SCIENCE SET
OPEN ACCESS PUBLISHERS

Research Article

Journal of Material Sciences & Applied Engineering

Characterizing Home Garden Practices in Vulnerable Communities: A Case from Phoukhoud District, Lao PDR

Suraj Shrestha*, Tek Maraseni, Armando Apan, and Kishor Aryal

Institute for Life Sciences and the Environment, University of Southern Queensland, Toowoomba, Queensland 4350, Australia

***Corresponding author:** Suraj Shrestha, Institute for Life Sciences and the Environment, University of Southern Queensland, Toowoomba, Queensland 4350, Australia.

Submitted: 18 July 2024 **Accepted:** 22 July 2024 **Published:** 29 July 2024

Citation: *Suraj Shrestha, Tek Maraseni, Armando Apan, and Kishor Aryal (2024) Characterizing Home Garden Practices in Vulnerable Communities: A Case from Phoukhoud District, Lao PDR J Mat Sci Apl Eng 3(4), 01-16.*

Abstract

The government of Lao PDR and other development organizations are implementing various agricultural initiatives, including home gardens, to support food security, nutrition and livelihoods. Despite the importance of home gardens among Lao rural upland vulnerable farming households, studies about the characteristics of home gardens are limited. Thus, this study is aimed at assessing the characteristics of home gardens among three categories of vulnerable farmer households (i.e., people with disability households, female-headed households, and other households) in rural upland region of Lao PDR. The study applied mixed methods integrating quantitative and qualitative research methods.

We conducted 425 household surveys, 13 key informant interviews, and three focused group discussions to collect primary data which were analyzed and presented using descriptive and statistical tools. Results showed that home gardens were mainly characterized by the distance from home and location, varying in garden size, crop selection and crop diversity, fertilization and cultivation methods, and its contribution to the overall food demand of the households. The study indicates that 84% of vulnerable households home garden crops were primarily used for household consumption, only a few proportions selling surplus crops, adding a supplementary income to their livelihood. Female-headed home gardens were the largest and furthest, whereas household with people with disability had smallest and closest home gardens. Notwithstanding home gardens' popularity only 37% of the households harvested crops all year-round. We found the households cultivating different types of crops, for example, female-headed households were producing 65 different types of crops while the other vulnerable households producing up to 74 types of crops, applying various home gardening practices and producing their own seeds.

Findings from this study can contribute to optimizing home garden practices in Lao and other countries with similar socio-demographic characteristics.

Keywords: Home Garden, Vulnerable Households, Food Security, Livelihood, Crop Diversity

Introduction

Home gardens are an important food source for a rural farming household and are one of the oldest farming systems with several common characteristics found globally [1, 2]. Home gardens are often a small plot of land either next to the home or within close proximity whereby access, availability, and suitability of land plays an important determining factor of a successful home garden [3-6]. Emerging new methods such as aquaponic, hydroponic, aeroponics, vertical, hanging garden and rooftop garden are used throughout the world to produce crops and enable crop production in small and urban spaces where land access, availability and suitability often poses -constraining factors [7-10]. While land is an important factor for a home garden, new methods and technologies can assist people to grow food even without ideal land or space.

Home gardens play a crucial role in food security, nutrition and livelihoods in rural vulnerable communities (Balika et al., 2019) [11-16]. Those are mostly managed by women, while some studies suggesting men are playing an equal role [17-19].

Home gardens are often portrayed as an agriculture system that is in tune with the local context and need. Households apply low-cost, reliable, and tested methods, while utilizing local resources, and over time have generated a sense of confidence in knowing how and what to produce in their home garden [20]. Home gardens vary from household to household depending on the preferences in crop selection, utilization, seasonal planting, and cultural significance that influences a household's preference for what to plant and how to manage their home garden (Schneider, 2004; Ruthenberg, 1980) [21, 22].

Home gardens are popular in Lao PDR, especially in rural subsistence farming households as it is an important food source. A number of new studies suggest that home gardening practices have heightened in various countries as it provides regular and accessible food sources in times of crisis and contributes to food security [23-27]. In recent years, Lao PDR has experienced intensified social and economic shocks due to both global and local challenges [28, 29]. Many countries faced political and economic instability and trade conflicts which has caused fluctuation in global oil and food prices. Alongside an increase in natural disasters in the region and outbreaks of disease, such as the global pandemic of COVID-19 and Lao's current fiscal deficit and high inflation has been putting further challenges in food security in Lao [29, 30].

In such a context, home gardens can play an instrumental role in providing regular food access and food security for Laos' upland vulnerable farming households. The Government of Lao PDR, through Agriculture Development Strategy to the year 2025 and Vision to 2023 and various other related policies, have recognized the importance of improving the agriculture sector. The strategy focuses on implementing food security and nutrition sensitive agriculture initiatives (Ministry of Planning and Investment, NSEDP 2021 -2025). Supported by various donor and partner organizations, international non-governmental and local civil society organizations, significant home gardening initiatives are being implemented in Laos to address national targets of Sustainable Development Goals (SDGs) #2, #3, #12, #13, and #15 [31, 32, 29]. However, studies about home gardens in Lao rural communities are very limited. The characteristics of home gardens, including size and location, crop species and diversity, cultivation and harvesting, are largely unknown which are crucial in planning and implementing agricultural development and food security programs.

In this context, taking a case of Lao's upland vulnerable communities in Phoukhoud District, we aim to understand and characterize existing home garden practices in the rural communities. The outcome of this study is expected to contribute to design innovative solutions to food security, diversifying livelihood opportunities, optimizing food production and sustainable development of vulnerable communities through home garden practices in the region and beyond.

Methods

Study Area

The study was conducted in Phoukhoud District located in Xiangkhouang province in the north-central region of Laos. We selected this district because 16 out of total 44 villages (Figure 1) in the district were classified as vulnerable and disadvantaged villages by the Adventist Development and Relief Agency's (ADRA) Lao PDR food security project. The reason for classifying the vulnerable villages were attributed to a number of factors, such as only a small number of villages having year-round road access to the village. The households in the villages are small landholders with small size operations of 0.5 to 2.99 hectares of land [33]. The prevalence of food insecurity, poverty and malnutrition amongst children are high and a significant portion of land is contaminated with unexploded ordinance, making the land unusable for agricultural purposes [32, 34-37, 33]. These villages are also exposed to adverse climate change effects and are prone to natural disasters such as droughts, floods, landslides and various pestilence and diseases making their livelihoods fragile and vulnerable to external factors [38, 39].

Figure 1: Google imagery of 16 selected villages in Phoukhoud district, Xiengkhouang Province, Laos

Data Collection and Analysis

Field data were collected as a part of ADRA's food security project, with the support from the ADRA project survey team in 2021. We carried out household surveys, key informant interviews, and focus group discussions as a part of primary data collection. As noted, the research focused on the 16 uplands villages which were categorized as vulnerable household.

A total of 425 household surveys were carried out with a set of pre-determined questionnaire. Out of 1100 total households in those 16 villages, 835 households were classified as vulnerable households by ADRA food security project. Vulnerable households are exposed to natural disasters and their livelihood primarily depends on [40-43]. The basis of defining vulnerability were depending on numerous social and economic factors, including remoteness, poor access to key services such as health, education and employment, seasonal food insecurity, malnutrition, and financial hardship [33, 44]. From among the total vulnerable households, the survey was carried out in 425 households. Those households were randomly selected from the list of vulnerable households.

To further characterize the vulnerability in the study area, we subdivided the surveyed household into three major categories: people with disability households (PWDHH), female-headed households (FHHH), and other vulnerable households (OVHH). While doing the household survey (n=425), the percentage of PWDHH, FHHH, and OVHH were 31.8%, 5.6%, and 62.6%, respectively. These categorizations were developed within ADRA Laos project scope, and determined by the various vulnerable characteristic and challenges these households face.

People with Disability Households (PWDHH): Rural and remote subsistence farmer HHs that have one or more family members with long-term physical, mental, or sensory impairments. PWD members experience various barriers that hinder their participation in society, and often require additional resources and support from the household [45].

Female-headed Households (FHHH): Rural and remote subsistence farmer HHs, where the women are fully responsible for their household, often living alone or with others, but are the primary income producer and decision maker [46]. They may be widowed, divorced, single, or single female parent and are often solely responsible for themselves and possibly other HH members as well.

Other Vulnerable Households (OVHH): These households are often poor and experience various vulnerable scopes and are exposed to risks as defined above in vulnerable households. But they do not have PWD members in their household and are not led by a single female widow, a single mother, or a divorced female.

