrines | toilets | | Bush/Field | | | | |
| 6 | Fuel for cooking | Firewood | Firewood and | Gas | | | | | | |
| | | | gas | | | | | | | |
| 7 | Sufficient status of arable land | Landless | Lack of land | Enough land | Excess land | | | | | |
| 8 | Ethnic group | Muong | H Mong | Dao | Nung | Тау | Kinh | | | |
| 9 | HH Economic classification | Poor | Near Poor | Average | | | | | | |
| 10 | Know surrounding forest owner | Don't know | Know (Olam, | | | | | | | |
| | | | CPC Ia Le) | | | | | | | |
| 11 | Using firewood | Yes | No | | | | | | | |
| 12 | Using wood as livestock barn | Yes | No | No livestock | | | | | | |
| 13 | Intercropping | No | Yes | | | | | | | |
| 14 | Using fire for clearing | Yes | No | | | | | | | |
| | vegetation | | | | | | | | | |
| 15 | Require water for farming, | No | Yes | | | | | | | |
| | livestock? | | | | | | | | | |
| 16 | Sources of water for farming | No need | Well | Pond | Stream | | | | | |
| 17 | Source of drinking water | Piped water | Dug water | Water from | Rainwater | Delivered | Water kiosk | Packaged | Surface water | Other |
| | | (Olam) | | spring | collection | water | | water | | |
| 18 | Source of water for use | Piped water | Dug water | Water from | Rainwater | Delivered | Water kiosk | Packaged | Surface water | Pond |
| | | (Olam) | | spring | collection | water | | water | | |
| 19 | Source income from farm | No | Yes | | | | | | | |
| 20 | Source income from off-farm | No | Yes | | | | | | | |
| 21 | Access to loans | No | Yes | | | | | | | |
| 22 | Who makes decisions | Man, | Woman, wife | Both man | | | | | | |
| | | husband | | and woman | | | | | | |

| ID | Factors | Code | | | | | | | | |
|----|------------------------------|--------------|------------|------------|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 23 | HH income level (Person/Mil. | < 1.5 (Below | 1.5 - 2.25 | > 2.25 | | | | | | |
| | VND/month) | income | (Average | (Above | | | | | | |
| | | indicator) | income | average | | | | | | |
| | | | indicator) | income | | | | | | |
| | | | | indicator) | | | | | | |

Units of variables

| ID | Factors | Unit |
|----|---|-------------------------|
| 1 | Land area, cultivated land, contracted land, land for crop, forest land | ha |
| 2 | Length of contracted land | year |
| 3 | Productivity of crop | ton/ha/year |
| 4 | Yield of crop | ton/year |
| 5 | Forest honey | litter/year |
| 6 | Bamboo shoots | kg/year |
| 7 | Cash income | Mil. VND/year/Household |
| 8 | Expenditure | Mil. VND/year/Household |
| 9 | Income of per capita | Mil. VND/month/person |

6.6 Annex 6: Forms for forest survey Sheet 1: Sample plot describing ecology and measuring forest variables

1) Plot information Coordinates UTM: X/Y: ID of plot: Location (Village, commune, district): Forest owner: Forest type: Dominant species: Degraded level description: Forest canopy (1/10): Dispersion pattern: Tree layer: Regenerated tree layer: Slope (degree): Altitude (m): Soil type, color: Thick layer of soil (cm): Rate of small stone: Rate of rock: Soil erosion level: Pollution caused by fertilizers, pesticides, herbicides? (Type, degree): Source of spring water (Year-round, seasonal?), Length, source of pollution, level of pollution?. Flood situation in rivers and streams:

P (mm/year averaged): T (⁰C/ year averaged):

Data collectors:

Date:

2) Measure trees with $D \ge 5$ cm in 3 sub-plots 10×10 m

| Id sub- | Id | Species | D (cm) | H (m) | Distance | Tree |
|------------------|------|---------|--------|-------|----------|----------|
| plot 10 \times | tree | | | | tree to | quality |
| 10 m | | | | | nearest | (Good, |
| | | | | | tree (m) | average, |
| | | | | | | poor) |
| | | | | | | |
| | | | | | | |
| | | | | | | |

3) Measure the regeneration trees with D<5~cm and H>0.5~m in 2 sub-plots $5\times5~m$

| Id | Id | Species regenerated | Н | Id | Id | Species regenerated | Η |
|------------|-------------|---------------------|-----|--------------|-------------|---------------------|-----|
| sub- | regenerated | | (m) | sub- | regenerated | | (m) |
| plot | tree | | | plot | tree | | |
| $5 \times$ | | | | 5×5 | | | |
| 5 m | | | | m | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Sheet 2. Transect forest plants and animals recorded

1) Information of the transect

Id transect:

Coordinates UTM: Starting point: X/Y: Ending point: X/Y:

Location (Village, commune, district):

Forest owner:

Forest type:

Dominant species:

Degraded level description:

Description of water, food sources for wild animals:

Data collectors:

Date:

2.1. Record wild animals

| Id | Species | Class | Trace | Estimate the | Estimate | Coordinates | Remarks |
|----|---------|-------|---------|--------------|-----------|-------------|---------|
| | | | type of | number of | the | UTM X/Y | |
| | | | animals | individuals | number of | | |
| | | | | (if | herds (if | | |
| _ | | | | applicable) | possible) | | |
| | | | | | | | |

| 2.2 | 2.2. Record rare and endangered plants | | | | | | | | |
|-----|--|-------------|---------------------|--|--|--|--|--|--|
| Id | Species | Living form | Coordinates UTM X/Y | Remarks: Number of plants, D, H averaged | | | | | |
| | | | | | | | | | |