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Enhancing Food Security Through Home Gardening: A Case Study in Phoukhoud District, Lao PDR

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Abstract: Food insecurity is a global challenge, particularly affecting developing nations. This study evaluated the role of home gardens in addressing food security in rural upland regions of Laos among three different types of vulnerable households. To address this objective, household survey data of project baseline 2019 (n = 504), midterm in 2021 (n = 425), and final 2022 (n = 435) were analyzed and tested. Additionally, focus group discussion (n = 3) and key informant interviews (n = 42) were carried out to gain deeper insights and triangulate and supplement household survey findings. The study found a 21% drop in food insecurity from 2019 to 2022, mainly due to a 12% increase in the number of home gardens, boosting crop production and harvests. We also found that dietary habits significantly improved between 2019 and 2022, with minimum diet diversity rising to 41% for three types of vulnerable households: 62% for female-headed households, 41% for households with disabilities, and 67% for other households. While there has been an improvement among different types of vulnerable households, about 15% of them still faced severe food shortages as of 2022. However, food insecurity among the three predetermined categories reveals significant disparities. Female-headed households experienced the most severe food insecurity and showed the least progress between 2019 and 2022. Additionally, we compared crop and diet diversity and various food insecurity coping methods across different time periods among these three vulnerable households. We provide several recommendations for targeted interventions and policies to address the remaining food security challenges in rural upland areas, ultimately contributing towards reducing global food insecurity.

Keywords: home garden; vulnerable household; crop production; food security; rural development

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1. Introduction

While smallholder farmers produce most of the world's food, paradoxically, they often grapple with food insecurity [1]. Food insecurity is a complex challenge influenced by societal, cultural, economic, and political factors that directly impact food production, distribution, access, and utilization [2]. This multifaceted issue is exacerbated by various determinants such as conflicts, climate extremes, economic downturns, the unavailability of affordable nutritious foods, and growing inequality [3,4]. Although food insecurity is more prevalent in developing countries, it is increasingly becoming a global concern, affecting both the global north and south [5,6]. Currently, an estimated 193 million people worldwide are facing acute food insecurity, primarily in the global south [7]. Efforts to address these challenges and meet Sustainable Development Goal (SDG) targets, including

ending hunger, have fallen behind schedule [5]. Moreover, food-insecure countries often grapple with critical levels of undernutrition and poverty [8,9], further deteriorating the health and well-being of those affected [10–12].

Developing countries in the global south are more concerned with food insecurity and hunger. For example, in Laos, while acute food insecurity is not widespread, many households continue to experience persistent hunger and nutritional challenges. These challenges often take the form of food shortages, poor-quality diets, and high rates of malnutrition [7,13–16]. With the majority of Laotian households relying on agriculture for their livelihoods [17], they remain highly vulnerable to unexpected shocks that can drive them into food insecurity [14]. To cope with such shocks, especially in developing countries vulnerable households often employ various strategies, including borrowing cash or food, selling assets, foraging in forests and rivers, and reducing both meal quantity and quality [17,18]. Unfortunately, these situations often have a cascading impact, further neglecting the needs of children, women, and individuals with disabilities. Adding to the complexity, Laos is experiencing significant currency depreciation and rising global prices, resulting in a 40% inflation rate as of April 2023 and the devaluation of the local currency. Domestic revenue is lower than pre-COVID-19 levels, and high debt-service obligations have left fewer resources available to support poor households [19–21]. Consequently, Laotian families are experiencing reduced purchasing power and exacerbating food insecurity [22]. Addressing this issue requires multifaceted responses aimed at reducing poverty, improving education, enhancing agricultural productivity, promoting sustainable practices, and ensuring equitable access to resources. However, despite government and development agency efforts, food demands remain unmet among rural upland vulnerable households [23–25]. Many vulnerable households rely on multiple food sources, including local forests, rivers, and home gardens, as well as borrowing food or money from family, relatives, and friends [26–28]. Among these, home gardens serve as a crucial and reliable source of food, contributing to household nutrition and food security [29].