Household survey was carried out based on questionnaire survey, which contained number of questions under 10 major thematic areas: (1) demographic characteristics, (2) food security and coping methods, (3) income-generating opportunities, (4) home gardening practices, (5) seed production and usage, (6) food storage and processing, (7) farmer organizations, (8) water management and usage, (9) livestock management, and (10) social inclusion. The questionnaire comprised closed-ended categorical questions, single response with single choice, multiple choice with multiple response, multiple choice with single response, and numerical values [47]. Participation in the research was voluntary and it was conducted only upon the consent of the respondents. Before the start of the survey, respondents were given an information sheet which contained the objectives of the survey and its major content to clarify the respondents about the purpose of data collection and data use. As a part of the project survey, the questionnaire contained high volume of questions, up to 183 questions, however, there were number of skip logic based on the vulnerability category and subsequent network of questions for each category. The survey took 45 – 90 minutes in to complete based on individual households' relevant information. We followed the approved human research ethics protocol and ethical clearance was obtained from the University of Southern Queensland Research Ethics Committee (HREC Approval Number H22REA115).

Three focused group discussion (FGD) were carried out representing three different vulnerability categories in the study area. To carry out FGD, we first identified the villages with abundancy of each of the vulnerability group (PWDHH, FHHH, and OVHH), the village with higher number of each vulnerability group were then selected for the group discussion. FGD was carried out to further understand and triangulate patterns, themes, and characteristics of the data collected under each vulnerability group. In addition, we carried out 13 key informant interviews with the key stakeholders in the region, representing community groups, civil society, development organizations and government representatives. Information gathered from FGD, and key informants' interviews were used for triangulation and validation of the household survey and to interpret and understand the trends observed in the survey [48, 49]. Data analysis was done based on various statistical and visualization tools, especially by using the Kinaki Software platform. The findings of the data analysis were then presented in charts, figures, and tables as appropriate.

Results

Livelihood Alternatives of the Vulnerable Households and Availability of Home Garden

The study found that crop (72.9%) and livestock (36.9%) production were the top two livelihood activities among the respondent vulnerable households (n=425), making them primarily agriculturally dependent households. There were only 9.8% of OVHH, and 5.2% PWDHH had access to employment and family business opportunities but none among FHHH (Figure 2).

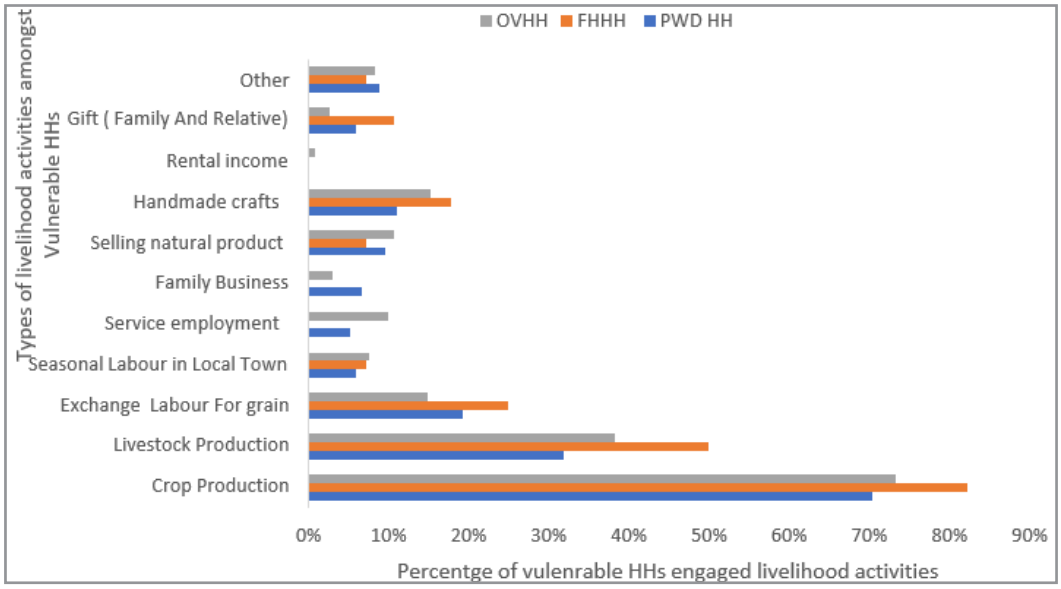

Figure 2: Livelihood activities among the three types of vulnerable households, PWDHH (n= 135HH), FHH (n= 23HH) and OVHH (n= 265 HH) respondents from 16 Villages of Phoukhoud District, Lao.

Among the respondents (n=425), 85% of households (PWDHH 87%, FHH 82%, and OVHH 85%) had a home garden and 15% did not. We found various reasons for not having a home garden in our study, for example, lack of (suitable) land, lack of external support (no help), insufficient water access, and not having time to practice home garden (too busy) (Figure 3). The three types of households that did not have a home garden (n=63) face at least one barrier that deterred them from having a home garden, with FHHHs facing multiple deterrent factors. On average, 32% of FHHH experienced multiple deterrent factors compared to 25% OVHH and 22% PWDHH.

Area, Scale, Cultivation, Production and Home Garden Practices

The study also examined three different characteristics of home gardening practices, such as land size, distance of the home garden from their home, and harvest quantity. The variation between the land size and proximity from home among the three types of vulnerable HHs are displayed below (Table 1). An average distance of 72.1 meters to the home garden from household was found with FHHHs home gardens are the furthest from their home with an average of 145 meters, whereas PWDHHs home gardens are the closest to their home with an average of 19 meters. Regarding the size of the home garden, an average area per household was found to be 155.3 sq. m FHHH having the highest average of 236 sq. m while PWDHH having the lowest average (i.e., 77 sq. m)

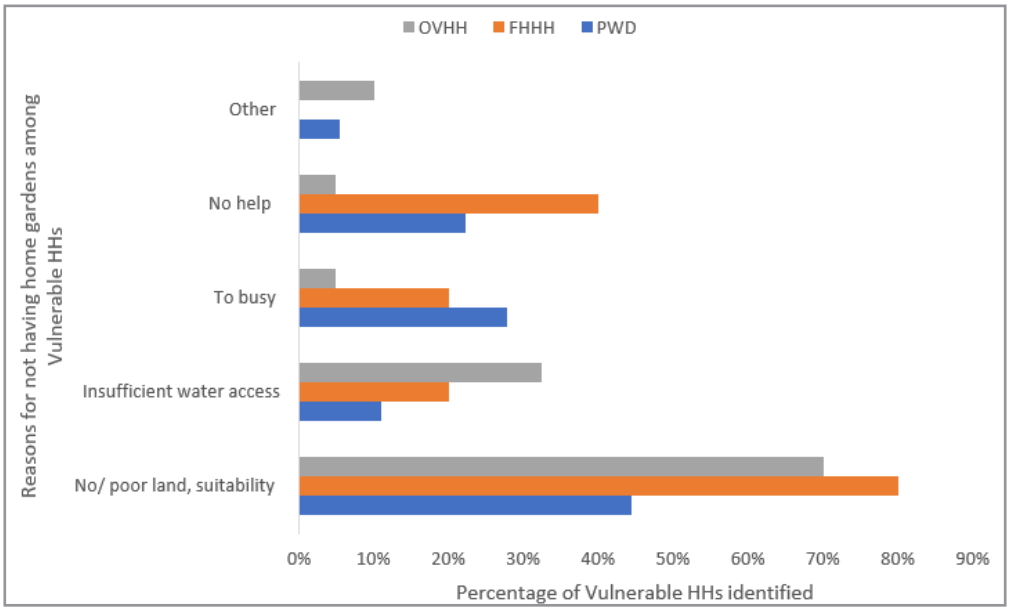

Figure 3: Home gardening deterrent factors among the three types of vulnerable households, PWDHH (n= 135), FHH (n= 23) and OVHH (n= 265) from 16 villages of Phoukhoud District, Lao.

Table 1: Variation among the three types of vulnerable households, PWDHH, FHH and OVHH

	Proximity from home in meters	Home garden area in m²
Average for PWDHH (n-10)	19.00 (SD= ±46)	77.10 (SD= ± 44)
Average of FHHH (n=10)	145.00 (SD= ±136)	235.70 (SD= ±228)
Average of OVHH (n=10)	52.5 (SD= ±56)	153.1 (SD= ±81)

Regarding the cultivation and production practice from home garden, we considered three major factors, such as type of plants, gardening methods and practices, seed management strategies. Eighty-three types of edible plant-based crops from various groups were found in vulnerable household's home gardens, including root vegetables, grains and tubers, dark green vegetables, legumes and nuts, herbs, fruits and other vegetables (Annex A). This included: 26 types of fruits; 19 types of herbs and spices; 13 types of other vegetables; 9 types of dark green vegetables; 8 types of grains, root vegetables and tubers; and 8 types of legumes and nuts. PWDHH home gardens had 64, FHH 55, and OVHH 74 types of edibles plant-based crops. Amongst them, herbs and spices and dark green vegetables were the two most popular edible plant-based crops among all three types of households. However, the overall crops planted varied amongst the households, with 47% OVHH, 42.5% PWDHH and 36% FHHH, thus OVHH home gardens had the most different types of crops produced compared to FHHH home gardens.

