CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Master's Thesis

Topic:

Linking Agro-biodiversity, income diversification and food security in ethnically mixed region of northern of Laos

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Declaration

I hereby declare that I have done this thesis entitled "Agrobiodiversity, nutrition and income from homegardens in mountainous areas of northern Laos" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

26th April 2019 .....

Thang Sian Pau

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Abstract

This study sought to analyse the contribution of home gardens to household food security in the ethnically mixed region, located in the Khoun district of northern Laos. Specifically, it documents the food species grown in home gardens by both ethnic groups and to obtain their capacity and use using frequencies, estimate agrobiodiversity of food species grown in local home gardens using Margalef and Shannon- Wienner indices, analyse household resources capacity and potential mutual effects with agrobiodiversity with multiple linear regression and tabulated the nutritional value of food species from home gardens with special respect to household consumption. A combination of convenience and snow ball sampling, non-probability sampling, were used to sample 59 and 41 home garden households of the Lao Loum and Hmong ethnicities respectively making a total sample size 100. The study results documented 132 plant species with most of these species used for diverse purposes such as food, income generation, spices, ornaments, medicines, fodder, cultural purposes and materials for textiles and construction. It again document food to be the dominant use although an increasing attention is given to the commercialization of home gardens. In all, 12 were identified as dominant with 14 species underutilized. The Margalef and Shannon-Wienner indices also indicates an average level of species richness and diversity with relatively higher levels of species density and abundance. The linear regression also established a positive mutual effect between agrobiodiversity and access to information and technology, off-farm income and livestock keeping whereas higher family labour, usage and farm size were found to have inverse effect on agrobiodiversity. Food crops species grown in home gardens and consumed at the household level were also found to be highly nutritious since majority of the domestically consumed species had higher nutritional values relative to other species their food category. The study recommends traditional local species rather than commercialising home gardens by both Lao Loum and Hmong ethnicities.

Keywords: Food security, diversity indices, home garden, Lao Loum and Hmong ethnic groups, Laos.

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List of the abbreviations

FAO	Food and Agriculture Organization
HSRC	Human Sciences Research Council
HDI	Human Development Index
KDAFO	Khoun District Agricultural and Forestry Office
LSB	Lao Statistic Bureau
LDCs	Least Developed Countries
MAF	Ministry of Agriculture Forest
MDGs	Millennium Development Goals
NABP	National Biodiversity Strategy and Action Plan
SERC	Sustainable Environmental Research Centre
SPSS	Statistical Package for Social Science
IIED	International Institute for environment and development
SUN	Scaling up Nutrition
UN	United Nation
UNDP	United Nation Development Program
WB	World Bank
WHO	World Health Organization
WFC	World Food Conference
WFP	World Food Programme

1. Introduction

Globally, food security is a complex issue (Godfray et al. 2010) and remains a major challenge for developing world as expected the population will increase more than nine billion by 2050 (Galhena 2012; Von Grebmer et al. 2012). Currently, around 820 million people are affected by hunger and food scarcity in developing countries, particularly in Africa, Asia and Latin America. In terms of the regions, the prevalence of undernourished people stood at 515 in Asian, 39.3 million in Latin America, and 256.5 million in Africa (FAO 2018). They have the challenge of constantly increasing food production and buffer stocks to meet the growing demand and efficiency of food (FAO 2006).

The term " Food security" become prominent after the 1974 World Food Conference. Since then it became a household name and attracted to many definitions from different organizations and individual researcher. The commonly accepted impression of food security is as "Food security exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meet their dietary needs and food preferences for an active and healthy life"(FAO 1996; WEP 2007). It is undeniable fact that every country around the world need to respond to promote food security because food is the primary necessity of human life that has to satisfied before any developmental issue.

There are different strategies which are adopted by different households in obtaining food to feed their household members. These strategies are such as own production, buying and support. In the past, rural resident used to be dependent on own production (Baipheti & Jacob 2009). From these strategies, the only reliable one is own production which is homegardening (Bonti-Ankomah 2001; Ndaeyo 2007). Therefore, Homegardening can be used by a household for food production. Musotsi et al. (2008) argues that homegardening remains the most important method of food production for the majority of people in developing countries.

Homegarden represents one of the oldest global food production systems that has been practices until these days (Landauer & Brazil 1990). They are widely adopted and used by

local communities with limited resources and institutional support under different circumstances. Homegarden have a long tradition and offer great potential for improving food security and micro deficiencies in the household. Globally, homegarden can be found in the tropics and subtropics and they have been recognized as a very important supplemental source of contributing to food and nutritional security and livelihoods (Kumar & Nair 2004; Galhena 2012). Moreover, they are still important for construction material and firewood (Kumar & Nair 2006). They are diverse agroforest system managed by poor people and small farmers throughout the wet tropics and they contain a variety of useful crops and traditional knowledge and supply a crucial diverse and year-round supply of food (Kumar & Nair 2004; Galluzzi et al. 2010). Agricultural biodiversity is essential for the survival and the well-being of people. In this regard, most Laos households have several livelihood strategies and they are engaging in many different activities to achieve a possible household economy and most of them do homegardens to provide for the household consumptions. They are growing various fruits packed with nutrient and vegetables which are contributing to better nutrition of the household members.

In 2011, Lao PDR has been part of the global Scaling Up Nutrition (SUN) movement and has adopted a series of national food and nutrition security policies to address food and nutrition security. Although local rural people grow mainly vegetables for their consumption, however the supply of vegetables are not enough to meet the needs of the household. The main problems of vegetable production in Lao PDR is soil fertility, the lack of knowledge of farmer to improve the soil and transportation from vegetable garden to the market is very far and the transportation mean that it is limited. These could be a negative impact on household food security as well as nutrition security. Furthermore, there is not much study done on homegarden in Laos. Therefore, the thesis will be focused on contribution of homegardens production to household food security and to document diversity of food plant species and the uses among Lao Loum and Hmong ethnic groups in mountainous areas of northern Lao.

2. Literature review

2.1. The role of homegarden in household food security

In 2000, one of the aims of the Millennium Development Goals was to eliminate hunger and poverty. Many countries around the world have agreed to end hunger and malnutrition which is important for both development and socio-economic well-being. As there are a number of hungry people in the world is growing at the rate of four million a year, the trend is not falling fast enough to achieve the goals, especially in African and Southern Asia (FAO 1996). Many households in developing countries are challenging to meet these goals, especially in rural villages and remote areas (Muller & Krawinkel 2005; United Nations 2015; Kharas et al. 2017).

The current food systems are unsustainable in both supply and demand of food (Weinberger 2013). On the supply side, the agriculture requires high environmental cost because of high greenhouse emissions, contamination of natural environment, loss of biodiversity or soil erosion (ADB 2009; Godfray et al. 2010; Stavi & Lal 2012). According to Helen (2002) states that political instability and unpeaceful coexistence among the people while inadequate intake of food can be the results of poor health and poverty. This has caused many households to negative impact of survival such as reducing their consumption of food, eating staple foods instead of micronutrient rich foods, disposing of household and agriculture assets, increased borrowing for survival and financial debt for many households. All of these have long-term negative effect on food security, nutrition, health and development of people (FOA 2008; Klotz et al. 2008). Food security should be a goal to achieve any person or nation because food security is one of the constitutes indices for measurement of poverty level. A household or individual who spend more than 70% of one's total income on food is said to be poor and food insecure. Therefore, food security is more important than anything (Ndaeyo 2007).

In this regard, governments around the world attempt to find the solution that will support sustainable agriculture and achieve food security (Whitney 2017), there is more attention toward on homegardens as a strategy to ensure food security because homegardens are apart of agriculture and food production system in many developing countries and widely

practice as remedy to reduce hunger and malnutrition (Johnson 2000). Primarily, homegardens are intended to grow and produce food stuffs for family consumption but they can be diversified to produce outputs with multiple uses, including indigenous medicine and home remedies for certain diseases, inflammation and alternative source of fuel, manure, construction materials and animal feed. The excess output can also be sold to generate additional income (Ninez 1985; Torquebiau 1992; Trinh et al. 2003; Eyzaguirre & Linares 2004; Sthapit et al. 2006).

For many years, homegardens have been a fundamental component of family farming and local food system. homegardens can be found in both rural and urban areas, mostly they are small scale subsistence agriculture systems (Nair 1993). Homegardens have been recorded as important source of food which contribute to food and nutritional security and livelihood of household member. They are classified as farmyard, kitchen, backyard and homestead etc (Terra 1958; Ruthenberg 1980; Rowe 2009; Nair 2004). Many households have practiced livestock keeping and vegetable production in homegarden. This has provided direct access to diversity of nutritional rich foods, which include root, tuber, green leafy vegetables, condiments, nut, legumes, fruits and livestock products (FAO 2001; Shrestha 2001).

Since household food security is related to many issues such as education, hygiene and nutrition, the physical infrastructure, agricultural and environmental sector, WFP (2007) observe that households with homegardens tend to be more food secure because these gardens provide household food, fresh vegetables and cash income. Homegardens contribute also to livelihood of households through providing their households with food, medicines, energy, shelter and many other needs of people. In additional, they act as a secondary source of income (Kumar & Nair 2004). Thus, they reflect the cultural history of the different ethnic groups who practice it and they involve management of many useful plant species over prolonged periods of time (Blackaert et al. 2004; Srithi et al. 2012), providing rural employment by engaging villages in the cultivation of different crops and creating opportunities for the development of rural food production (Torquebiau 1992; Kumar & Nair 2004). As stated earlier, homegarden are very helpful in times of food

shortage or failures of staple crops. They can provide a wide range of resources for the high diversity of plant species such as nutritious foods, marketable products, firewood, herb, spices, medicinal plants (Gari 2003).

2.2. Homegardens contribute significantly to nutrition

Food security could be understood feeding the people in term of quality of the food eaten by the households. So, it is important to look at nutritional components as well. Adequate nutrition is a necessity for human development and socioeconomic well-being (Muller & Krawinkel 2005). Hunger or acute malnutrition is defined as not having enough to eat to meet requirement, referring specifically to lack of energy, carbohydrates and fats. Micronutrient deficiency is usually caused by a lack of essential vitamins and minerals in the diet (Biesalski 2013). This micronutrient deficiency can lead to blindness, illness, impaired development and premature death. Those suffering from micronutrient deficiency may be stunted (too short for their age), have poor night vision and suffer frequently from illness (Biesalski 2013). Those who suffering from micronutrient deficiency are due to eating unbalance diet with many staples' carbohydrate foods but lack of enough proteins and micronutrients, for example low amount of micronutrient rich foods and food crops (Ssewakiryanga 2015). By growing of plants diversity, raising of domestic livestock and poultry can be provided a variety of foods which are high in vitamins, mineral and proteins such as vegetables, fruits, pulses, staples and meat (Marsh 1998; Shrestha et al. 2002; Gari 2003; Sswakkiryanga 2015).