Home gardens (HGs) are among the oldest and most important traditional farming systems, practiced for centuries worldwide in both urban and rural communities [29,30]. HGs typically consist of small plots of land located next to or near the home, depending on topography, suitability, and land availability [31]. While HGs share common characteristics globally, they vary between households based on crop selection, utilization, seasonal planting, and cultural significance. These factors influence what individuals choose to plant and the agricultural methods they apply in managing their HGs [32,33].

Home gardens are an integral part of food sources for upland farmers in Laos and are conveniently located near households, providing accessible and readily available food sources [34]. For thousands of years, home gardens have been proven to generate a steady and secure food supply for households, contributing significantly to household's food needs [30]. They offer regular access, quality, and stability of diverse fresh food supplies [35–39]. Due to these invaluable characteristics, home gardens are practiced across the world and play a crucial role in improving human health and enhancing household food security, endorsed both in the global south and north. Numerous studies confirm the positive contribution of home gardens to food security [39–41]. They are promoted in both rural and urban settings as households have access to and consume a variety of crops rich in essential nutrients [35,42]. Consuming a diverse range of food groups is crucial for the cognitive and physical development of children, pregnant, and lactating women [5,43,44]. Therefore, having access to home garden production can improve household nutrition as they offer a variety of vegetables, fruits, herbs, and grains rich in key nutrients. The ability to provide regular availability to food, along with improved access,

utilization, and stability, makes home gardens a robust agricultural system contributing to household food security and nutrition [45].

Many governments, international non-governmental agencies (INGOs), and various United Nations (UN) agencies recognize home gardens as an important agricultural system that not only addresses food insecurity but also improves household nutrition [38,42,46]. In Laos, government's national plans of action on nutrition for 2021–2025 and various agricultural strategies [23,47,48] promote a multisectoral approach that includes nutrition-sensitive agricultural practices, acknowledging the importance of home gardens in providing more accessible and nutritious food for households [7,13].

While global studies highlight the benefits of HGs in improving household nutrition and resilience, there is a significant gap in empirical evidence on how they support food availability, access, utilization, and stability, both globally and in Laos [30,34,48]. Existing studies provide only basic insights, lacking in-depth analysis of their long-term impact on food security. Furthermore, little is known about how households cope with varying levels of food insecurity and the extent to which HGs mitigate these challenges over time. This study focuses on Laos, analyzing food insecurity trends across different periods and evaluating coping mechanisms among three vulnerable groups using data collected from 2019 to 2022. By providing evidence-based insights, it informs policymakers, development practitioners, and multisectoral stakeholders on the crucial role of HGs in reducing food insecurity in upland Laos.

Laos presents a unique case as it not only grapples with food insecurity but also has one of the highest disability rates in the region. With about 1% of its population having disabilities and climate change increasing vulnerability in one of the most at-risk countries, food security challenges are worsening [48], making it a suitable country for this research. Understanding how HGs can serve as a lifeline for such marginalized groups is crucial. This study aims to bridge this knowledge gap, highlighting the untapped potential of HGs in fostering resilience and food security for Laos' most vulnerable populations.

2. Methods

The research used a mixed research methodology, including survey data, key informant interviews, group discussion, field observations, and a review of various secondary sources, including project reports, policy documents, and the literature. The research utilized food security project data from the Adventist Development and Relief Agency (ADRA) in Laos, gathered through household surveys at three time points: 2019 baseline, 2021 midterm, and 2022. Additionally, data were collected between October and November 2022 after securing human research ethical clearance from the University of Southern Queensland (H22REA115).

We investigated three types of vulnerable households that were supported by the project intervention. The definitions of these three vulnerable households (VHHs) were adapted through the consultation with ADRA Lao PDR's and various literature [13,49–52]. They are:

People with disability households: These PWDHHs refer to rural and remote farming households that include one or more family members with long-term physical, mental, or sensory impairments. These households often lack adequate support services and medical treatment, making it difficult to address the unique challenges they face. Such impairments can significantly hinder the full and effective participation of individuals with disabilities in society on an equal basis with others [52]. Moreover, PWDHHs are particularly vulnerable to various hazards and have limited access to essential social, healthcare, and economic resources, further exacerbating their marginalization [50].