Regarding the fertilizer application, we found that 84% PWDHH, 83% OVHH and 82% FHHH directly applied dried or fresh animal manure to their home garden with a respondent reiterating during the household survey: "we used this since I can remember". However, only 10% PWDHH and OVHH and 4% FHHHs used compost while 2% PWDHH and OVHHs applied chemical fertilizer while FHHH were not found to be using any chemicals on their home garden. Qualitative findings are consistent with household survey result as most of the respondent stated they want to eat safe and natural organic food that is safe, tasty and healthy. Though this may not be the case for their cash crops but in their home garden they did not want any chemical inputs. The results also found that on average, 30% (36% FHHH, 27% OVHH, 25% PWDHH) of households had access to water, with 56% (64% PWDHH, 54% OVHH, 50% FHHH) accessing water from ponds or rivers. Practices such as mulching and intercropping were also low among all vulnerable households (Figure 4).

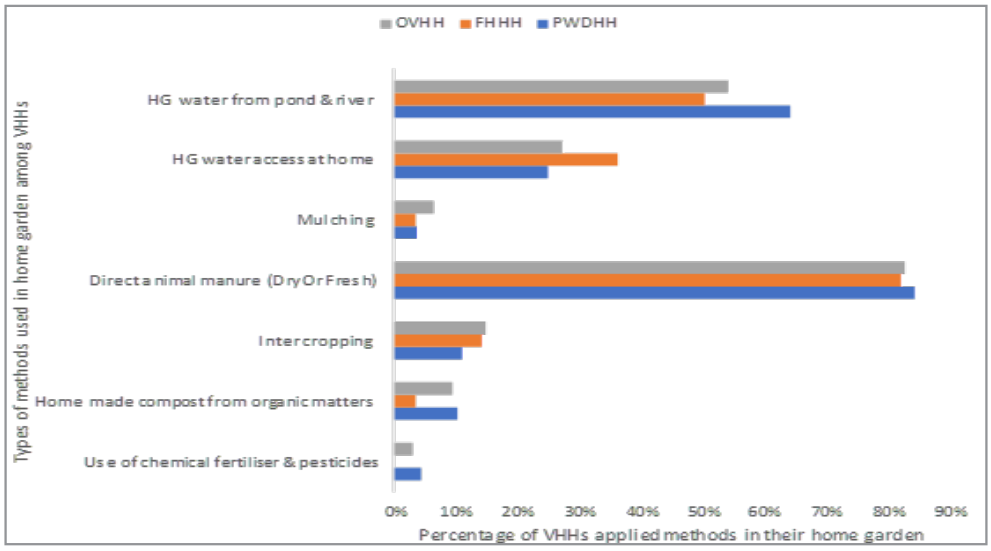

Figure 4: Home Garden methods applied among the three types of vulnerable households, PWDHH (n= 135), FHH (n= 23) and OVHH (n= 265) from 16 villages of Phoukhoud District, Lao.

Seed management is a prominent home garden characteristic among vulnerable households, with 73% (PWDHH 74%, FHHH 71%, 75% OVHH) of vulnerable households selecting, saving, and utilizing their own seeds in their home garden. They also received seeds from friends, relatives, neighbors and buying from the markets. Respondents commented that: "we only buy hybrid seeds; newer types of crops seeds and when we do not have enough or we lose them", "we mostly save and produce our own seeds" were repetitive themes from qualitative engagement. On average 67% (75% FHHH, 66% OVHH and 61% PWDHH) of vulnerable households practiced seed storing methods using bags made of plastic, cloth and other materials. The result indicates, less than 10% of VHHs used methods of storing in vacuumed glass or plastic containers/jars (11% PWDHH, 10% OVHH, and 9% FHHH). Only 4% OVHH and 1% PWDHH stored seeds with ashes and charcoal, but they applied all 6 methods of seed storing, while FHHH only applied 2 methods (Figure 5). The study also found that 81% of PWDHH, 79% of OVHH and 54% of FHHHs stored their seeds in a dry place without moisture, while 32% of FHHH, 5% of OVHH, and 4% of PWDHHs stored their seeds where sunlight was present.

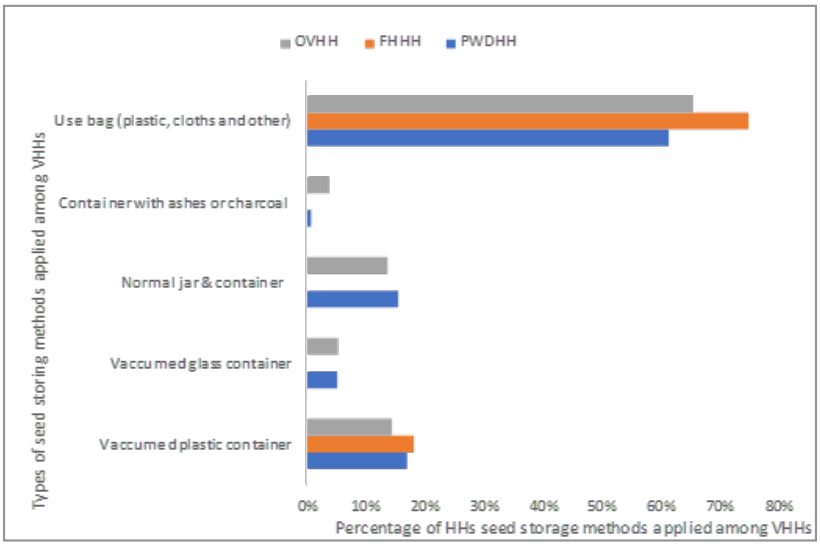

Figure 5: Seed storing methods applied among the three types of vulnerable households, PWDHH (n= 135), FHH (n= 23) and OVHH (n= 265) from 16 villages of Phoukhoud District, Lao

Use and Adequacy of Home Garden Products

The study found that on average 82% of vulnerable households (n=423) consumed harvested crops, with 29.6% of households selling surplus home garden harvested crops. During the interviews, most VHHs said, "We love to eat green vegetables, salad and herbs, and we ensure we have them most of the year.

Herbs make food tasty, and green vegetables and salads are easy to grow." Though there were various crops were grown in the home garden, the herbs and vegetable where the most preferred crops were grown. The result also found that 13% of PWDHH and 9% of OVHH households also preserved and processed their harvested crop that were used for future food consumption, while FHHH did not.

The research found substantial variations in harvest according to different season throughout a year (Figure 6). During November, December, January and February, 64% of vulnerable households harvested edible plant crops from their home garden making these four months the most harvested months. However, between March and October the harvest patterns among all three types of households decreased. We also found that 39% of PWDHH, 38% of OVHH, and 35% of FHHH harvested crops every month for over the past 12 months. During the qualitative engagement numerous reasons were provided why this was the case but the most highlighted reason was "busy with preparing for their rice paddy", "exchanging labor", and "busy with cash crops", thus respondent seemed to be too busy in other works so that unable to manage time to look after their home gardens. Some respondents also stated that there is too much rain and issues with water logging and only being able to grow a few types of crops in their home garden during monsoon seasons.

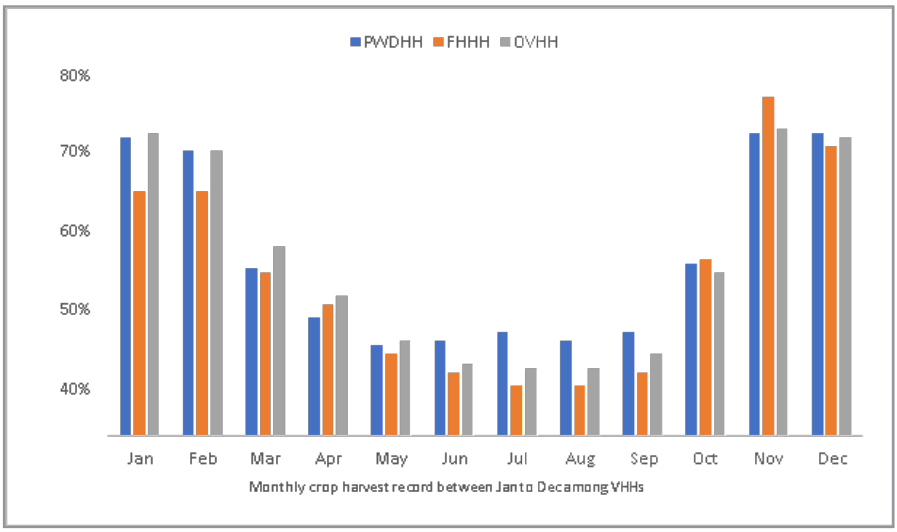

Figure 6: Monthly harvest trend among the three types of vulnerable households, PWDHH (n= 135), FHH (n= 23) and OVHH (n= 265) from 16 villages of Phoukhoud District, Lao.

Role and Workload of Women in Home Gardening

Women were the main workforce and manager of the home garden. Our findings showed the average time spending on home garden of 1.43 hours, 1.52 hours, and 1.31 hours by PWDHHs, FHHH, and VHHH, respectively. Both men and women respondents repeatedly stated that "Men helped with some tasks such as fencing" and most of the other works are done by women. Women also felt that they were solely managing their home garden and cultivated what they wanted, sold surplus and shared surplus when they could. A strong sense of control and ownership and pride was amongst many female home gardeners as comments show: "I'm happy to grow healthy and eat tasty food", "good feeling when we share crops to other family and friends" and "we get some money when we sell our crops". The home garden characteristic derived from above results summary snap shots are also present in Annex B.