As diet and nutrition are major factors associated with health status, food security and poverty, understanding of diet and nutrition is very important. Therefore, government around the world have agreed to end hunger and support sustainable agriculture to achieve food security (United Nation 2015). The development efforts use the popularity of homegardens around the world, to link their activities with nutrition education. Homegardens are always a complementary source of the household food needs, they have often provided vitamin-rich fruits and vegetables, as well as minerals and other nutrients to the household, for example; India homegardens contributed 60% of the household's total fruits and vegetable consumption, in Philippines, 20% of the foods consumed by families

are produced in the homegardens while in Vietnam 51% of their produce is used by household members (Gautam et al. 2004). Furthermore, Torquebiau (1992) estimated that up to 44% of total calories and 32% of the protein intake for a household comes from homegardens. Moreover, due to the fact that little or even no chemistry is used in gardening can be a very high rate of nutritional quality of food.

The fruits and vegetables are very important for people to meet daily need of nutrients. An average person requires a daily diet is 2,800 calories, 55 g of protein, 450 mg Ca, 20 mg Fe, 3,000 mg β-carotene, 50 mg of Vitamin C, 100 mg of folic acid, 1.0 mg of Vitamin B, 1.4 mg of thiamine 1.5 mg of riboflavin 19 mg of niacin and 5 mg of Vitamin D (Sharma 2009) According to Prathiba and Rani (2012) states that a healthy person should eat 125 g leafy vegetables, 100 g of root vegetables, 75 g of other vegetables and 85 g of fruits in his/her daily diet, a part from 475 g of cereals and 85 g of pulses. Therefore, vegetables and fruits are very important for people because they provide the needs of people's carbohydrate, protein, vitamins, mineral and fats which are very essential to our body. Thus, homegardens can provide nutritious and balanced of diet to the household members (Thapa 2004).

In order to ensure a healthy diet, fruits and vegetables should be systematically grown in the homegarden. This is very important for rural people where they have limited income and poor market access (Indumathi et al. 2012). Vitamin A deficiency is as a major health issue in many countries and it caused 6 to 8% of the death of children under five years old in African and Asia (WHO 2009), more than 35% of the world's fatalities are caused by nutritional deficit. Many countries where this problem is acute. Therefore, homegarden production have been established to help and to address the vitamin A deficiency and to improve the quality of diet by facilitating a year-round production of vegetables and fruits (Iannotti et al.2009; WHO 2009).

2.3. Linkage between crop and dietary diversity in homegarden

Rich and diverse nutrition is usually linked to agrobiodiversity, which is another typical feature of homegardens. The diversity of plant species contributes to enhancing the nutrition of rural and urban household member. The vegetables are rich in micronutrients,

increase diet diversity and are important for the prevention of various disease and malnutrition (Engel 2001). Vegetables are traditionally grown in homegardens, which differ in size, biodiversity, seasonal produce and local resource use and preferences. Although most of the rural people grow vegetables mainly for their household consumption, the yield is not always enough to meet for the household needs. Therefore, malnutrition became a critical concerned for the government of Laos with a high prevalence of chronic energy deficiency among adults and children (Bhattachrjee et al. 2006).

Homegardens are typically areas with rich agrobiodiversity, their production may increase the availability and consumption of micronutrients, and to improve food security, particularly in areas with food deficit. The crops selected for the homegarden depends on the region, the size of the area available, and the preferences of the family. The selected crops should be highly adaptable to the high yielding areas. Vegetables are traditionally grown in homegardens.

For subsistence and poor farmers, varieties of crop and cultivars adapted to specific micro-niches around homesteads are crucial and accessible resources to provide a secure livelihood (Sthapit et al. 2004). Homegardens provide a means of growing a wide variety of nutrient-rich indigenous vegetables, which constitute a heterogeneous group of food plants, whose vegetables are consumed as leaves, fruits, tubers, roots, tender stems, flowers, beans or bulbs. These include the leafy greens such as amaranth, kangkong, basella, mustard, spinach, gourds, pumpkins, cucumber, chili, eggplant, tomato, beans, cabbage and lettuce etc. Depending on the agro-ecological condition, agricultural dynamics, and food habits, each rural community has a specific range of horticultural crops.

In this regard, the availability of water, moist and sub-moist areas are more suitable for homegardens. They are generally more diverse in horticulture and more practice in arid and semi-arid lands. Improving of homegardens require the optimal use of local agrobiodiversity, as well as integration of additional crops and crop varieties with specific values and uses preferable for the area. Many neglected crops constitute important plant genetic resources for developing homegardens. The introduction of new crops generally remains a feasible and desirable strategy. There are many crops suitable to expand the

agrobiodiversity base of homegardens, including leafy vegetables, fruit vegetables, root crops, and legume crops. The consideration of seed access and seed multiplication aspects is also relevant for the effective and continued development of homegardens (Gari 2003).

2.5. The benefits and difficulties of homegarden production

Homegardens provide multiple social benefits to the owners include food and nutritional security in many socio-economic, improving family health and human capacity, political situations, empowering women, promoting social justice and equity and preserving indigenous knowledge and culture (Mitchell & Hanstad 2004). They are also contributed to household food security by increasing availability, accessibility and utilization of the products. Many people, especially resource poor families are depended on homegarden for their main food because they cannot effort expensive animal product to fulfil their nutritional needs. However, the homegardens offer a cheap source of nutrition foods and household can access a better diversity of plant and animal food, which is led to increase in dietary intake. Thus, the activities of livestock and poultry can increase food and nutritional for the households as milk, eggs, meat etc. (Dela Cerda & Mukul 2008). In many parts of the world, plants are grown in homegardens because they are an important source of medicine for people and animals especially in developing countries, around 80% of the people use herbs and medicinal plants to treat various illness, diseases and to improve their health condition (Rao 2006).

A number of case studies carried out that homegardens contribute to household economic well-being in many ways (Mitchell & Hanstad 2004). Homegardens can provide extra income from selling a high quantity of vegetables and fruits. Some studies from Cambodia, Nepal and Papua New Guinea report that household's income was generated from the sale of homegarden such as vegetables, fruits and livestock products (Vasey 1986; Iannotti 2009).

While there are many benefits of running homegardens for many countries, especially developing countries. Hoogerbrugge and Fresco 1993 provide the main difficulties to homegardening. They identified that insufficient of land to establish a homegarden as well

as lack of ownership and the right of usages as the most important limiting factors to homegardens such as year-round availability of water, particularly in cities, and the availability of seeds, chemicals, capitals, credits, planting materials, knowledge and access to markets. Other barriers of development of productive homegardens include lack of water, cultural preferences (green leafy with poor), lack of information on the nutritional benefits of homegardening, lack of advice on agricultural extension, lack of available labour and lack of available labour for the poor people (Hoogerbrugge & Fresco 1993; Mitchell & Hanstad 2004).

2.6. Challenges in food and nutrition and the role of homegarden in Laos

Above mentioned issues are typical for Laos. Since rice is dominant food item, adequate amount of rice throughout the year is essential to achieving food security, which is even within the lowlands, where rice production is in surplus. However, the food supply is not secured. The diet of the household level is very poor (low) in term of proteins, fats and micronutrients (WFP 2013). The insufficiency of dietary intake can cause common diseases and infections to human body, especially childhood such as pneumonia, diarrhoea, respiratory tract infection, and malaria which often results of malnutrition. Although the diet in Laos is diverse, this diversity is hard to measure variables as quantity of food consumed. Several case studies were approved that the consumption of fats and protein is very low in northern of Laos because generally, the basic source of protein and fats come from wild animal meats and fish (WFP 2007; FAO 2011; Bartlett 2012; Ministry of Agriculture and Forestry 2013). Several experts suggest that diversification of household food production can ensure a better-balanced diet, especially for protein intake (Khemmatath 2002).

Laos was ranked 83rd of 119 qualifying countries on the 2018 global hunger index. Malnutrition is a critical concern for the country as it struggles with prevalence of stunting (44%) and underweight (27%) and is closely associated with poverty and hunger. Thus, the country is far from meeting Millennium Development Goals. Food security and nutrition is increasing prominence in the national discourse in recent years, appearing centrally in such strategic documents as the 2020 Strategy for Agriculture Development and the first ever

five-year National Nutrition Strategy and Plan of Action (WFP 2013). With widespread subsistence farming as a livelihood strategy, most rural households have incorporated homegardening as central tool towards food procurement and security. Food security in Laos is further threatened by the limited access to food as a result of poor road network especially the mountainous of northern regions. Approximately one in three village loses access to roads during the rainy season and consequently to lasting markets in this northern region.

There are many people still suffering from hunger and micronutrient deficiencies. About 40% of children suffer from chronic malnutrition and 13% of adults are chronically undernourished. The lack of vitamins can cause children serious health problems, such as permanent blindness and under-development of the brain (Leena et al. 2004). Additionally, a diet rich in energy for people but without other essential components may also lead to diabetes, cancer, heart disease and obesity (Frison et al. 2004). To improve this situation, local government has responsible to support homegardening as agrobiodiversity provides for food security as well as nutrition security for the households.

Food security remains a very high priority for the governments of less developed countries especially for Laos. In this regard, Laos government encourages the establishment of homegardens for the reduction of hunger and malnutrition and the improvement of livelihoods of the rural households. Homegardens seem to be found in many parts of the country and there are various types of gardens, varying in size, crops and technique used (Sodarak et al. 2003). Homegardens help rural household to improve the production of vegetables, fruits and animal food next to their houses and increase nutritional status of the population. Furthermore, homegardens play an important in household food supply and subsistence, and household income. With this importance of homegardening, Laos government has to pay more attention on homegarden and support in expanding and improvement of homegardens that contribute to food security, nutrition, poverty reduction and conservation of the country's agrobiodiversity (Dyg & Phithayaphone 2004). Almost 95 % of local households are engaged in agriculture and almost all households are involved in some forms of agricultural activities (WFP 2007). However, there is limited knowledge

of the impact of homegarden on biodiversity, nutrition and food security in scientific article public available.

3. Aims of the Thesis

The aim of the thesis is to analyze the contribution of homegardens to household food security in the ethnically mixed region, located in mountainous areas of northern Laos.

The specific objectives of the thesis are:

1. To document food species grown in homegardens by the ethnic groups and to obtain their capacity and use.
2. To calculate agrobiodiversity of food species grown in local homegardens, household resources capacity and analyse potential mutual effects.
3. To estimate nutritional value of food species from homegardens with special respect to household consumption.