Female-headed households: These FHHHs comprise rural and remote farming households where women carry full responsibility for their household's management. They either live alone or with others and serve as the primary income generators and decision-makers [53,54]. This category encompasses widows, divorced women, single individuals, or single female parents who are vulnerable to various hazardous events. Similar to PWDHHs, FHHHs often have limited access to crucial social, healthcare, and economic resources [50].

Other vulnerable households: These OVHHs encompass rural and remote farming households other than PWDHHs and FHHHs that face vulnerability due to factors such as climate change, financial instability, and health risks. These households typically possess limited coping and adaptive capacity [55]. They often lack access to essential services like healthcare, safe drinking water, and education, resulting in a higher prevalence of malnourished children. OVHHs experience recurrent seasonal food insecurity, financial hardships, and limited employment opportunities [56].

2.1. Study Area

The study was conducted in 16 rural upland villages of Phoukhoud District, XiengKhouang Province of Lao PDR (Figure 1) where 97% of the households are subsistence farming households [13]. These rural households are small landholders who follow both traditional and modern agricultural practices and have a small size of operations to secure their livelihoods primarily through agricultural activities, with only a small percentage of households having access to diverse sources of income. Thus, these households are classified as vulnerable households based on the presence of multiple vulnerability dimensions such as remoteness, poor access to key services, seasonal food insecurity, proneness to financial hardship, higher prevalence of malnourished children, and exposure of livelihoods to natural disasters. Vulnerable households often are resource-poor, with various financial and health risks, have low coping and adaptive capacity to natural disasters [13,49–51,55,57], and are exposed to adverse climate change effects [25,58]. Overall, 25% of these rural farmers in the province are experiencing food insecurity, with a 21.5% poverty rate, which is the fourth highest in Lao PDR; 40% of children under 5 are chronically malnourished [25,47,59]; and they are exposed to significant unexploded ordnance contamination that continues to injure people and cause loss of life [60].

Figure 1. A Google image of the study area: the location of 16 villages marked with a white house symbol, Phoukhoud district, XiengKhouang Province, Lao PDR.

2.2. Household Data Collection and Analysis

There was a total of 835 vulnerable households in the study area, including 235 households with persons with disabilities (PWDHHs), 45 female-headed households (FHHHs), and 555 other vulnerable households (OVHHs). A random sample was drawn from these three strata. The sample size for each stratum and each sampling year (2019, 2021, and 2022) is provided in Table 1. There are different sample sizes in each year, but the percentage of sampled households is never less than 28% from each category. Due to the homogeneity in terms of socioeconomics, demographics, and cultural settings, we believe that the sample size truly represents the total population it reflects. A semi-structured questionnaire was then developed, pretested with a small group of farmers, refined, and used for the final interviews.

Table 1. The household size and sample size of the three vulnerable household types: persons with disabilities (PWDHHs), female-headed households (FHHHs), and other vulnerable households (OVHHs).

Types of Households	Number of Total HHs	Number of HHs Sampled in 2019	% of HHs Sampled in 2019	Number of HHs Sampled in 2021	% of HHs Sampled in 2021	Number of HHs Sampled in 2022	% of HHs Sampled in 2022
PWDHH	235	168	71.5	135	57.4	71	30.2
FHHH	45	15	33.3	24	53.3	13	28.9
OVHH	555	261	47.0	266	47.9	350	63.1

The questionnaire comprises categorical closed-ended questions using a single response with a single choice, a multiple choice with multiple responses, a multiple choice with a single response, and numerical values. The study investigated the following food insecurity conditions and experiences among three types of vulnerable groups throughout different time periods of 2019, 2021 and 2022.

2.2.1. Food Availability and Access

Food availability and access are assessed if vulnerable households experienced any food shortage in the past 12 months and in the past 4 weeks at the time of the survey [45]. Food access and availability are being investigated through the household food supply and adjustments to household food management, including reduced quality of food, increased unusual coping patterns, and repeatedly experiencing the physical sensation of hunger [61].

2.2.2. Food Quality

Food quality is determined by investigating the household diet diversity consumption record—whether the household members consumed a minimum of 5 food groups out of 10 food groups over 24 h [36]. Household diet diversity on an ordinary day is investigated using recall methods of 24 h food consumption records.