Discussion

Livelihood Opportunities from Home Gardens to Vulnerable Communities

Two-thirds of Lao PDR's population consists of small farmer households, relying on the agriculture sector for food and livelihoods [50]. Livelihood activities in our study showed 11 groups of activities with crop production and livestock husbandry being the primary source of livelihood activities across all vulnerable households. A large proportion of vulnerable household's reliance and dependency on agriculture poses a significant risk due income dependency on perishable outputs that rely on weather, nature and uncertainties [51-53]. Thus, livelihood diversification strategies are crucial to cope with the risks associated with agricultural which can include both on-farm and off farm livelihood opportunities [54].

Results also indicate that various households were engaged in off farm activities, such as working as casual laborers in the nearby district or province, in a small business or were employed. The findings showed that a small percentage of PWDHH and OVHH had employment opportunities and family businesses, while FHHHs had no employment or family business opportunities. This might be because FHHHs often lacked adequate education and are trapped in time-consuming unpaid domestic tasks with limited options to work or build a business [55]. During the in-depth interviews, a FHHH respondent disclosed, "If I did not receive the money from my daughter regularly, it would be difficult for me to meet my needs on my own", and such sentiment was common among most FHHH. Their agricultural production was insufficient and did not meet their daily needs without monetary aid from relatives, making them more dependent on others and having less opportunities for employment.

Although FHHH may have lesser livelihood opportunities compared to PWDHH and OVHH, FHHHs primarily relied on agricultural activities for their livelihood.

Livelihood diversification opportunities for VHHS will be a desirable policy aspiration that could provide vulnerable households with more capabilities to improve livelihood security and living standards (Frank, 2007) [56]. There are plenty of opportunities to expand livestock production, handmade crafts, natural products, support local businesses incentives, and employment opportunities within the current context (Ellis, 1999) [57, 58]. Increasing public, private, and civil society collaboration would be instrumental to develop tailored programs that builds on the strength of vulnerable households [59]. Other supporting opportunities might involve assisting local business ventures, improving infrastructure, access to low-interest loans and market, improving knowledge and technology, investing in crop packaging, processing and transportation opportunities, and supporting incentives to improve and increase agricultural production [60, 61].

Although majority of these participant were agricultural dependent, there were about 15% of VHHs who did not have home garden due to several deterrent factors. In this regard, feasibility study and endorsement of other methods such as indoor and hanging garden should be promoted. Crops such as leafy green vegetables and herbs such as roket salad, leaf, bok choy, kale, micro green, lettuce, spinach, basil, dill, mint, and coriander are grown in the garden bed at the study areas. While such crops are grown in garden bed in land, they could also be grown in tall 10 cm containers 10-15 cm apart. There are also other crops such as carrot, garlic, spring onion, radish, cabbage and cruciferous vegetables that can also be grown in a deeper container that requires only space for pots and containers and can be grown in small space [62]. Such vegetables could be grown on a window ledge, hanging from posts, on a table or trestle, or simply placed in empty spaces around or inside the house. Pots and containers could be made out of local resources such as bamboo, wood, straw or use recycled materials such as sack bags, pots, used tires etc. (Wang 2020) [63].

Interestingly, some households were found to be doing this already in the communities which can be replicated, promoted and scaled up. Home gardens produce food and are found to be a vital food source amongst the majority of the agricultural dependent promoting such alternative practices potentially increase the home garden for those 15% of VHHs. It supports the Lao government's policy direction to support and improve agriculture production for domestic consumption and improve food security relevant to these communities (ACIAR, 2020).

Reflecting on Scale of Cultivation and Production from Home Garden

Home garden closer proximity and small in size are often associated with convenient in management and access to fresh food the closer the home garden is, it is easy to manage, maintain and readily available of fresh vegetable access due to its convenient in size, proximity and location [64, 65]. Thus, FHHs household found to have some inconvenience in terms of the distance and sizes. They often stated "home garden are further and we spent more time taking care of the making care of it" and "we do not get needed help". The home gardens were also found in various locations, both on flat and steep land. For the villages on flat land with sufficient land within their village boundary, home gardens were found next to their home or close by. Some houses have a small bamboo-fenced enclosure home garden which helps in protection from depredations of the free-ranging and household livestock [66]. However, if the village lacked land within the village the home garden was further away from their home but most likely they had access to water. Often VHHs stated who

didn't had home garden close by their home stated "Our village do not have enough land and water so we find suitable land for our home garden away from home". The villages that had hilly terrain had home gardens on steep hills or slopes or below the hills where the "land was carefully selected for adequate moisture, was fertile, and cultivated their preferred crops which required less maintenance" reiterated by local experts and VHHs.

Regarding the diversity in production, our findings showed an opportunity to expand and share with communities the advantages of intensive gardening systems by growing legumes, which is beneficial for both soil health and food consumption [67]. During the interviews, most participants said, "We love to eat green vegetables, salad and herbs, and we ensure we have them most of the year.

Herbs make food tasty, and green vegetables and salads are easy to grow." They also stated that they grow herbs and vegetables "In our rice paddies, slash and burn fields and corn fields" during the monsoon season between May to August. The study also noted that the idea of home gardens was extended among all VHHs during the period of monsoon season. Types of crops that are often grown in home garden is also cultivated around and near their paddy fields, shifting cultivation field and cash crop field. Such explanation was provided repeatedly during the qualitative engagement, affirming the transitional nature of home garden's location especially in planting seasons. The study finding suggests that most of the VHHs applied various other methods in their home garden recognized as local or traditional methods. They used manure from cattle, poultry, pigs or goats, to their home garden and often commented that "Our methods keep food safe, natural (organic), tasty and healthy" and "we don't use any chemicals". A home garden often starts with preparing the land by clearing and slashing green vegetation. Once the burnt green vegetation is dried, ashes are sprayed over the tilled soil and manure is added and the seeds are sowed, then the soil is covered with hay, green leaves, twigs, or mulch. The order of this process may vary, but it appears to be the general practice among many vulnerable households and often stated "our traditional practice". The respondents described "We grow food without using any chemicals and we like to follow traditional ways of manuring that produce safe food".

This practice needs to be noted that for their home garden as there are numerous other studies suggesting the high use of chemical inputs in agriculture production that are mainly associated with commercial crop production amongst upland farmers [68-70].

The study also found fewer households applied new learned methods such as compost and biochar application prepared by using locally sourced materials. Such practice was introduced to prevent erosion, reduce water runoff, and improve soil structure and nutrient content. Other households produced biochar such from green waste, which they said they learned. Such methods seem to be increasingly recognized as a green, cost-effective approach and an environmental remedy that improves soil fertility (EPA, 2023) [10, 71]. Home garden practices among vulnerable also used methods, such as picking the pests manually from the plants and feeding them to the ducks and chicken. Whereas fewer households applied newly learned integrated pest management in their home gardens, such as biopest spray, different traps and nets. Combination of both newly learned old methods were found common among VHHs home garden.

The study finding on the water source management for their home garden demonstrated that households that had water access to their home garden stated "we use gravity feed system (GFS)" when water is plenty in reserve tank. However, households that don't have direct water access at home they used water of a small dam, pond, creek or river. The participant also stated that in the dry season small creeks, pond and dam gets dried up and we face water scarcity. Improving water access and management can maximize crop yield and production, with one participant stating, "when water gets scarce in the driest season, we can't produce much, so we grow less in our home garden". In given context there is a potential to improve and expand water sources and management of water. This will benefit not just home gardens but also to agriculture system.

Regarding seed management practices, this study found that it has been passed down from generation to generation among vulnerable households, with responders stating, "we learned from our parents and value our seeds", "we don't have to buy them, and seeds suit our environment". They store seeds in small quantities in clean cotton cloths or small-weaved local traditional jars and kept on top of the cooking area, or hanged to a dry warm place away from moisture, sunlight, pests, and rats. Seed saving practices are found amongst developing countries where farmers continue to maintain their traditional knowledge and seed management practices [72, 73]. This valuable practice of seed saving can maintain seed independence, preserve local seed varieties that are suitable for their local environment and conditions [74]. Although seed storing practice were prevalent among all VHHs, they often stated "sometimes seeds are not germinating and lasting as they should". We found that poor seed storage conditions resulted in frequent seed loss in both quantity and quality. When seeds are exposed to insects and stored in the room temperature and are prone to moisture ultimately affects their quality (Ellis and Roberts, 1980). VHHs noted that seed management could be improved to minimize their current seed loss. Few participants stated that hybrid seeds germinate better and have better yield for the first few seasons, but those seeds struggle to maintain consistent yield. They also said we can't save seed and reuse them and cost us every time we buy them. Most of the VHHs value their seed saving practice and recognizes its benefits and want to maintain their seed independency.

Along with improving seed saving methods, it is crucial to maintain the balance between local seeds and newer hybrid seeds.