3.1. The research questions and hypothesis

The study seeks to achieve its aim by answering the following research questions and hypothesis.

1. Is biodiversity, species abundance, richness and evenness, higher and dissimilar for food species grown in local home gardens of ethnically mixed regions in Laos?
2. Do home gardens food species consumed by households in ethnically mixed regions in Laos contain appropriate proportions of food nutrients?

H_0: There is no significant mutual effects between agrobiodiversity of food crops grown in local home gardens and household resource capacity.

H_1: There is a significant mutual effect between agrobiodiversity of food crops grown in local home gardens and household resource capacity.

4. Methodology

4.1. The description of study site

The study was conducted in the Khoun district which is located in Xieng Khoung Province, northeast of Laos and the province is distance from the Capital city of Vientiane around 400 km. The total land area of the province is 15,880 km2 on the mountainous Xieng Khoung plateau. The total population of the province is 244648. The average of altitude is 1,300 m, due to the relatively high altitude, a number of unique plants, fungal and animal species are known for Xieng Khoung Province. These include two species of pines, the evergreen Dacrydium elatum (local name: Mai Hing Hom) and the cypress of Fujian (local name: Mai Long Leng) and a wide range of non-timber forest products are used or sold to traders locally, especially Chinese. The average of temperature is range between 22.2-27.4 C˚, the average of humidity is 73 %, the total annual rainfall is 1,232 mm and the total annual sun shine is 2,566 hours. The province of Xieng Khoung is one of the main producers of crops for consumption such as maize, cabbage, chilli, rice, cauliflower, garlic and animal raising and others (Lao Statistics Bureau 2016).

4.2. Demographic, topography and climate of Khoun District

Khoun District is the study site with the total population of 35,332 (17,292 are female), distributed within 77 villages and 5,856 households. There are four major ethnic groups such as Lao Loum (36.37%), Hmong (58.81%), Khamu (4.17%) and Erdu (0.65%) (Khoun District Statistic Office 2016). The District is located about 32 km from the southeast of the Phonesavan municipality (19°18´40´´N, 103°22´03´´E). The total rain falls is between 1,500-1,900 mm per year, air humidity average is 73%, the average of annual temperature is 24˚C and annual average sunshine is 1,658.7 hours. The geographic area is diverse with a variety of agricultural production systems including rainfed rice-based farming systems in lowland of the plateau, shifting cultivation in upland areas, cash crops and livestock production. There are two different seasons observed in this province: dry season and rainy

season. A dry season is running from April to October and the rainy season is from May to September (Ministry of Agriculture and Forestry 2014).

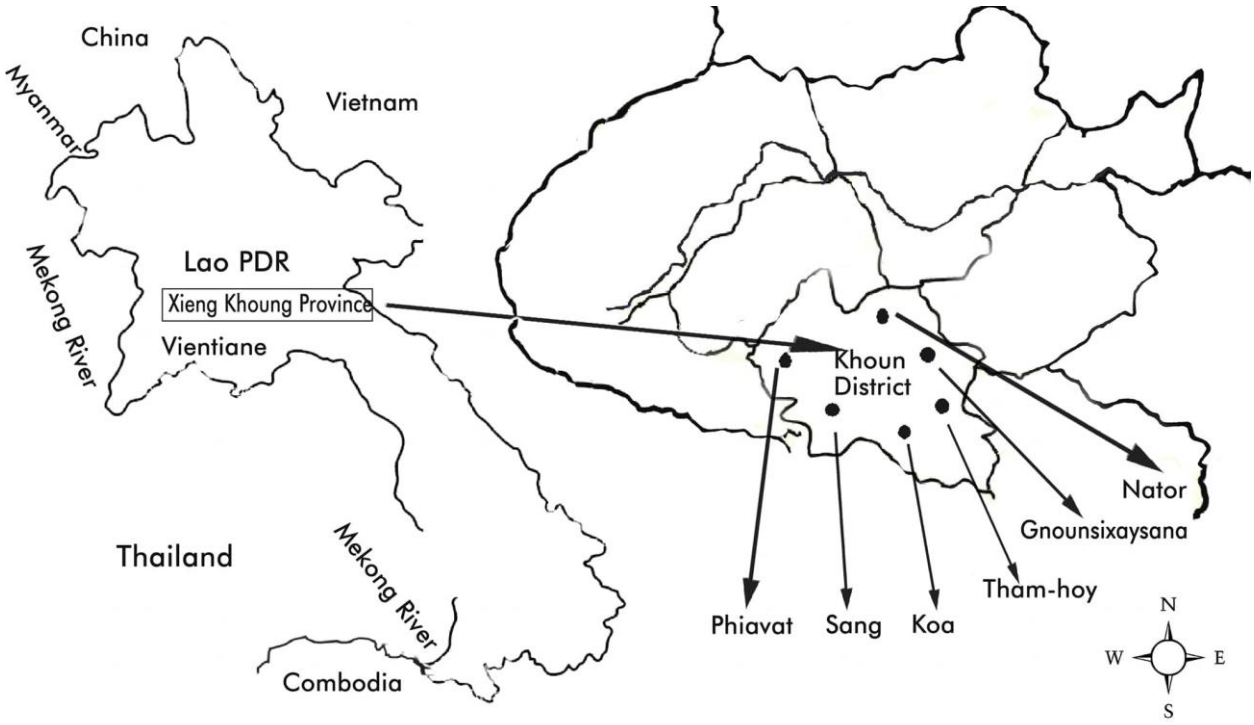

Figure 1: Location of Xieng Khoung province and Khoun District

4.3. Economic activities and household use

Khoun district is one of the areas rich in natural resource and there is one important river (Namn giew river) which is providing water for agricultural activities for the whole year. There are 37 permanent weirs, one semi-permanent weir and 135 traditional weirs. All of

them could cover around 2,400 ha in the rainy season and 484 ha in the dry season. Most of the families in Khoun district are dependent on agricultural production. According to the following statistic of agriculture production areas: total annual harvested area in rainy season was 4,142.2 ha in 2016. Many crops were produced in rainy season such as paddy rice 2,400 ha, upland rice 420 ha, maize 128 ha, coffee 356.7 ha, fruit trees 126 ha, vegetables 199 ha, root crops 280 ha, pineapple 35 ha, banana 28 ha, and others crops 169.5 ha. In dry season, the total cultivated areas are 288 ha, mainly produce vegetables, leaf 125 ha, fruit crops14 ha, and rhizome 80 ha, cabbage 35 ha, garlic 48 ha, sweet corn 17 ha, and beans 17 ha. For animals raising cattle 19,549 units, buffalo 4,289 units, horse 652 units, pig 19,147 units, goat 1,535 units, and poultry 76,528 units. The pasture area is 1,011.9 ha in total, and the fish pond is 470.3 ha. Majority of the farmers in this region were able to produce a high number of crops from the farms and some families carried out crops production and animal production for household consumption and market oriented (Khoun District Agricultural and Forestry Office 2016).

4.2. Sampling design

A total number of 100 households with homegardens were selected for our survey. Data were collected in six villages at different biophysical and ethnical characteristics with accessible road to the villages as the following (Table 1).

Table 1: Overview of selected villages and ethnics.

No.	Village name	Total number of households	Lao Loum household	Hmong households
1.	Nator	27	8	1
2.	Gnounsixaysana	246	10	34
3.	Tham-hoy	78	19	0
4.	Koua	48	10	5
5.	Sang	95	4	0
6.	Phiavat	218	7	1
Total household of ethnics		712	59	41

Non-probability sampling was used which comprised convenience and snowball sampling methods. The data was obtained during the main growing season for the northern region

through personal visits to homegarden. Priority was given to the head of the household through personal interviews by using Lao language and a structured questionnaire. The data was collected as the following information: the first part is household demographic such as age, gender, school attendance and main occupation, overview of household assets, capital, main activities, income diversification and utilization of homegarden are recorded. The second part is the characteristic of homegardens which are included: years of homegarden, size, elevation from sea level, ownership of land, constraints in homegardens and perception of homegarden owner. The third part is vegetable survey, we documented the following data: species names by local names, scientific name, number of species, number of individuals of each species per homegarden, main purpose of use, frequency of cultivation in during the year and yearly production, and labour participation on homegarden. After that we documented the groups of the most important food plant species for the consumption by the ethnic groups (Questionnaire in Appendix 1).

The research was done in three steps:

First, transect walked and discussed with the local key-informants in order to understand complexity of the farming system in the study site.

Secondly, focus group discussions was done with village heads, household heads and other main relevant farmers in order to get more detailed information on local homegardens diversity, food security, social, economic, cultural and population dynamics in the study area. We used a structured interview with household members to ensure that each interview is presented exactly with the same questions in the same order.

Thirdly, the study was compared of ethnic groups (Lao Loum and Hmong ethnics) on household food security from homegarden.

4.5. Data analysing

Data are summarised for each home garden and entered into MS Office Excel for cleaning and used for the calculation of agrobiodiversity of food species and coding. Statistical analyses were done in the SPSS and Stata. Descriptive statistics (frequencies) were used to document the crop species grown by the ethnic groups, their use and capacity. To establish the dissimilarities or otherwise among the two ethnic groups, number of plant species, plant

density, plant abundance, Margalef index, Shannon-Wienner index and Shannon equitability index, were used following a similar approach by Vlkova et al. (2010). We again established the mutual effect between biodiversity and household assets capacity using a multiple linear regression model. Below are the specifications of the models used.

4.5.1. Margalef Index

Margalef index *(d)* is a simple measure of species richness (Margalef, 1958). Specifically,

$$d = S - 1/\ln(N)$$

Where *S* is the total number of species, *N* is the total number of individuals in the sample and *ln is the natural logarithm sign*.

4.5.2. Shannon-Wienner Index

Shannon-Wiener Index *(H)* is an information index commonly used as diversity index in ecology. It technically quantifies the vagueness in predicting the identity of a new taxa given quantity of taxa and evenness in abundances of individuals in each taxon. It is specified as;

$$H = -\sum(Pi * Ln(Pi))$$

$$Pi = \frac{ni}{N}$$

Where *ni* is the quantity of individuals of amount (or biomass) of each *i* specie and *N* is the sum of individuals (or biomass) for the site. *H* values ranges from 0 to 5. Albeit, the Shannon-Wiener index typically fall between 1.5 and 3.5. it is also underpinned by the underlying assumption that sample for the site was collected randomly.