Similarly, integrating locally perceived traditional practices and innovative safe new modern agriculture practices is beneficial in adapting various weather and seasonal challenges [75, 76]. Access, availability and improvement in water management has potential to improve home gardening to effected VHHs. Study suggest the VHHs value their seeds and desire to maintain the control, thus initiatives to improve seed selection and storing methods for vulnerable households could maintain seed sovereignty. Since many traditional seeds are still available, creating seed bank systems at the provincial level to protect and preserve precious and valuable traditional local seeds is a worthy investment. Thus, raising awareness and establishing provincial seed

banks to preserve and save local seeds for future generations is an investment for future seed sovereignty. The government must recognize the benefits of modern and traditional practices and promotes the development of clean, safe and sustainable home gardening with a gradual shift toward the modernization of the production of competitive agriculture commodities [68, 75, 76, 50].

Use and Adequacy of Home Garden Products

Edible plant-based crops are harvested from home gardens primarily were used for household food consumption among all vulnerable households. Interestingly, the study found that PWDHH and OVHH households preserved and processed some of their surplus harvested crop mainly through drying, fermenting or pickling methods that preserved and extended the time of harvested food, while FHHH did not. Thus, home gardens harvest are vital food sources (Malberg et al., 2005) for VHHs providing accessible and readily available daily food contributing to household's daily food needs [2].

It offers regular access, quality, and stability of diverse fresh food supplies (Guzman et al., 2021; WFP, 2020) [77, 78, 11]. Due to such characteristics of home gardens, it is crucial that these food sources are improved. The importance of home garden is recognized in both global south and north such importance is also recognized amongst the VHHs, "it is an important food source", "when we come home from farm tired, we can just go to our home garden to collect herb and vegetable", "home garden provides convenient food we like and prefer" and are often reiterated during the study [76, 11].

While home garden crops were primarily used for food consumption various VHHs stated, they also sold the crops mainly the villages that were close by the main road and market. But there were plenty VHHs who wanted to sell but "the market is too far." "We only sell sometimes when a buyer comes to our village to buy". The lack of market linkage, poor road conditions and infrastructure, lack of market knowledge prevented VHHs ability to sell surplus crops for rural upland communities [75]. Numerous studies support that home garden with access to market can provide significant benefits to household income [79, 11, 80].

Perhaps improvement to these conditions could also help VHHs to sell their crops and generate additional income is an untapped potential.

Regarding year-round harvesting, our findings are consistent among all three VHHs, and the pattern suggesting that there are plenty of room to increase home garden production for eight months.

Challenges with water scarcity, too much rain affecting VHHs crops and being busy seemed to be the key reasons provided. Often, participants stated, "there is too much rain in the wet season, making it very difficult to grow vegetables in our home garden". We mainly grow grew herbs, eggplant and some leafy vegetables only fewer types of crops during wet seasons. We face challenges, for example, waterlogging is one of the abiotic stresses that affects crop growth [81-83]. VHHs also stated, "after too much the rain, the soil gets hard" and "We sometimes don't know how to resolve these issues". VHHs experiencing leach of nutrient, plant injuries, prevent bacterial, fungus, mold growth and compact soil effecting plant growth [84]. Thus, we need to focus on new methods and technologies that could help farmers grow crops in wet season.

The importance of home gardens as sources is recognized among vulnerable households. These gardens not only provide accessible and diverse fresh food supplies but also contribute significantly to the household's daily food needs. However, despite their importance, challenges such as lack of market linkage, poor infrastructure, and seasonal variations in crop production hinder the ability of vulnerable households to fully utilize and benefit from their home gardens. Addressing these challenges through improved market access, infrastructure development, and the adoption of new agricultural technologies could unlock the untapped potential of home gardens, enabling vulnerable households to not only meet their own food needs but also generates additional income. Furthermore, initiatives aimed at enhancing crop production during the wet season, such as implementing new methods and technologies to address issues like waterlogging, soil compaction and nutrient leeching, are crucial for maximizing the productivity and resilience of home gardens year-round. Overall, recognizing the significance of home gardens and implementing targeted interventions to support their development can empower vulnerable households to improve their food source and livelihoods.

Gender Perspective on Home Garden Products

Majority of participants responded that "wife", "mother", "daughter in law', and "daughter" are primarily responsible of their home garden. Women were involved in preparing, planting, maintaining and harvesting home garden crops. However, there were women who said men mainly helped with collecting material for fencing and building fences for the home gardens making women the sole manager and responsible of their home garden. Often women joked and burst out laughing stating "Men help with eating". Women's interaction with home gardens and the choices they have of what to plant and what they do with the harvested crops seem to be an empowering experience as the women confidently shared their experiences during the interviews and found in various other studies [85-87]. Woman mainly made decisions on selection of crops and overall management of home garden [88]. This study found a strong sense of control and ownership over what women planted and how they used their harvest. While home garden mainly used for the food source, few households also made extra income and increasing the access to the market, infrastructure and knowledge to other VHHS who wants to sell but are limited due to the challenges have further potential to women to tap into this opportunity. Capacity development, equity, employment and economic growth are major strategies to reduce poverty, where women play a key role in socioeconomic development (Ardrey et al., 2006), which is reflected among vulnerable household women on how they interacted with the home garden and the crops they harvested [89].

On average, FHHs were burdened with multiple responsibilities, and lacked other members to share the workload thus their experience was slightly different about home garden compare with PWDHH and OVHHs. However, despite of this, FHHHs do recognize the importance of the home garden. While discussing the

workload with PWDHH and OVHH, they found home garden management easier and lighter work. They often said it is less labor intensive, requires less time, and simple tools are sufficient and "gives me fresh food to cook for family" [90-100].

This study sheds light on the women important role in managing home gardens within vulnerable households. Across various responsibilities including preparation, planting, maintenance, and harvesting, women emerge as the primary caretakers of these essential food sources. Their active involvement not only ensures the availability of fresh produce but also grant them a sense of empowerment and control over decision-making regarding crop selection and garden management [101-107].

Additionally, while female-headed households may experience greater time burdens and responsibilities, they still recognize the importance of home gardens as a source of fresh food for their families. Ultimately, home gardens not only serve as vital food sources but also as platforms for women's empowerment and socioeconomic advancement [108-113].

Conclusion

The study indicates that agriculture is the primary livelihood activity among all vulnerable households in the study area. The results found significant gaps and opportunities among existing livelihood activities, such as livestock production, service employment, family business, handmade crafts, and selling natural products. The study found 83 types of edible plant crops, grown mainly for household consumption, with a small portion of households selling surplus crops. Female-headed households planted the fewest types of crops and harvested least number of products in the past 12 months, despite having larger home gardens. People with disabled households harvested the higher number of crop products, despite having a smaller home garden plot. Only 37% of vulnerable households planted and harvested the home garden products every month a year. Many constraints, such as unable to grow due to seasonal challenges both in dry and wet seasons and time constraint limited the remaining 71% of vulnerable households' ability to grow every month on year-round. Thus, there is a significant potential to improve all year-round home garden crop production.

The study indicates that all vulnerable households experienced many issues hindering home garden production and livelihoods, such as poor management of existing resources, inadequate infrastructure, technical knowledge, inability to deal with weather variability-related cropping, soil management, and incompatible seed management. There were fewer vulnerable households that applied new methods such as improving soil infiltration, applying mulch, creating trenches to reduce surface runoff, increasing organic matter in home garden soil by applying compost biochar, crop rotation, building a raised garden bed, growing cover crops, or using greenhouses.

Acknowledging the lack the resources and skills to home gardening, following interventions could help improve home gardens and inform the Lao PDR government agriculture development policy and strategic objectives and contribute to reducing poverty and vulnerability amongst agricultural dependent vulnerable households.

1. Expand existing livelihood opportunities in livestock production, handmade crafts, nature-based products and service employment supporting enabling environment and ventures.
2. Promote indoor and small space crop production methods for those who lack access to suitable land.
3. Increase private and public collaboration, to support and link empowered women-led organic, safe, and healthy food production effectively and efficiently beyond household consumption to market knowledge access and networks.
4. Protect and preserve traditional seeds through local seed banks and support vulnerable households to improve seed selection quality and seed storage methods to reduce seed loss.
5. Build the capacity and technical skills set among local water authorities and community to improve water management plans that effectively manage, regulate, and use of water while strengthening community water governance.
6. Train vulnerable households to adapt to weather based seasonal challenges and improve soil management, including compost making, mulching, cover crops, crop rotation, raised beds, good drainage and irrigation management systems, and the application of new technologies to improve all season home garden production.

Declaration of Interests

The authors declare that they have no known conflict of interest not competing financial interests that could influence the work reported in this paper.