We also estimate the Shannon Equitability index (E_H) as;

$$E_H = \frac{H}{H_{max}} \text{ but } H_{max} = Ln(x)$$

Where *x* is the species richness per home garden (number of species) in an ethnic group.

E_H assumes values between 0 and 1 with 1 representing absolute ***eveness***.

4.5.3. Multiple Linear Regression

To establish a potential mutual effect between biodiversity and the resource capacity of a given home garden for a household, we adopted the Ordinary Least Square (OLS) method. For an i^{th} household's home garden, the model is specified as;

$$Y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \ldots\ldots + \beta_{12} x_{12} + \varepsilon_i$$

Where

Y_i = the dependent variable, number of species grown per household's home garden.

α = is the constant

$\beta_1, \beta_1, \beta_1, \ldots\ldots \beta_{12}$. = parameter estimates of the regressors *(x).*

x_i = household resources – home garden size, active labour force, off-farm income, milling drill machine, vehicle, motorbike, bicycle, phone, television, fridge, heads of poultry birds and heads of duck birds.

4.5.4. Definition of Variables

Home garden size (land) was in square meters (m^2) whereas family labour was measured as the number of active labour force (15 – 60) per household, representing availability of family labour, poultry birds' heads and duck birds' heads were measured as the quantity owned by given household whilst access to milling drill, motor bike, bicycle (i.e. processing and transportation machinery ownership) fridge (i.e. storage facilities). It is anticipated that households with processing machines such as milling drill, personal means of transportation such as motor bike bicycle and vehicle as well as access to fridge for their cultivated home garden products will be more diverse. We again included phone, television ownership to capture the impact of access to information on species agrobiodiversity. It is farmers who have access to phone and television might be information rich, hence might improve agrobiodiversity. Access to milling drill, motor bike, bicycle, vehicle and fridge were measured as dummy variables with one been having access to the said asset and zero otherwise. Off-farm income was however measured as a sum of incomes from salary/wages from other sources, forest products, firewood collection, handicrafts and other non-farming activities (kip).

5. Results

5.1. Characteristics of selected homegardens and households

Table 2: Descriptive statistics of home gardens and households

Variable	Lao Loum			Hmong		
	n[a]	Mean (Std. Dev.)	Range	*n*	Mean (Std. Dev.)	Range
Household size	59	5.27 (1.563)	2 – 10	41	5.90 (1.85)	2 – 10
HGD[b] size (m^2)	59	1298 (1102)	1130 – 76582	41	2158.20 (1640.90)	210 – 7500
Labour force	59	3.34 (1.23)	1 – 6	41	3.76 (1.45)	2 – 6
HHM[c] dependent	38	1.93 (1.42)	1 – 5	37	2.17 (1.58)	1 – 5
HHM members age	59	41.47 (10.03)	25 – 69	41	36.85 (12.25)	16 – 68
HHM schooling years	45	7.69 (3.06)	2 – 14	32	4.20 (3.66)	1 – 14
Poultry birds	55	39.83 (30.30)	8 – 200	37	22.49 (16.51)	1 – 80
Duck birds	48	25.76 (14.58)	8 – 80	35	14.12 (12.54)	1 – 55
Off-farm income	59	42672881.36 (30116400)	4000000 – 1226100000	41	12448780.49 (12725764.67)	500000 – 79000000
HGD income	59	20766949.15 (18539579.31)	500000 – 75000000	41	12436585.37 (12726444)	2500000 – 60000000
		Frequency	*Percent*		*Frequency*	*Percent*

Information access:						
	59	57	97%	41	30	73%
Television						
Radio	59	24	41%	41	17	41%
Phone	59	56	95%	41	36	88%
Machinery ownership:						
Motor bike	59	56	95%	41	40	98%
Bicycle	59	18	31%	41	9	22%
Vehicle	59	32	54%	41	13	32%
Milling drill	59	3	5%	41	2	5%
Fridge	59	55	93%	41	22	54%

[a] *number of surveyed households*

[b] *HGD home garden*

[c] *HHM household members*

birds relative to 22 poultry and 14 duck birds were owned per household for Lao Loum and Hmong respectively. Furthermore, phone, bicycle, vehicle, and fridge ownership was higher (95%, 31%, 54% and 93%) relative to Lao Loum ethnicity (88%, 22%, 32% and 54%), except for motor bike which was higher (98%) for households in Hmong relative to Lao Loum (95%).

Table 2 again indicates that home gardening is gradually shifting towards commercialization rather than its core purpose of household consumption. Because each household surveyed sold a proportion of their home garden products. Income earned per house from home garden ranged from 500,000 to 75,000,000 for both ethnicities whereas averagely 20766949.15 kip and 12436585.37 kip were realised by households of Loa Loum and Hmong respectively through the sales of home garden products. Like home garden income, the average off-farm income per household was higher (42672881.36 kip) among Loam Loum households relative to Hmong (12448780.49 kip). This is also an indication of a richer resource base for Loa Loum households relative to Hmong households.

5.2. Household Capacities, Home Garden Uses and Components Used

In all, 132 plant species were encountered between Lao Loun and Hmong ethnicities. These species are used for purposes such food, sales (income generation), spices, ornaments, medicines, fodder, animal feed, cultural purposes, materials for textiles and construction. The results again indicate that home garden plant are important source of food (66.7%), income (16.67%), ornaments (5.80%), species (2.90%), medicine (2.90%), fodder (2.17%), cultural materials (1.44%) and materials for textile and construction (0.72). Among the encountered species, 41% were used for multiple purposes whereas 59% were for single uses.

The most multipurpose specie encountered is *Manihot esculenta Crantz* used for food (roots, young leaf), fodder (matured leaf, roots back) and ornamental purposes (young flower). Furthermore, 46% of the species had two or more of its parts used with the remaining 54% having a single part of use. Plant leaf (mature and young), were the most used parts (55%) of the surveyed species followed by fruits (47%), flower (15%), stem (12%), Rhizome (7%), seed (4%), trunk (4%), whole plant (3%), roots (2%). The least used parts were however the back and bulb of the species which recorded 1% each.

The analyses also revealed that *Coriandrum sativum L* is the most dominant specie (i.e. 37.09% of total quantity of species cultivated) cultivated in both Lao Loum and Hmong home gardens for purposes of food (whole plant) and medicine (seeds). This specie *(Coriandrum sativum L.),* together with *Zea mays, Zea mays Line.Var Saccharata, Cucumis sativus L., Allium cepa L, Ipomoea reptans L., Brassica oleracea var. italica, Brassica juncea, Brassica rapa subsp. Pekinensis, Brassica Chinensis Linn. and Brassica juncea*, accounted for 94.52% of the total quantity of all species grown in the home gardens of the two ethnicities mostly used as food, fodder, spices, herbs, and income generation (sales). Albeit, *Phyllanthus acidus Linn., Morus alba, Hibiscus sabdariffa Linn., Basella alb., Oldenlandia corymbosa L., Phyllanthus acidus Linn., Fragaria vesca L., Punica granatum L., Sesamum indicum, Litchi chinensis Sonn., Oroxylum indicum (L.) Kurz, Prunus domestica ssp. Italica, Leucaena leucocephala de Wit, and Curcuma longa L.* were the least cultivated species among both ethnicities (refer to Table 2), notwithstanding their nutritional, economic and cultural importance coupled with their multiple usage.

The vertical structure of Lao Loum and Hmong home gardens are tall trees dominant (48%) with other plant life forms such as shrubs (23%), herbs (15%), climbers (9.5%) and graminoids (4.5%).

Table 3: Ethnobotanical data on plant species cultivated in Lao Loum and Hmong home gardens.

Local Name	*English Name*	*Scientific Name*	*Capacity*		*Purpose of Use*	*Part Used*
			Lao Loum	*Hmong*		
Bai poo	Betel piper	*Piper betle Linn.*	4	-	Chewing stick	Leaf
Bone	Cocoyam	*Colocasia esculenta (L.) Schott*	35	20	Animal feed	Root, stem
Café	Coffee	*Coffea arabica L.*	1333	2	Food	Fruit
Dork dowhieang	African marigold	*Tagetes erecta L.*	75	3	Ornamental	Flower
Dork fueng	Orchid	*Dendrobium spp.*	6	-	Ornamental	Flower
Dork khae	Unknown	*Sesbania grandiflora*	6	-	Food	Flower, fruit
Dork koularb	Damask rose	*Rosa x damascena*	4	-	Ornamental	Flower
Dork leav	Tree jasmine	*Mayodendron igneum (Kurz) Kurz*	12	4	Food	Flower
Dork sethtea	Christ thorn	*Euphorbia splendens Bojer ex Hook.f.*	12	-	Ornamental	Flower
Dork taven	Sunflower	*Helianthus annuus L.*	15	-	Ornamental	Flower
Hoa carrotkao	Chinese radish	*Raphanus sativus L.*	5000	5000	Sale	Root
Hoa kha	Ginger	*Alpinia galanga*	125	55	Sale	Rhizome, trunk
Hoa kheang	Ginger	*Zingiber officinale Roscoe*	1359	272	Food	Rhizome
Hoa peurk	Taro	*Colocasia esculenta (L.) Schott*	162	142	Food	Rhizome
Hoa sykhai	lemon grass	*Cymbopogon citratus (DC.)*	374	139	Sale	Grass

		Stapf.				
Kea minh	Curcuma longa	*Curcuma longa L.*	2	-	Culture	Rhizome
Kiea kaohor	Heart leaved moonseed	*Tinospora crispa Miers ex Hook.f.et Thoms.*	12	-	Medicine	Stem
Lumtoon	Elephant's ear plant	*Colocasia gigantea*	53	30	Food	Leaf, trunk
Mai ketsana	Agarwood	*Aquilaria malaccensis*	3	-	Ornamental	Whole plant
Manh dang	Sweet potato	*Ipomoea batatas (L.) Lam.*	15402	14802	Food	Rhizome, young leaf
Manh pouw	Yam bean	*Pachyrrhizus erosus Urban*	16	-	Food	Rhizome
Manh ton	Cassava	*(L.) Urban (Manihot esculenta Crantz)*	514	370	Fodder	Rhizome, young leaf, young flower
Mark avocado	Avocado	*Persea americana Mill.*	6	1	Dessert fruit	Fruit
Mark burb	Smooth luffa	*Luffa aegyptiaca*	147	114	Food	Fruit, young shoot, young flower
Mark chong	Asian pear	*Pyrus pyrifolia*	103	21	Sale	Fruit, young leaf, trunk
Mark fangdeng	Sappanwood	*Caesalpinia sappan*	10	-	Ornamental	Whole plant
Mark fieung	Star fruit	*Averrhoa carambola L.*	4	-	sweet, sour fruit	Fruit, young leaf
Mark hong	Papaya	*Carica papaya L.*	220	65	Food	Fruit
Mark hongdeng	Castor	*Ricinus communis L.*	5	-	Medicine	Fruit, leaf

Mark katanh	Green plum	*Prunus domestica ssp. Italica*	1	-	Sweet, sour fruit	Fruit
Mark katinh	Ipil-ipil	*Leucaena leucocephala de Wit*	1	-	Vegetable	Fruit, young leaf, trunk
Mark khaeng	Torvum eggplant	*Solanum torvum Swartz.*	91	18	Food	Fruit
Mark khaengkhom	Nightshade	*Solanum trilobatum L.*	63	42	Food	Fruit
Mark kharm	Tamarind	*Tamarindus indica L.*	7	-	Food, sweet, sour fruit	Fruit, young leaf
Mark khay	Peach	*Prunus persica (L.) Stokes*	57	24	Sale	Fruit
Mark kheehood	Kaffir lime	*Citrus hystrix*	2	-	Mature leaf, fruit	
Mark khiea	Thai eggplant	*Solanum virginianum L.*	13707	1260	Food	Fruit
Mark khieahumma	Eggplant	*Solanum melongena.*	9	9	Food	Fruit
Mark khieakhom	Eggplant	*Solanum melongena L.*	55	40	Food	Fruit
Mark khoaw	Spiny ground	*Momordica cochinchinensis Spreng*	13	-	Food	Fruit
Mark khore	Palm	*Pholidocarpus kingi*	57	8	Food	Fruit, leaf
Mark khouy	Banana	*Musa paradisiaca L.*	1190	488	Food	Fruit, flower, leaf, trunk
Mark kieng	Orange	*Citrus sinensis Osbeck*	7	-	Sweet fruit	Fruit
Mark ko	Persimmon	*Diospyros kaki L.f.*	5	-	Sale	Fruit

Mark korfalung	Chestnut	*Castanea spp.*	6	-	Food	Fruit
Mark lamyai	Longan	*Dimocarpus longan Lour.*	65	10	Food	Fruit
Mark lenhnoy	Tomato	*Solanum lycopersicum L.*	267	42	Food	Fruit
Mark linchee	Lychee	*Litchi chinensis Sonn.*	6	-	Sale	Fruit
Mark linhmai	Broken bones tree	*Oroxylum indicum (L.) Kurz*	7	-	Food	Fruit, flower, bark
Mark lord	Unknown	*Unknown*	29	3	Sale	Fruit
Mark manh	Common plum	*Prunus domestica*	238	87	Sale	Fruit
Mark mard	Unknown	*Unknown*	20	5	Spice	Fruit, young leaf
Mark mee	Jackfruit	*Artocarpus heterophyllus Lam.*	14	1	Sweet fruit	Fruit, seed, young leaf
Mark mieak	Okra	*Abelmoschus esculentus L.*	70	70	Sale	Fruit
Mark monekhai	Souteria lucuma	*Pouteria lucuma*	19	3	Food	Fruit
Mark moung	Mango	*Mangifera indica L.*	135	24	Food, sale	Fruit
Mark mungkhone	Dragon fruit	*Hylocereus undatus (Haw.)*	25	-	Food	Fruit, leaf
Mark nga	Sesame	*Sesamum indicum*	3	-	Spice	Fruit
Mark nord	Passion fruit	*Passiflora edulis Sims*	57	30	Food	Fruit, young shoot
Mark now	Lime	*Citrus aurantifolia (Christm.) Swingle*	31	4	Sale	Fruit
Mark nut	Pineapple	*Ananas comosus (L.) Merr.*	83	49	Sale	Fruit

Mark phet	Chilly	*Capsicum annuum L.*	50987	8287	Food	Fruit
Mark phetyai	Sweet pepper	*Capsicum annuum L.*	124	-	Sale, spice	Fruit
Mark pila	Pomegranate	*Punica granatum L.*	3	-	Sweet fruit	Fruit
Mark pouk	Pomelo	*Citrus maxima merr.*	72	10	Sweet & sour fruit	Fruit
Mark pow	Coconut	*Cocos nucifera L.*	1	1	Ornamental	Fruit
Mark sai	Bitter gourd	*Momordica charantia L.*	25	25	Sale	Fruit, young leaf
Mark salee shaeng	Maize	*Zea mays*	29770	29770	Animal feed	Seed
Mark salee warn	Sweet corn	*Zea mays Line.Var Saccharata.*	28055	250	Food	Seed
Mark sida	Common guava	*Psidium guajava L.*	35	6	Sweet fruit	Fruit
Mark ttorbery	Strawberry	*Fragaria vesca L.*	15	-	Sweet fruit	Fruit
Mark tenghai	Cucumber	*Cucumis sativus L.*	12832	12800	Food, sale	Fruit
Mark toadinh	Peanut	*Arachis hypogaea L.*	10160	8500	Food	Seed
Mark toapeb	Lima bean	*Phaseolus lunatus L.*	12	-	Food	Fruit
Mark toapoo	Winged bean	*Psophocarpus tetragonolobus*	96	17	Food	Fruit
Mark toasunh	Common bean	*Phaseolus vulgaris L.*	8946	1106	Food	Fruit
Mark toayow	Yard long bean	*Vigna unguiculata L. Walp.*	7147	1562	Food	Fruit
Mark ue	Pumpkin	*Cucurbita maxima*	1039	715	Food	Fruit, flower, young shoot, seed

Mark yom	Star goose berry	*Phyllanthus acidus Linn.*	9	1	Sour Fruit	Fruit, young leaf
Mark zou	Chayote	*Citrus hystrix(Sechium edule)*	841	332	Food	Fruit, young shoot
Nor mai	Bamboo	*Bambusoideae*	114	20	Food	Bamboo shoot, trunk
Oiy	Sugarcane	*Saccharum officinarum L.*	261	66	Food	Stem
Pak baimengkae	Perilla	*Perilla frutescens (L.) Britton*	38	-	Food	Leaf, young stem
Pak boa	Green onion	*Allium cepa L.*	259440	29950	Food	Bulb, leaf
Pak boalafa	Thai basil	*Ocimum basilicum*	134	24	Spice	Leaf, flower
Pak boaliey	Welsh onion	*Allium fistulosum*	80	80	Food	Leaf
Pak bong	Water convolvulus	*Ipomoea reptansL.*	124700	4500	Food	Leaf, stem
Pak celery	Celery	*Apium graveolens var. secalinum*	7860	-	Food	Leaf, stem
Pak eahoum	Moringa tree	*Moringa oleifera Lamk.*	4	-	Food	Young leaf
Pak ealert	Wildbetal Leafbush	*Piper sarmentosum Roxb.*	402	70	Food	Leaf
Pak eatou	Lamon basil	*Ocimum × africanum*	570	96	Food	Leaf, flower
Pak homdeng	Bireum	*Amaranthus tricolor L.*	6400	-	Food	Whole plant
Pak homlarb	Mint	*Mentha x piperita L.*	25275	1200	Food	Leaf, young shoot

Pak hompae	Cilantro	*Eryngium foetidum L.*	1250	-	Food	Leaf
Pak hompom	Coriander	*Coriandrum sativum L.*	757560	79600	Food, medicine	Whole plant, seed
Pak homyai	Amaranth	*Amaranthus viridis L.*	34922	52	Food	Whole plant
Pak kalumdorkkhao	Chinese cabbage	*Brassica rapa subsp. pekinensis*	8000	-	Sale	Flower, leaf
Pak kalumdorkkiew	Broccoli	*Brassica oleracea var. italica*	20800	4500	Sale	Flower
Pak kalumpee	Cabbage	*Brassica oleracea L. var. Capitata*	124580	9300	Food	Leaf
Pak kapout	Holy basil	*Ocimum citrioddourum*	39	20	Food	Leaf, flower
Pak kardhai	Chinese mustard	*Brassica juncea*	141960	141960	Sale	Leaf
Pak kardkaohor	Chinese cabbage	*Brassica rapa subsp. pekinensis*	86980	74000	Sale	Leaf
Pak kardkhao	Chinese white cabbage	*Brassica rapa var. chinensis)*	12840	400	Food	Leaf
Pak kardkhiew	Kale	*Brassica integrifolia (West.) O.E.*	2100	300	Food	Leaf
Pak kardna	Chinese broccoli	*Brassica oleracea L. Cv. Alboglabra Group*	896	-	Sale	Leaf, stem
Pak kardsom	Choi sum	*Brassica Chinensis Linn.*	178260	9700	Food	Leaf, stem, flower
Pak kardteenmea	Chinese mustard	*Brassica juncea*	147060	12540	Food	Leaf
Pak kayeng	Stevia	*Stevia rebaudiana Bertoni M.*	866	12	Sale	Leaf

Pak kha	Climbing wattle	*Acacia pennata (L.) Willd.*	15	-	Spice	Young leaf
Pak kowthong	Fish mint	*Houttuynia cordata*	1060	100	Food	Leaf, stem
Pak laefae	Diamnel flower	*Oldenlandia corymbosa L.*	3	-	Food	Leaf, stem
Pak nork	Gotu kola	*Centella asiatica Urb.*	100	-	Food	Leaf, stem
Pak paeng	Garlic chives	*Allium tuberosum Rottler ex Spreng.*	507	-	Food	Leaf
Pak peow	Vietnamese mint	*Polygonum odoratum Lour.*	2189	233	Food	Leaf, stem
Pak pung	Malabar spinach	*Basella alba L.*	18	4	Food	Leaf, young shoot
Pak sai	Unknown	*Unknown*	18	4	Food	Leaf, fruit
Pak salad	Lettuce	*Lactuca sativa L.*	18810	300	Food	Leaf
Pak saladdeng	Red leaf lettuce	*Lactuca sativa L.*	200	-	Food	Leaf
Pak saladthai	Unknown	*unknown*	184	24	Food	Leaf
Pak shung	Malabar spinach	*Basella alb.*	8	-	Food	Leaf
Pak tamnin	Coccinia	*Coccinia grandis Voiht.*	10	-	Food	Leaf
Pak tiam	Garlic	*Allium sativum L.*	53800	1000	Food	Bulb, leaf
Pak toumtem	Black nigh tshade	*Solanum nigrum L.*	56	30	Food	Leaf
Pak tung O	Glebionis coronaria	*Chrysanthemum coronarium L.*	11430	-	Sale	Leaf, stem
Pak warn	Melientha	*Melientha suavis*	51	-	Food	Leaf, stem
Pak zee	Dill	*Anethumgraveolens Linn.*	33400	4200	Food	Leaf
Sompordee	Roselle	*Hibiscus sabdariffa Linn.*	5	-	Food	Fruit, young

						leaf
Ton fay	Cotton	*Gossypium herbaceum L.*	2	-	Textile	Flower
Ton mone	Mulberry	*Morus alba*	4	1	Sweet fruit	Fruit, young leaf
Wan zonh	Boat-lily	*Tradescantia spathacea Sw.*	20	-	Medicine	Leaf
Yalaosoung	Unknown	*Unknown*	81	28	Medicine	Whole plant