References

1. Food and Agriculture Organization (2004) Livelihoods grow in gardens. http://www.fao.org.
2. Marsh R (1998) Building on Traditional Gardening to Improve Household Food Security. FAO.
3. Dhakal A, Maraseni TN, Timsina J (2022) Assessing the potential of agroforestry in Nepal: socio-economic and environmental perspectives. Agriculture, natural resources and food security: lessons from Nepal 375-394.
4. Kunhamu TK (2013) Tropical Home Gardens. Agroforestry-Theory and Practice. Raj, AJ and Lal, S B (eds). Scientific Publishers, India 365-375.
5. Dhakal A, Maraseni TN, Timsina J (2012) Evolution of agroforestry-based farming systems: a study of Dhanusha District, Nepal. Agroforestry systems 86: 17-33.
6. Watson JW, Eyzaguirre PB (2002) Proceedings of the Second International Home Gardens Workshop: Contribution of Home Gardens to in Situ Conservation of Plant Genetic Resources in Farming Systems (2001) Witzenhausen, Federal Republic of Germany. International Plant Genetic Resources Institute, Rome 3-10.
7. Fussy A, Papenbrock J (2022) An Overview of Soil and Soilless Cultivation Techniques—Chances, Challenges and the Neglected Question of Sustainability. Plants 11: 1153 .
8. Al-Kodmany K (2018) The Vertical Farm: A Review of Developments and Implications for the Vertical City Buildings 8: 24.
9. Despommier D (2014) Vertical farms in horticulture. Book Encyclopedia of Food and Agricultural Ethics. Thompson, PB, Kaplan, DM, Eds 1860.
10. Xinde C, Lena M, Yuan L, Bin G, Willie H (2011) Environmental Science & Technology 45: 4884-4889.

11. Galhena DHG, Russel F, Karim M (2013) Home Garden: A Promise Approach to Enhance Food Security and Wellbeing. Agriculture and Food Security 2: 8.
12. Weinberger K (2013) Home and Community Gardens in Southeast Asia: Potential and Opportunities for Contributing to Nutrition Sensitive Food Systems. Food Security 5: 847- 856.
13. Keatinge J, Yang RY, Hughes Jd, Easdown W, Holmer R (2011) The Importance of Vegetables in Ensuring both Food and Nutritional Security in Attainment of the Millennium Development Goals. Food Security 3: 491-501.
14. Food and Agriculture Organization (2006) Policy Brief: Food Security. FAO.
15. Nair PKR (2001) Do Tropical Home Gardens Elude Science, or is it the Other Way Around? Agroforest Syst 53: 239-245.
16. Ninez VK (1984) Household gardens: Theoretical Considerations on an Old Survival Strategy. Potatoes in Food Systems Research Series Report. No.1. International Potato Center (CIP), Lima, Peru P 103: 1-41.
17. Mitchell R, Hanstad T (2008) Innovative Approaches to Reducing Rural Landlessness in Andhra Pradesh: A Report on the Experience of the IKP Land Activities. WA Rural Dev. Inst, Seattle.
18. Howard PL (2006) Gender and Social Dynamics in Swidden and Home Gardens in Latin America 159-182.
19. Nguyen H, Ly S, Biskupska N, Pravalprukskul P, Brown S, et al. (2017) Understanding Gender and Power Relations in Home Garden Activities: Empowerment and Sustainable Home Garden Uptake. World Vegetable Center, Taiwan. Publication number 813: 1-46.
20. Dekens J (2008) Local Knowledge on Flood Preparedness: Examples from Nepal and Pakistan, in Shaw, R., Uy, N., Baumwoll, J. (Eds.), Indigenous Knowledge for Disaster Risk Reduction: Good Practices and Lessons Learned from Experiences in the Asia-Pacific Region. Bangkok 35-40.
21. Agbogidi OM, Adolor EB (2013) Home Gardens in the Maintenance of Biological Diversity. Delta State University, Nigeria 2: 11-26.
22. Eyzaguirre P (2006) Agricultural Biodiversity and how Human Culture is Shaping It. In: Cernea M, Kassam A (eds) Researching the Culture in Agriculture. CABI, Wallingford, UK 264-284.
23. Marsh P, Diekmann L, Egerer M, Lin B, Ossola A, Kingsley J (2021) Where birds felt louder: The garden as a efuge during COVID-19. Wellbeing, Space and Society 2: 100055.
24. Corley J, Okely J, Taylor A, Page D, Welstead M, et al. (2021). Home Garden Use During COVID-19: Associations with Physical and Mental Wellbeing in Older Adults. J. Environ. Psychol. 73: 101545.
25. Ma NL, Peng W, Soon CF, Noor Hassim MF, Misbah S, et al. (2021) COVID- 19 Pandemic in the Lens of Food Safety and Security. Environ. Res 193: 110405.
26. Randin G, Turagabaleti P (2021) COVID-19 and Food Security in Fiji's Urban Areas: The Rise of Urban Farming and Home Gardening as a 'New Way of Life'. A comparative perspective on the Caribbean and the Pacific 353-366.
27. Sofo A (2020) Converting Home Spaces into Food Gardens at the time of COVID-19 Quarantine: All the Benefits of Plants in this Difficult and Unprecedented Period. Hum Ecol 48: 131-139.
28. Trading Economics (2023) Laos GDP Annual Growth Rate. Laos GDP Annual Growth Rate | 1989-2020 Data.
29. World Bank (2022) East Asia and Pacific Region, Country Partnership Framework for the Period
30. FY2023-FY2026 - Lao PDR. Washington, D.C. http://documents.worldbank.org.
31. Phimmavong S, Maraseni TN, Keenan RJ, Phongoudome C (2023) Impact of the coronavirus pandemic on financial returns of smallholder coffee plantations in Lao PDR. Agroforestry Systems 97: 533-548.
32. Mekong Institute (2023) Lower Mekong Food Security database. https://foodsecurity.mekonginstitute.org/partner-127.
33. ADRA Laos (2023a) Enhanced Nutrition and Health for Upland Phoukoud (ENHUP) Project Publications | ADRA Laos.
34. Centre for Development and Environment (2018) Ministry of Agriculture and Forestry, Lao PDR, Atlas of Agriculture in Lao PDR, Patterns and trends between 1999 to 2011. Bern Open Publishing, Swiss Agency for Development and Cooperation SDC. http://dx.doi.org/10.7892/boris.116598
35. ADRA Laos (2023b) Phoukhoud Integrated Climate Resilient Agriculture and Improved Livelihoods Project https://adralaos.org/impact/agriculture.
36. Lao Statistics Bureau, World Bank (2020) Poverty Profile in Lao PDR: Poverty Report for the Lao Expenditure and Consumption Survey 2018-2019 17. https://www.lao-pdr-poverty-profile-and-poverty-assessment-2020.
37. Northern Uplands Sustainable Development (2008) Diagnostic Study on Northern Uplands Sustainable Development, Sub-Working Group Northern Uplands Sustainable Development.
38. Mines Advisory Group, International (2021) https://www.maginternational.org.
39. Ministry of Agriculture and Forestry, Lao PDR (2017) Lao PDR Agriculture Commercialization Project, Environmental and Social Management Framework 6.
40. United Nation Development Programme (2009) National Adaptation Programmer of Action to Climate Change. UNDP, Lao PDR.
41. Yong C, Yan T, Andreas G (2021) Rural vulnerability, migration, and relocation in mountain areas of Western China: An overview of key issues and policy interventions. Chinese Journal of Population, Resources and Environment 19: 110-116.
42. Blaikie P, Cannon T, Davis I, Wisner B (2014) At risk: natural hazards, people's vulnerability and disasters. Routledge.
43. Birkmann J (2006) Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. In Birkmann, J. (Ed.) Measuring vulnerability to natural hazards: Towards disaster resilient societies. United Nations University Press, Tokyo 5: 7-54.
44. Chambers R (1989) Vulnerability and coping policy. IDS Bulletin 20: 1-7.
45. Marin-Ferrer M, Vernaccini L, Poljansek K (2017) Index for Risk Management INFORM Concept and Methodology Report. EUR 28655 EN 1-85.