5.3. Diversity of Plant Species

Table 4:Agrobiodiversity indices

Observed Characteristics	Lao Loum (n^a = 59)	Hmong (n = 41)
Number of observed species	132	84
Average no. of species/HGD[b]	21.12	14.10
Average species density/HGD	1.63	0.65
Average abundance/HGD	29945.93	13072.02
Average Marglef index/HGD	2.05	1.47
Average Shannon-Wienner index /HGD	2.52	2.28
Shannon Equitability index/HGD	0.52	0.51

Results from Table 4, the total number of identified species (100%) were found in Lao Loum home gardens whereas 63.63% were found in Hmong home gardens. The poorest home garden recorded 7 and 4 species whilst the richest home garden recorded 47 and 39 for Lao Loum and Hmong home gardens respectively. Again, cultivated species per home garden was higher (21.12) for home gardens of the Lao Loum ethnicity relative to Hmong (14.10). In respect of number of plant species per 100 m^2 of per home garden, Lao Loum was again more diverse (1.63/100 m^2) relative to Hmong (0.65/100 m^2). Averagely, Lao Loum home gardens were more species abundant (29945.93) per home garden compared to Hmong home gardens (13072.02). The high species abundance recorded for home gardens of both ethnicities were due to higher cultivation of some 11 major species *(Coriandrum sativum L., Zea mays, Zea mays Line.Var Saccharata, Cucumis sativus L., Allium cepa L, Ipomoea reptans L., Brassica oleracea var. italica, Brassica juncea, Brassica rapa subsp. Pekinensis, Brassica Chinensis Linn. and Brassica juncea)* which accounted for 94.52% and are used for food and income generation.

The Margalef index, which indicates species richness shows that average species richness per home garden for the surveyed villages ranges 1.47 to 2.05. Again, species richness was higher for surveyed Lao Loum villages relative to Hmong villages although both are considered as higher values.

The Shannon-Wienner and Shannon equitability indices per home garden which represent evenness and abundance of species were similar for the surveyed home gardens of Lao Loum and Hmong. The mean indices recorded for in Loa Loum and Hmong home garden ranged between 2.28 to 2.52 (Shannon-Wienner index). The mean Shannon equitability index per home garden also ranged between 0.51 to 0.52, implying that species diversity in home gardens of Lao Loum and Hmong ethnicities are a little above average (with 1 being absolute diversity).

5.4. Species Diversity and Household Resources

Table 5:A Linear Regression of Species Diversity and Household Resources

Regressors	Coef.	Std. Err.	P>t
HGD size	-0.001	0.001	0.241
Active labour force	-2.005	0.887	0.028
Off farm income	0.000	0.000	0.040
Milling drill*	4.682	3.753	0.218
Vehicle*	-1.115	1.481	0.455
Motorbike*	-1.849	1.245	0.143
Bicycle*	-2.966	1.577	0.065
Fridge*	1.541	1.496	0.307
Phone*	2.077	1.049	0.053
Television*	4.751	2.513	0.064
Poultry birds	0.031	0.046	0.502
Duck birds	0.182	0.084	0.035
_cons	9.832	3.493	0.007
Number of Obs.	*67*		
Prob > F	*0.000*		
R-squared	*0.481*		
Adj. R-squared	*0.365*		

** dummy variable with 1 = have access and 0 otherwise*

The multiple linear regression in Table 5 was used to analyse the relationship between agrobiodiversity and household resources capacities. Results in Table 5 indicates a statistically significant relationship between agrobiodiversity and the selected household resources, at 5% alpha level, as shown by the p-value of the model (Prob>F = 0.000). Again, the Adjusted R-squared value of 0.365 implies that up to 37% and of variations in plant species diversity is caused by variations in the selected household resources, better for social science research.

Moreover, off-farm income, heads of poultry and duck birds owned as well as milling drill, fridge, phone and television ownership increases plant species diversity. Albeit, milling drill and fridge ownership as well as heads of poultry birds owned were statistically insignificant. The co-efficient of off-farm income (0.000) also implies that its causality effect is insignificant although statistically significant.

Furthermore, the size of a home garden (m^2), active labour force (indicating family labour availability), as well as vehicle, motor bike and bicycle ownership (representing personal means of transport) reduces plant species diversity. However, except for active labour force and bicycle ownership, the remaining are statistically insignificant determinants of species diversity. Thus, for every family labour employed, the number plant species cultivated reduces by approximate 2 species per home garden whilst reducing by approximately 3 species for owning a bicycle.

By implication, for agrobiodiversity (plant species diversity) of a home garden to improve, households must reduce excess family labour in home gardens whilst improving access to information (phone and television ownership).

5.5. Nutritional Values of Food Species in Home Gardens

Table 6: Nutritional components of species consumed at household level

English Name	***Scientific Name***	***Carbohydrate***	***Protein***	***Total Lipids***	***Fiber***	***Calcium***	***Iron***	***Magnesium***	***Phosphorus***	***Potassium***	***Sodium***	***Zinc***	***Vitamin A***	***Vitamin B***	***Vitamin C***	***Vitamin D***	***Vitamin E***	***Vitamin K***
Coffee	*Coffea arabica L.*	**		**	**	A	**	A	A	A	A	**	**	A	**	**	**	A
Ginger	*Zingiber officinale Roscoe*	M	M	A		A	M	A	**	M		M	**			**	**	**
Lemon grass	*Cymbopogon citratus (DC.) Stapf.*	M	A	A	**		M	A	**	M		M	**	M		**	**	**
Sweet potato	*Ipomoea batatas (L.) Lam.*	A			A				A		A		M	A		**	A	
Yam bean	*Pachyrrhizus erosus Urban*	A			M				**					**	A	**	M	
Cassava	*Manihot esculenta Crantz*	A												A		**		
Avocado	*Persea americana Mill.*		A	M	M		A	A	A	A	A	M		M		**	M	M
Asian pear	*Pyrus pyrifolia*	A	A		A	A	**	A	A	A	**	**	**	**	A	**	A	A
Star fruit	*Averrhoa carambola L.*	A	A	A	A						A	A				**		**
Papaya	*Carica papaya L.*							A			M		A	A		**		
Peach	*Prunus persica (L.) Stokes*	A	A	A	A			A		A	**	A	A			**	M	A
Thai eggplant	*Solanum virginianum L.*																	
Eggplant	*Solanum melongena.*															**	M	
Eggplant	*Solanum melongena L.*															**	M	
Palm	*Pholidocarpus kingi*		M	A	A	M	M	M	M	A	M	M	**	A	A	**	**	**
Banana	*Musa paradisiaca L.*	A						A		A						**		
Orange	*Citrus sinensis Osbeck*	A			A	A	M							A	A	**		
Chestnut	*Castanea spp.*	M	A		M	A			A	A			M	A	A	**	**	**
Longan	*Dimocarpus longan Lour.*		**	**	**	**	**				**	**	**	**		**	**	**
Tomato	*Solanum lycopersicum L.*										M					**	M	
Lychee	*Litchi chinensis Sonn.*	M	A	A							A	A	**			**		

Common plum	*Prunus domestica*	A	A	A	A		A	A	A	A	A	A		A	A	**	A	A
Jackfruit	*Artocarpus heterophyllus Lam.*	M	M	A		A		A		A	A	A		A		**		
Okra	*Abelmoschus esculentus L.*										M			M		**		M
Mango	*Mangifera indica L.*												A	A		**		
Passion fruit	*Passiflora edulis Sims*						A				A		A			**		
Lime	*Citrus aurantifolia (Christm.) Swingle*	A				A				A					M	**		
Pineapple	*Ananas comosus (L.) Merr.*	A					A					A		A	A	**		
Chilly	*Capsicum annuum L.*	A					A	A	A					A	A	**		
Pomegranate	*Punica granatum L.*	M	M	M	A	A	A	A	A	A	A	M	**	A	A	**	A	M
Pomelo	*Citrus maxima merr.*	M		M	A	**	**	**	**	**	**	**			A	**	**	**
Coconut	*Cocos nucifera L.*	A		A	M		A		M	A	M		**			**		A
Bitter Gourd	*Momordica charantia L.*							A	A	A	A			M	A	**	M	M
Sweet corn	*Zea mays Line.Var Saccharata.*	M	M		A		**			A	**		A		A			
Common Guava	*Psidium guajava L.*		A		A			A	A	A		A		A	M	**		
Strawberry	*Fragaria vesca L.*	A	A	A	A	A	A	A	**	A	A	A		A		**	M	**
Cucumber	*Cucumis sativus L.*	A						A				A				**		
Peanut	*Arachis hypogaea L.*	A	M	M	M	M	M	M	A	M	A	M	**	M	**	**	M	**
Winged Bean	*Psophocarpus tetragonolobus*		A	A	**	A		A	M		A	A		M	**	**		
Green Bean	*Phaseolus vulgaris L.*	A	A		A			A	A		A	A	**	A				
Yard long bean	*Vigna unguiculata L. Walp.*				**				A		A			A				
Pumpkin	*Cucurbita moschata Duchesne*										A		A			**	A	
Chayote	*Sechium edule*	M	A	**	A	A		A		A			**	**	A	**		
Bamboo	*Bambusoideae*		A	A	A					M		M				**	M	**
Green Onion	*Allium cepa L.*		A	A	A		A									**		
Moringa	*Moringa oleifera Lamk.*		A			A		A	A		A		A	M		**		A
Amaranth	*Amaranthus viridis L.*				**	A		A	A	A	A	A	A	A	A	**	**	M

Coriander	*Coriandrum sativum L.*	A	A	A	A				A	A		A	A	A	A	**		A
Broccoli	*Brassica oleracea var. italica*	A	A	A	M	A				A		A	A		A	**		A
Cabbage	*Brassica oleracea L. var. capitata*													A	A	**		A
Chineses mustard	*Brassica juncea*	A	M[1]	**	A	M	A		A	A	A		M	**	A	**	M	M
Kale	*Brassica integrifolia (West.) O.E.*	A	M	M	A	M	A	M	M	M	A	M	M	A	A	**	**	A
Chinese Broccoli	*Brassica oleracea L. Cv. Alboglabra Group*	A			A	A	**	A	A				M	**	A	**		M
Lettuce	*Lactuca sativa L.*						A				A		A	A		**		A
Garlic	*Allium sativum L.*	M	M	A	A	A	M		M	A	M	A				**	A	
Dill	*Anethumgraveolens Linn.*	A	M	M	A	A	A	A	A	A		A	M	A	A	**	**	**
Mulberry	*Morus alba*	A	A	A		M	M		**		A	A			A	**	A	A

Source: Extracted from USDA National Nutrient Database (2012) Commonwealth of Australia, Food Standards Australia New Zealand, and the University of New South Wales 2012; Siemonsma and Piluck 1993; Duke 1983; Umar, et al. 2007; Galhena 2012

[1] "M" detonates that the referred vegetable contained the maximum amount of the corresponding nutrient compared to the collection of its specific classification (i.e. vegetable, root tuber, fruits, shrub, herbs, spices)

"A" indicates that the corresponding vegetable contain above average amount of the corresponding nutrient relative to the collection of its specific classification

Light-yellow indicates that the corresponding vegetable contain above average amount of the corresponding nutrient relative to the collection of its specific classification

** shows that respective nutrient data was not found.

Blue cell shows that corresponding nutrient is present in the referred specie

White cell shows that corresponding nutrient is not present in the referred specie.