46. United Nations (2021) Disability Language and Guidelines-Guiding Principles of the Convention | United Nations Enable.
47. International Labor Organization (2007) ABC of Women Workers' Rights and Gender Equality. http://www.ilo.org/wcmsp5/gender/documents
48. ADRA Laos (2019) Phoukhoud Integrated Climate Resilient Agriculture and Improved Livelihoods Project. Baseline Report.
49. Creswell JW, Plano Clark VL (2007) Designing and Conducting Mixed Methods Research. London: Sage Publications Ltd 16.
50. Bernard HR (2002) Social research methods: Qualitative and Quantitative Approaches. Thousand Oaks CA: Sage Publication.
51. Ministry of Agriculture, Forestry Lao PDR (2015) Agriculture Development Strategy to the Year 2025 and Vision to 2023. https://www.maf.gov.MDS-2025-and-Vision-to-2030-Eng.pdf.
52. Hossain MR, Al-Amin AA, Acharjee DC, Rahaman MS, Ahmed M, et al. (2015) Changes in Biodiversity and its Impact on Agro-ecosystem in Some Selected Areas of Mymensingh District, Bangladesh. IOSR Journal of Agriculture and Veterinary Science 8: 35-40.
53. Hossain MR, Khan MA, Ahmed M (2016) Impact of agro-ecosystem on risk management in agriculture in some selected areas of Bangladesh. J Agric Econ Rural Dev 3: 85-90.
54. Wan J, Li R, Wang W, Liu Z, Chen B (2016) Income diversification: A strategy for rural region risk management. Sustainability 8: 1064.
55. Hossain MR (2024) Evaluating household's risk management strategies considering heterogeneities in the livelihood diversification: Evidence from farm households of Bangladesh. Social Sciences & Humanities Open 9: 1-10.
56. United Nation, Women Australia (2023) End Poverty. https://unwomen.org.au/our-work/focus-area/ending-poverty
57. United State International Aid and Development (2023) US. Government Global Food Security Strategy; Diversifying Livelihoods, Resilience, and Pathways Out of Poverty. http://www.feedthefuture.gov/
58. Nelson S, Frankenberger T, Langworthy M, Finan, Tim Bower T (2016) The Effect of Livelihood Diversity on Recovery and Shock Impact in Ethiopia, Kenya and Uganda. Report prepared 1-25.
59. Liao C, Barrett C, Kassam KA (2014) Does Diversification Translate into Improved Livelihoods? Evidence from Pastoral Households in the Altay and Tianshan Mountains of Xinjiang, China. SSRN Electronic Journal 46.
60. Garloch A (2015) A Framework for a Push/Pull Approach to Inclusive Market Systems Development. USAID 1-14.
61. Kumar D, Kalita P (2017) Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing Countries. Foods 6: 8.
62. Campbell R (2014) A Framework for Inclusive Market System Development. USAID 1-8.
63. Smith K (2020) The Easiest Herbs and Vegetable to Grow Indoors. https://www.foodnetwork.com/how-to/articles/easiest-vegetables-herbs-grow-indoors
64. Parker J (2023) 5 vegetables you can grow indoors all year - experts on the home-grown produce that just keeps on coming. https://www.livingetc.com/advice/vegetables-you-can-grow-indoors-all-year
65. Amdie T, Mulu D (2017) The Role of Women in the Management and Utilization of Home Garden: The Case of Dale District, in Southern Ethiopia 41-54.
66. Lutter CK, Daelmans BM, de Onis M, Kothari MT, Ruel MT, et al. (2011) Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. Pediatrics 128: e1418-e1427.
67. Chapman EC, Bounthong B, Hansen Peter K (1998) Upland Farming Systems in the LAO PDR - Problems and Opportunities for Livestock. Proceedings of an International Workshop held in Vientiane, Laos 18-23.
68. Blair MW, Wu X, Bhandari D, Zhang X, Hao J (2016) Role of Legumes for and as Horticultural Crops in Sustainable Agriculture. In: Nandwani, D. (eds) Organic Farming for Sustainable Agriculture 9: 185-211.
69. Food and Agriculture Organisation, European Union and CIRAD (2022) Food Systems Profile – The Lao People's Democratic Republic. Catalysing the sustainable and inclusive transformation of food systems. Rome, Brussels and Montpellier, France 1-44.
70. Catherine MH, Thilde BB, Andreas de N (2019) Transitioning towards commercial upland agriculture: A comparative study in Northern Lao PDR. NJAS - Wageningen Journal of Life Sciences 88: 57-65.
71. Rassapong S, Syfongcay C, Panthanivong I, Syhalad B, Phimmahthut S, et al. (2018) Briefing notes; Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service.
72. Liang B, Lehmann J, Solomon D, Kinyangi, J, Grossman J (2006) Black Carbon Increases Cation Exchange Capacity in Soils. Soil Sci Soc Am J 70: 1719-1730.
73. Jarvis DI, Brown AHD, Cuong PH, Collado-Panduro L, Latournerie-Moreno L, et al. (2008) A global perspective of the richness and evenness of traditional cropvariety diversity maintained by farming communities. Proceedings of the National Academy of Sciences of the United States of America 105: 5326-5331.
74. Brush SB (2004) Farmers' bounty. Locating crop diversity in the contemporary world. New Haven, CT: Yale University Press.
75. Bellon MR, Dulloo E, Sardos J, Thormann I, Burdon JJ (2017) In situ conservation—harnessing natural and human-derived evolutionary forces to ensure future crop adaptation. E vol Appl 10: 965-977.
76. Alexander Kim S, Case Peter Jones, Michael J, Connell John G (2017) Commercialising smallholder agricultural production in Lao People's Democratic Republic. Development in Practice 27: 965-980.
77. Shrestha P, Gautam R, Singh R, Singh G (2017) Traditional Agriculture: A Climate- Smart Approach for Sustainable Food Production. Banaras Hindu University, India 2: 296-316.
78. Blakstad M, Mosha D, Bliznashka L, Bellows A, Canavan RC, et al. (2022) Are home gardening programs a sustainable way to improve nutrition? Lessons from a cluster-randomized controlled trial in Rufiji, Tanzania. Food Policy 109: 102248.

79. Food and Agriculture Organization (2021) Addressing the Impact of COVID-19 on Nutrition Insecurity of Vulnerable Groups through Nutrition Sensitive. Agricultural Home Gardens and Urban Agriculture Systems 5: 1-15.
80. Irham I, Gusfarina DS, Widada AW, Nurhayati A (2021) Contribution of home-garden farming to household income and its sustainability in Yogyakarta City, Indonesia. IOP Conference Series: Earth and Environmental Science 883: 1-11.
81. Guuroh, Reginald, Uibrig, Holm, Acheampong, Emmanuel (2012) Home gardens as a Source of Income for Rural Households - A Case Study of Bieha District, Southern Burkina Faso. Journal of Agricultural Science and Technology B2 7: 798-813.
82. Linkemer G, Board JE, Musgrave ME (1998) Waterlogging Effects on Growth and Yield Components in Late-Planted Soybean. Crop Sci 38: 1576-1584.
83. Setter T, Waters I (2003) Review of Prospects for Germplasm Improvement for Waterlogging Tolerance in Wheat, Barley and Oats. Plant Soil 253: 1-34.
84. Lone AA, Khan MH, Dar ZA, Wani SH (2018) Breeding Strategies for Improving Growth and Yield under Waterlogging Conditions in Maize: A Review. Maydica 61: 11.
85. Hubbard TP (2023) How Too Much Rain Affects Your Garden. Penn State Extension Accessed 22 March 2024 https://extension.psu.edu/how-too-much-rain-affects-your-garden.
86. Hallman K, Lewis D, Begum S (2003) An integrated economic and social analysis to assess the impact of vegetable and fishpond technologies on poverty in rural Bangladesh. International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection.
87. Patalagsa, MA, Schreinemachers P, Begum S (2015) Sowing seeds of empowerment: effect of women's home garden training in Bangladesh. Agric & Food Security 4: 24.
88. Kumar N, Quisumbing A (2010) Does social capital build women's assets? The long-term impacts of group-based and individual dissemination of agricultural technology in Bangladesh. CAPRi Working Paper 97, Washington, DC: International Food Policy Research Institute. http://dx.doi.org/10.2499/CAPRiWP97.
89. Ebile P, Phelan L, Jens W (2022) The role of Home Gardens in Empowering Minority Women and Improving Food and Nutrition Insecurity: A Case of Mbororo Community in Cameroon's Northwest Region. Agroecology and Sustainable Food Systems 46: 1002-1024.
90. Thompson S, Baden S (1993) Women and Development in Laos Report prepared for Women, Health and Population Division, Report No 9. Australian International Development Assistance Bureau.
91. Australian Centre for International Agricultural Research (2021) Integrating soil and water management in vegetable production in Laos and Cambodia. ACIAR.
92. Asian Development Bank, The World Bank (2012) Country Gender Assessment for Lao PDR- Reducing Vulnerability and Increasing Opportunity, Mandaluyong City, Philippines and Washington, DC, USA. Country Gender Assessment for the Lao People's Democratic Republic (adb.org).
93. Matthew W Blair, Xingbo Wu, Devendra Bhandari, Xiaoyan Zhang, Junjie Hao (2016) Role of Legumes for and as Horticultural Crops in Sustainable Agriculture. Organic Farming for Sustainable Agriculture185-211.
94. Cochran WG (1963) Sampling Techniques. 2nd Ed., New York: John Wiley and Sons, Inc.
95. De la Pena R, Hughes J (2023) Improving Vegetable Productivity in a Variable and Changing Climate in The Impact of Climate Change on Tropical Agriculture. The World Vegetable Center 4.
96. Ellis F (1998) Household strategies and rural livelihood diversification. The Journal of Development Studies 35: 1-38.
97. Engels J (2002) Home Gardens - A Genetic Resource Perspective in: Watson JW Eyzaguirre PB (eds). Home Gardens and in situ Conservation of Plant Genetic Resources in Farming Systems.
98. Gautam R, Sthapit B, Shrestha P (2004) The role of Home Gardens to On-Farm Agro Biodiversity Management and Enhancing Livelihoods of Rural Farmers of Nepal. On Farm Conservation of Agricultural Biodiversity in Nepal: Managing Diversity and Promoting its Benefits.
99. Hossain MR (2024) Evaluating household's risk management strategies considering heterogeneities in the livelihood diversification: Evidence from farm households of Bangladesh. Social Sciences & Humanities Open 9: 1-10.
100. International Labor Organization (2023) How much Time do Women and Men Spend on Unpaid Care Work. Accessed 16 April 2023, https://www.ilo.org/global/WCMS_721348.
101. Koppen B, Giordano M, Butterworth J, Mapedza E (2007) Community-based water law and water resource management reform in developing countries: rationale, contents and key messages. CABI 1-11.
102. Kumar BM, Nair PR (2004) The Enigma of Tropical Home gardens. Agrofor. Syst 61: 35-152.
103. Maleki R, Nooripur M, Azadi H, Phiippe L (2018) Vulnerable Assessment of Rural Households to Urmia Lake Drying, Sustainability. MDPI 10: 1-20.
104. Manik SMN, Pengilley G, Dean G, Field B, Shabala S, Zhou M (2019) Soil and Crop Management Practices to Minimize the Impact of Waterlogging on Crop Productivity. Front Plant Sci 10: 140.
105. Ministry of Planning and Investment Agriculture, UNDP Lao PDR (2022) National Human Development Report, UNDP. https://www.undp.org.
106. Ministry of Planning and Investment, Lao PDR (2021) 9th Five Year National Socio-Economic Development Plan 2021-2025. https://9th-five-year-NSED-plan-2021-2025.
107. Technical Consortium, a project of the CGIAR. Technical Report Series No 2: Strengthening the Evidence Base for Resilience in the Horn of Africa. Nairobi, Kenya: A joint International Livestock Research Institute (ILRI) and TANGO International publication.
108. O'Neil A (2021) Laos: Share of Economic Sectors in Gross Domestic Product from 2010 to 2020. World Bank, Accessed 30 October 2021, Statista. https://www.statista.com/statistics/804979/share-of-economic-sectors-in-the-gdp-in-laos/.
109. In Campbell Y, Connell J (eds) COVID in the Islands: A comparative perspective on the Caribbean and the Pacific. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-16-5285-1_20.
110. Rockström J, Barron J, Fox P (2002) Water Productivity in Rain-Fed Agriculture: Challenges and Opportunities for Smallholder Farmers in Drought-Prone Tropical Agroecosystems. https://doi.org/10.1079/9780851996691.0145.