Following Galhena (2012) and data from *USDA National Nutrient Database for Standard Reference*, released in 2012, we categorised the nutritional components of the species consumed as food at the household level into "M, A, blue, light yellow, stars (**) and white. The "M and A" represents maximum and above average level of nutrient contained in a particular specie classification (i.e. vegetable, root tuber, fruits, shrub, herbs, spices) relative to the corresponding nutrients in all the crops under that specific classification. The "blue and light-yellow also represented average and below average of a corresponding species amid all species under its classification whereas white and star cells represented data on corresponding nutrient not found and absence of the corresponding nutrient in a specie.

Out of the 132 encountered species, 87 were consumed at the household level as food. Out of this number the nutritional data on 57 were found. The results show that 89% of the species contained nutritional values above average whereas 56% (32) contained the maximum level of nutrients relative to their specie classification. Again, data on the representative nutrient for 36% (21) of the food species consumed at the household level were not found of one or more of the nutritional classes of *carbohydrate, protein, lipids, fibre, calcium, iron, magnesium, potassium, sodium, zinc, as well as vitamin A, B, C, D, E and K.* Vitamin D was the only nutrient whose nutritional values were difficult to access. In all, one can generally say that species cultivated in Lao Loum and Hmong home gardens are nutrients rich for consumption.

6. Discussion

The average household size of five for both Lao Loum and Hmong ethnicities of the Xieng Khoung province of Laos is an indication of a relatively large household sizes of the surveyed villages. This is in consonance with Vlkova et al. (2010) who found same (five) household size for surveyed home garden households of the Phong My Province of central Vietnam. The youthful mean ages of the two ethnicities (41.47 and 36.85 years) is also an indication of a younger labour force for home garden activities which is beneficial. Furthermore, years of schooling (1 – 14) is an indication of higher level of education attained among household members which is contrary to Vlkova et al. (2010) who found no higher level of education attained in surveyed home garden households of Phong My, Vietnam. The average surveyed home gardens sizes 1,298 m^2 and 2,158.20 m^2 for Lao Loum and Hmong ethnicities corresponds to Kumar et al (1994) who called the range of 1,000 m^2 to 5,000 m^2 as worldwide average. Vlkova et al. (2010) later confirms Kumar et al. findings when they found when eighty-six percent of their surveyed home gardens in Phong My fell between 1,000 m^2 to 5,000 m^2.

The household is an integral part of homegardens, to De la Cerda and Mukul (2008), the family cycle stages ranging from formation, to reproduction, maturity, and collapse are intertwined with the household and home garden. Households' ownership of assets such farm lands, vehicle, motor bike, fridges, for storing home garden products as well as livestock ownership, poultry and duck birds, a source of wealth to household, might better their home garden investment. Although the primary objective of home gardening has focused on subsistence production (Vlkova et al. 2010), its role as an alternative income generation source to the household cannot be underestimated (Kumar & Nair 2004). Again, Trinh et al. (2003) found over fifty percent of home garden produce sold for income generation. Although the main purpose of over sixty-seven percent of the surveyed species were consumed as food in household, the growing interest in the sales of home garden produce, seventeen percent, coupled with the income range of 500,000 to 75,000,000 kip realised from selling of home garden products is an indication towards commercialisation of home gardens in the Xieng Khoung Province of Laos.

Home gardens are mainly for the production of fresh food (Torquebiau 1992; Eyzaguirre and Linares 2004) and the generation of extra income (Vlkova et al. 2010; Galhena, 2012) to support household expenses. It is therefore not surprising that out of the total species encountered, sixty-seven and seventeen percent were mainly cultivated for food and income generation through sales in the market.

Generally, the one hundred and thirty-two plant species were encountered in the home gardens of the surveyed villages, used diversely for food and income as enumerated as well as spices, ornaments, medicine, fodder, cultural activities and materials for textile and construction, is relatively higher than the seventy found in the Phong My Province, Vietnam (Vlkova et al. 2010), and the 70 in Sri-Lanka (Galhena, 2012) but lower than the 153 found in the Kerala State of India (Mohan et al. 2007), the 309 found in northeastern Peruvian Amazon (Perrault-Archambault and Coomes 2008), the 419 in southwestern Bangladesh (Kabir & Webb 2008) and the 233 in Oaxaca, Mexico (Aguilar-Stoen et al. 2009).

Manihot esculenta, cassava as commonly called, as the most multipurpose specie among the Lao Loum and Hmong ethnicities of Xieng Khoung contribute significantly to enrich the food security of the surveyed households. Its roots tubers are great sources of carbohydrate whereas its young leaves and matured leaves are use good sources of vitamins and fodder for feeding livestock. Furthermore, the multipurpose nature of most of the encountered species (forty-six percent of species had more than one part used) is an indication that surveyed home gardens were not only diverse in terms of species but also diverse in purpose. This correspond with Vlkova et al. (2010) who found seventy-seven percent of home garden species in Phong My to be multipurpose although their study again identified *Manihot esculenta* as the most market-oriented species.

Coriandrum sativum L, is crucial to Lao Loum and Hmong home gardens due to its medicinal, nutritional and commercial purposes. *Coriandrum sativum* seeds are used to solve digestion and other sicknesses such as stomach upset, loss of appetite, hernia, nausea, diarrhoea, bowel spasms, and intestinal gas. It is also used to treat measles, haemorrhoids, toothaches, worms, and joint pain, as well as infections caused by bacteria and fungus. It is

also used by Brest-feeding mothers to increase milk flow. It is again used as a culinary spice and food poisoning prevention whilst been used as a flavouring agent in commercial medicines and tobacco as well as a fragrance in cosmetics and soaps in manufacturing. It was therefore not surprising that *Coriandrum sativum* was the most cultivated specie, thirty-seven percent of the total quantity, among encountered species. This coupled with *Zea mays, Zea mays Line.Var Saccharata, Cucumis sativus L., Allium cepa L, Ipomoea reptans L., Brassica oleracea var. italica, Brassica juncea, Brassica rapa subsp. Pekinensis, Brassica Chinensis Linn. and Brassica juncea,* accounting for ninety-five percent of the encountered species, contribute significantly towards household food security since these crops were mostly grown for food with the excesses sold for income thereby enriching access to nutritious food by the surveyed households. However, some vital but underutilized species such as *Morus alba, Hibiscus sabdariffa Linn., Basella alb., Basella alba L., Oldenlandia corymbosa L., Phyllanthus acidus Linn., Fragaria vesca L., Punica granatum L., Sesamum indicum, Litchi chinensis Sonn., Oroxylum indicum (L.) Kurz, Prunus domestica ssp. Italica, Leucaena leucocephala de Wit, and Curcuma longa L*. For instance, *Morus alba* is a shrub which is valuable with its edible fruit and medicinal and ornamental uses. Such species can be crucial towards improving food security due to its nutritional value and commercial potentials. This confirms Vlkova et al. (2010) who found some neglected species in Vietnam to be valuable due to their economic significances and strong cultural connections.

Furthermore, all the 132 plant species were identified in the home gardens of Lao Loum households whereas only 84, sixty-four percent were identified in the home gardens of Hmong households. The total of 4 species recorded by the poorest home garden with the richest recording 49 is above 2 and 24 recorded by Vlkova et al. (2010) in the Phong My Province of Central Vietnam. Again, average number of species, species density and species abundance per home garden were higher in Lao Loum ethnicity, with a mean of 21.12, 1.63 species per 100 m^2 and 29,945.93 respectively. These indices are relatively higher than the 11.5 mean species, 0.8 species per 100 m^2 and the 15,740 mean species abundance recorded by Vlkova et al. (2010) but lower than the mean species per home garden of 23.4 recorded by Trinh et al. (2003) both in Central Vietnam.

The average Margalef index, ranging from 1.47 to 2.05 shows a higher level of species richness in the home gardens of the two ethnicities in the Xieng Khoung Province of Laos relative to the 0.99 to 1.51 found by Vlkova et al. (2010) in Phong My in Central Vietnam. Albeit, it is lower than the 5.43 to 6.42 recorded by Mohan et al. (2007) in Indian home gardens. This higher range like this study was attributed to the higher number of encountered species – 32 to 38 species per home.

Moreover, varied values of Shannon-Wienner index, representing species evenness and abundance, have been recorded by studies in the tropical zone. The range of 2.28 to 2.52 recorded, coupled with Shannon equitability index range of 0.51 to 0.52 (1 = absolute diversity) shows that home gardens of the surveyed villages in the Xieng Khoung Province have average species diversity. This is again higher than diversities recorded in previous studies such as 0.54 – 0.78 from Central Vietnam, 1.3 from South Andaman (Pandey et al. 2007), 1.15 – 1.42 from Kerala State in India (Mohan et al 2007) and the 1.63 – 1.79 from Cuba. However, it falls below the 1.92 – 2.7 (Gajaseni & Gajaseni 1999) and 4.03 – 4.42 (Sunwar et al. 2006) recorded in Thailand and Nepal.

Again, the study results show achieving agrobiodiversity in home gardens is highly dependent on household resources and decision-making process. Off-farm income generated from activities such collection of forestry products, firewood collection, handcrafts making, and many more improves the wealth the household which ten to improves a households ability to be diverse in its cultivated species in their home gardens. It is therefore not surprising that off-farm income had a positive impact on species diversity in the survey home gardens. This finding is in consonance with Abebe (2013) who found a positive relationship between off-farm income and agrobiodiversity in agroforestry home gardens in southern Ethiopia. Furthermore, access to information and technology is crucial towards achieving agrobiodiversity (Giampietro 1997; Heal, Walker et al. 2004; Rana, Garforth et al. 2007; Bajracharya, Rana et al. 2010). Mobile phone and television are however key to improving access to information and technology by farmers. It is therefore not surprising that access to mobile phone and television proved to significantly increase plant species diversity in the home gardens of the surveyed villages. This confirms the

findings of Paudel et al. (2012) who found access to information as a significant determinant of agrobiodiversity in Nepal home gardens. Most households in the surveyed area farm livestock in their home gardens. This this serves as a source of additional income to such households hence, improving their ability to improve species diversity in their home gardens. The positive relationship between heads of duck birds owned and diversity of species is again in consonance with Paudel et al. (2012) whilst contradicting Abebe (2013) who found now significant relationship between species diversity and livestock ownership. The active labour force of a household, which shows its and ownership of personal means of transport such as motor bike, used to assist in home garden activities, reduced diversity of species in the home gardens of the surveyed villages. This although unexpected a priori can be attributed to the smaller size nature of home gardens making it inefficient to deploy more family labour in home gardens. This finding confirms previous studies by Abebe (2013) in Ethiopia whilst contradicting Paudel et al. (2012). Abebe (2013), like this research, again found no significant effect between farm size and plant species diversity.

Plant species cultivated in the home gardens and consumed at the household level by Lao Loum and Hmong ethnicities are generally nutritious. Out of the 57 consumed at the household level with available data on their nutritional values, fifty-six and eighty-nine percent contained the maximum land above average level of nutrient. This result is essential since achieving food security is highly dependent on the availability of food in the right nutrient at the household level. This is in consonance with Galhena (2012) and Abebe (2013) who using a similar approach found a high level of nutritional content for species cultivated in Sri-Lankan and Ethiopian home gardens and consumed at the household level.

7. Conclusion

This research analysed the contribution of home gardens to household food security in the ethnically mixed region, located in mountainous areas of northern Laos. It specifically documents the food species grown in home gardens by both ethnic groups and to obtain their capacity and use, agrobiodiversity of food species grown in local homegardens, household resources capacity and analyse potential mutual effects and estimate nutritional value of food species from homegardens with special respect to household consumption. Generally, 132 plant species cultivated by the Lao Loum and Hmong ethnicities were documented. The diverse nature of cultivated species was estimated mainly with the Shannon-Wienner, Shannon equitability and Margalef indices. A multiple linear regression also used tom analyse to potential mutual effect between household resources and agrobiodiversity whereas the nutritional values of species consumed at the household level were estimated and presented in a tabular format.

In all, most of the encountered species are multipurpose with diverse parts of use. Again, majority of the documented species were grown for purposes of food and income which can significantly improve food security. Furthermore, the major component of the species consumed was the leaf followed by fruits. The study again reveals *Coriandrum sativum L* together 11 more species as the most dominant species in surveyed home gardens due to their domestic and commercial significance. *Morus alba,* and 13 other species were also documented as less dominant and underutilized in the surveyed villages.

The species richness and diversity though were average, the surveyed home gardens were reservoirs for crucial local food plant species crucial to the living standards of households. It is therefore important to leverage on the species diversity to orient local farmers to create diversity in local home gardens using traditional crops rather than the commercializing home gardens.

Household resources are significant determinants of agrobiodiversity which is also to food security. The significant impact of the proxies of access to information and technology, livestock production and other machinery as well as the entire model indicates that farm

households should leverage on technology to enrich their knowledge in home gardening, improve their incomes with livestock keeping in home gardens whilst reducing inefficiencies associated with the cultivation of smaller home gardens with larger family labour to attained absolute diversity, holding other factors constant.

Lastly, food species cultivated in home gardens of Xieng Khoung Province and consumed by the Lao Loum and Hmong ethnicities are nutritious with majority of the consumed species containing the maximum and above average nutritional values relative to their corresponding species in its class (i.e. vegetable, root tuber, fruits, shrubs, herbs, spices). Farm households should therefore be convinced to consume more of the cultivated food species grown in their local home gardens rather than selling to generate income for other food crops that might tend to be less nutritious relative to the traditional food species grown in their home gardens. Achieving sustainable food security at local people involves a multifaced approach including home gardening which enhaces agrobiodiversity thereby improving the nutritional content of domestically produced food consumed in rural households.

The study is however cannot be generalised due the non-probability sampling techniques (convenience and snowball sampling) used. It is again limited due its inability to identify the common and scientific names of 5 encountered traditionally valuable species which could form as a bases for further research in the future.

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Appendices

Appendix 1. homegardens survey and household survey in Xieng Khoung Province.

Name of village:		Date:		Time:	
Interviewer:		Questionnaire #:		GPS:	
Interviewer		Record of HG		Area(m2	

I. Household members and history

Q. can you specify which people live together with you in your house now/during last year?

No.	Member	Gender [M/F]	Born [age]	School attendance [years]	Ethnicity		**Q:** Were you born in the village?			Lao language		
					Lao Loum	Hmong	Born here	Since [year]	Place of origin	Know	Read	Write
1	HH head				☐	☐	☐			☐	☐	☐
2	Wife/Spouse				☐	☐	☐			☐	☐	☐
3												
4												
5												
6												
8												
9												
10												
11												
12												

Note: Ask farmer for gender, age (or when member was born) and number of yours of school attendance. Then continue with ethnicity (which are expected to correlate with study sites) good to know from where parents of HH head and his wife came if they were not born in the same village.

II. Overview of assets and capital

Value-chain, Market	Note	Information	Note	Animals	Heads	Use …???
Vehicle (car, truck)		Phone		Cow		☐ Food ☐ $ ☐ Draft
Motor bike		Phone+Internet		Buffalo		☐ Food ☐ $ ☐ Draft
Bicycle		TV		Goat		☐ Food ☐ $ ☐

						Milk
Drying place, dryer		Radio		Pigs		☐ Food ☐ $ ☐ Babies
Milling drill				Duck/Goose		☐ Food ☐ $ ☐ Eggs
Fridge				Poultry		☐ Food ☐ $ ☐ Eggs

III. Main activities and income diversification

Q: can you specify what activities are important for your family?

Overview of the activities, let farmer speak and describe the most important ones	**Q:** Which HH member is very much involved in particular activity?	**Q**: Is there a need of hired labour?	**Q:** How much money this activity bring you?
Home gardens			
Rice			
Annuals – crops harvested every year			
Plantations/perennial (rubber, acacia …)			
Livestock production (meat, eggs …)			
Products from forest			
Fire wood collection			
Fishing (nature: river, lake)			
Fishing (own: pond)			
Handicraft			
Salary/Wage			
Government support			
Friends or relatives			
Others (minor, not further specified)			

Note: it is nice to have overview of cash inflows structure

IV. farming calendar…for the whole farm and finish with homegarden

Q: Describe me how main activities and events are distributed throughout the year

	1	2	3	4	5	6	7	8	9	10	11	12
Most important plant species	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Land preparation, seeding												
Harvest												
Not enough money	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not enough food from farm	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not enough rice to feed household members	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
In which months you feel lack of water for household	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Home gardening (crucial months)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Note: Above mentioned activities could be linked to calendar …
Or you can ask other way round …Enough money, Enough food …positive questions

V. Further information on home garden and perception of home garden by household members

When your HMG was established (age of home garden)? _____
Did you inherited it? ☐ Yes, ☐ No
Ownership of land for garden? ☐ Yes, ☐ No (if no please specific _____)
What types of watering systems do you have for home garden production? ☐ River ☐ wells ☐ drip water ☐ pond and ☐ other
Do you use home gardens products in food preparation, cooking every day?

Perception of main roles of home gardens by household members (or at least farmer and his wife):

Food benefits	**Very much**	**Rather yes**	**Not really**	**No**
Provides food for household member				
Provides specific plants making food tasty and healthy				
Use plants from garden reduce food expenses				
Social benefits	**Very much**	**Rather yes**	**Not really**	**No**
I can relax in my garden				
I love my garden because it is beautiful place (flowers)				
I love to work in home garden, it is my hobby				
I love to keep the tradition of my parents and grandparents				
Economic benefits	**Very much**	**Rather yes**	**Not really**	**No**
I can get easily food for household than from the market				
I can sell products from the garden to increase my income				
I can exchange the production with my neighbours				
Environmental benefits	**Very much**	**Rather yes**	**Not really**	**No**
It provides nice environment (shade, windbreak …)				
I consider more species as important				

VI. homegarden challenges/expectations

From whom you learnt gardening and provide you information about the homegarden?
Can you remember any changes in crop species from the past, e.g after having children?
Which species you would like to grow in the future? Or when you are retired?
What would you like to change in your homegarden?
Do you want to extend the size? Or make it smaller?
Are your plants being attacked by animals? Insects?
Do you have enough water?
Do you need to hire extra labour? Why, when?
Do you still have other problems in your homegarden?

VII. Homegarden utilization, (agro-biodiversity, use and economic)

Overview of the species grown in home garden (Let farmer name all species he/she knows and ask his/her to show you them in the garden …you can ask for those who were not mentioned)

Lao title / Hmong title	Number of individuals	Part used	What is the main use of the plant?	Is there any other use?	If used as a food, how?	Estimated annual production	How much do you sell?	Who cares about the species

Lao	Who	W	Where you sell the product and for what	Costs/Expenses

Note(s): part used: let him tell/show you, then ask how this part is used, underline the main use and ask for annual production and try to convert it into SI units, then ask for commercialization
Respect to food/nutrition: ask whether species is used fresh, cooked, fermented …you'll see soon after first pilot testing what are the typical answers. Good for further classification of use categories as well as for documenting food security. Take a photo of the garden, collect GPS (if it differs from house), try to measure the size let farmer show you the garden and species, count individuals.

Commercialized species: cost-benefit, processing, value-chain

title / Hmong title	sells? Who is involved in selling?	how decided to grow this crop?	price?								Transport	Seeds	Chemical fertilizer	Plant protection	Other material	Own manure	Hired labour	Household labour input in days
			Farm gate		Middle man		Local market		Distant market (city?)									
			[%]	Price	[%]	Price	[%]	Price	[%]	Price								
												Own, 20 kg	NPK 50kg bag	2l of XY	Do not buy	Yes, 20-30 kg	5 days, 2M, 1F	

Note(s): Species with high market orientation …
Main expenses categories would be obtained from FGDs
Other material: wooden sticks, plastic material, fence …