111. United Nations (2015) Department of Economic and Social Affairs Sustainable Development: The 17 Goals. https://sdgs.un.org/goals.
112. University of Florida (2023) Dealing with Heavy Rain. https://gardeningsolutions.ifas.ufl.edu/care/weather/dealing-with-heavy-rain.html
113. Vernon J (210) Hartley magazine; Why do Plants grow better in a Greenhouse. https://hartley-botanic.com/magazine/plants-grow-better-greenhouse/.
114. Wang C A (2022) How to garden and grow your own food indoors. SBS. https://www.sbs.com.au/how-to-garden-and-grow-your-own-food-indoors.

Annexes A

Crop diversity, edible plant-based crops collected during qualitative data collection through focus 799 group discussions and in-depth interviews among three types of vulnerable households in 16 villages, 800 Phoukhoud district.

Plant based edible crop found in the vulnerable home garden (n=30)				
1. Eight types of Grains, Roots, and Tubers				
	Description	**PWDHH**	**FHHH**	**OVHH**
	Total types of crops found among VHHs	**64**	**55**	**74**
	% of total crop found in VHHs	**77%**	**66%**	**89%**
1	Cassava	1	1	1
2	Maize, (white & yellow)	1	0	1
3	Taro	1	1	1
4	Yam bean	0	1	1
5	Sweet Potatoes	1	1	1
6	Yam bean	1	1	1
7	Yacoon	1	1	1
8	Arrowroot	1	0	0
Total	8	7	8	
2. Nine types of Dark green vegetables & Salad				
9	Chinese Cabbage	1	1	1
10	Choy sum	1	1	1
11	Thai mustard	1	1	1
12	Red and green lettuce	1	1	1
13	Spinach	1	0	1
14	Chaya	1	1	1
15	Crown Daisy	1	1	1
16	Kale Leaf	1	1	1
17	Morning Glory	1	1	1
Total	9	8	9	
3. Eight types of Legumes & Nuts				
18	Yard/Long Bean	1	1	1
19	Flat Bean	0	0	1
20	Flat winged bean	0	0	1
21	Peanut	1	1	1
22	Soy bean	0	0	1
23	Mung bean	0	0	1
24	Chestnut	0	0	1
25	Red beans	1	0	0
Total	3	2	7	
4. Nineteen 19 types of Herbs & Spices				
26	Basil	1	1	1
27	Coriander	1	1	1
28	Dill	1	1	1
29	Mint	1	1	1
30	Cilantro	1	1	1
31	Galangal	1	1	1
32	Garlic	1	1	1

33	lemongrass	1	1	1
34	Mint	1	1	1
35	Spring onion	1	1	1
36	Winged prickly ash	1	1	1
37	Ginger	1	1	1
38	Tamarind	1	1	1
39	Chillie	1	1	1
40	Wasabi mustard	1	1	1
41	Radish rat tailed	1	1	1
42	Heartleaf	1	1	1
43	Paracress	1	1	1
44	Piper lolot	1	1	1
Total	19	19	19	
5. Twenty-six types of Fruits				
45	Lemon	0	0	1
46	Kaffir lime	1	0	0
47	Mango	1	1	1
48	Peach	1	1	1
49	Plum	1	1	1
50	Banana	1	1	1
51	Watermelon	0	0	1
52	Muskmelon	1	0	1
53	Guava	0	0	1
54	Gac Fruit	1	1	1
55	Orange	1	0	1
56	Jack Fruit	1	1	1
57	Pomelo	1	0	1
58	Pear	1	1	1
59	Star fruit	0	0	1
60	Pineapple	0	0	1
61	Longan	1	0	1
62	Wild olive	0	0	1
63	Papaya	1	1	1
64	Eggyolk	1	1	0
65	Jujube	1	0	1
66	Star Apple	1	0	0
67	Strawberry	0	1	0
68	Dragon Fruit	0	1	0
69	Fruit Amla	0	1	0
70	Custard apple	1	1	1
Total	17	13	20	
6. Thirteen types of other Vegetables				
71	Chayote	1	1	1
72	Eggplant	1	1	1
73	Pumpkin	1	1	1
74	Gourd (Sponge, Snake)	1	1	1
75	Bamboo shoot	0	0	1
76	Sugarcane	1	1	1
77	Tomatoes	1	0	1
78	Turkey berry	1	0	1
79	Cucumber	1	1	1
80	Winter melon	1	1	1
81	Avocado	0	0	1

82	Broccoli	0	0	1
83	Peas	0	0	0
Total	9	7	12	

Annexes B

Summary of the Home Garden Characteristics derived from the results among the three types of 805 vulnerable households, PWDHH (n= 135), FHH (n= 23) and OVHH (n= 265), from 16 villages of 806 Phoukhoud District, Lao.

Home Garden characteristics among three types of vulnerable households			
Description	**Results**		
	PWDHH	**FHHH**	**OVHH**
1. Average size of home garden (meter square) and home garden proximity			
Average home garden size in meter square	71.25 m²	195 m²	128 m²
Average home garden proximity from home	5 m	75 m	41 m
2. Edible plant-based crop diversities (83 types of crops were found among three types of HHs)			
Grain roots and tubers, 10 types	8	7	8
Dark green vegetable and salad, 9 types	9	8	9
Legumes, nuts and seeds, 8 types	3	2	7
Herbs and spices, 19 types	19	19	19
Fruits, 25 types	16	12	19
Other vegetables, 13 types	9	7	12
Sub total of 3 types of HH crops:	64 (77%)	55 (68%)	74 (89%)
4. Time used daily, overall, for all = 1.42 hrs. per day			
Daily time used in home garden (n=30)	1.43 hrs.	1.52 hrs.	1.31 hrs.
5. Harvest crop usage in %			
Harvest - households' consumption (n= 425)	84%	82%	81%
Harvest – surplus sold (n=425)	21%	29%	34%
3. Home Garden management			
Home garden - Fencing local resource	Mostly men expect for FHHH if they have no men in their households		
Home garden preparation land clearing, & burning	Mostly women - mother, grandmother, daughter-in- law, daughter, etc., only in some cases men participated in breaking the soil and watering the garden but most of the respondents stated home gardens are women's responsibility.		
Soil preparation (soil breaking, preparing bed,			
covering bed with leaves and hay, burning, applying wet and dried manure			
Planting, mulching, weeding, watering			
Harvest crop usage - consume, sell & exchange			
Ownership of crops	Many women said they do what they like with the harvest, with some stating family collective Ownership		
7. Seed management			
Traditional Practice	Seeds selection, saving and storing methods were passed down from the generations extremely valued practice		
Modern Practice	Some new methods of seed storing (vacuumed jars) were practiced among some participants, benefits yet to be experienced since it is truly new		