2.2.3. Home Garden's Contribution

A home garden's contribution to food security is determined by examining home garden crop groups produced and harvested in the past 12 months and usage and storage records of harvested crops between 2019 and 2022.

2.3. Key Informant Interviews and Focus Group Discussions

The study conducted 42 key informant interviews and 3 focus group discussions. Key informants were selected for their expertise, experience, and active involvement in agriculture and garden activities, including three members of government technical staff, five civil society experts, and five village chiefs. Interviews consisted of many questions

(See Appendix A) addressing policy responses, program effectiveness, and resources allocated to food insecurity challenges.

There were 43 participants (11 men and 32 women) in 3 focus group discussions (FGDs). The FGDs were held separately for FHHH women, PWDHH (mixed group), and OVHH (mixed group). Participants were selected from 16 villages, focusing on those with the highest number of PWD and FHHH households to ensure adequate representation and logistical feasibility. Each FGD involved 9 open-ended questions and 2 participatory tools: a crop calendar for home gardens and a discussion of weather patterns, climate impacts, and natural disasters over the past five years. The discussions also explored coping strategies, adaptive measures, and their effects on home gardens, family nutrition, and food security. Focus group discussion questions are provided in Appendix B.

The interviews and FGDs complemented and enriched the quantitative data. Most importantly, responses from these interviews and FGDs were used to explain the reasons for certain results and write possible implications from these results and discussions in both the Results and Discussion sections.

3. Results

3.1. Status of Food Insecurity over Different Time Periods

3.1.1. Seasonal Food Unavailability Among Three Types of Vulnerable Households

We found that all three types of vulnerable households (FHHHs, PWDHHs, and OVHHs) experienced food shortages between 2019 and 2022. In 2019, 52% (57% of FHHHs, 54% of PWDHHs, and 49% of OVHHs) of them experienced food shortages. But when compared with the same sample population at the end of 2022, only 33% of vulnerable households (54% of FHHHs, 45% of PWDHHs, and 30% of OVHHs) experienced food shortages, a notable reduction of 19% among vulnerable households over time. However, we also found that not all types of VHHs experienced the same degree of improvement. We found food shortages among FHHHs have only decreased by 3%, the PWDHHs showed slight improvement with a 9% reduction in food shortages, and there was a remarkable improvement among OVHHs, exhibiting the most progress with a 19% reduction in food shortage experiences (Figure 2).

The study also revealed a critical food shortage experience among households during the months of August, September, and October. These months were the most severe food scarcity experience among all VHHs. Specifically, 52% of households reported experiencing food shortages in August, followed by a staggering 66% in September, and 57% in October.

The study also examined how many VHHs experienced food shortages for multiple months and found that 46% of households experienced food shortages for a minimum of two months according to the 2019 HH survey, but the 2022 HH survey revealed that the number was reduced to 30% (42% of PWDHHs, 38% of FHHHs, and 27% of OVHHs), a reduction of 16% among all VHHs.

3.1.2. Experiencing Food Insecurity Anxiety and Hunger

The study examined the extent of food shortage worries, the frequency of such concerns, and whether household members had to skip meals. Figure 3 demonstrates an overall average of 57% (67% of FHHHs, 56% of OVHHs, and 55% of PWDHHs) households in 2019, 72% in 2021, and 35% (46% of FHHHs, 44% of PWDHHs, and 32% of OVHHs) in 2022 were found to be anxious about the possibilities of food shortage. The overall percentage in 2022 demonstrated that VHHs were less worried about food shortages, but FHHHs and PWDHHs were worried more than OVHHs.

The finding demonstrates that 35% of VHHs worried about not having enough food, whereas only 15% (31% of FHHHs, 25% of PWDHHs, and 13% of OVHHs) skipped evening

meals and went to bed without eating anything, with FHHHs experiencing the most severe food shortage (Figure 4). The result found that the severe food insecurity experienced was reduced among all three types of VHHs to 15% (31% of FHHHs, 25% of PWDHHs, and 13% of OVHHs) in 2022, compared to the 2019 HH survey 33% and 2021 HH survey 37%, demonstrating notable reduction after interventions.

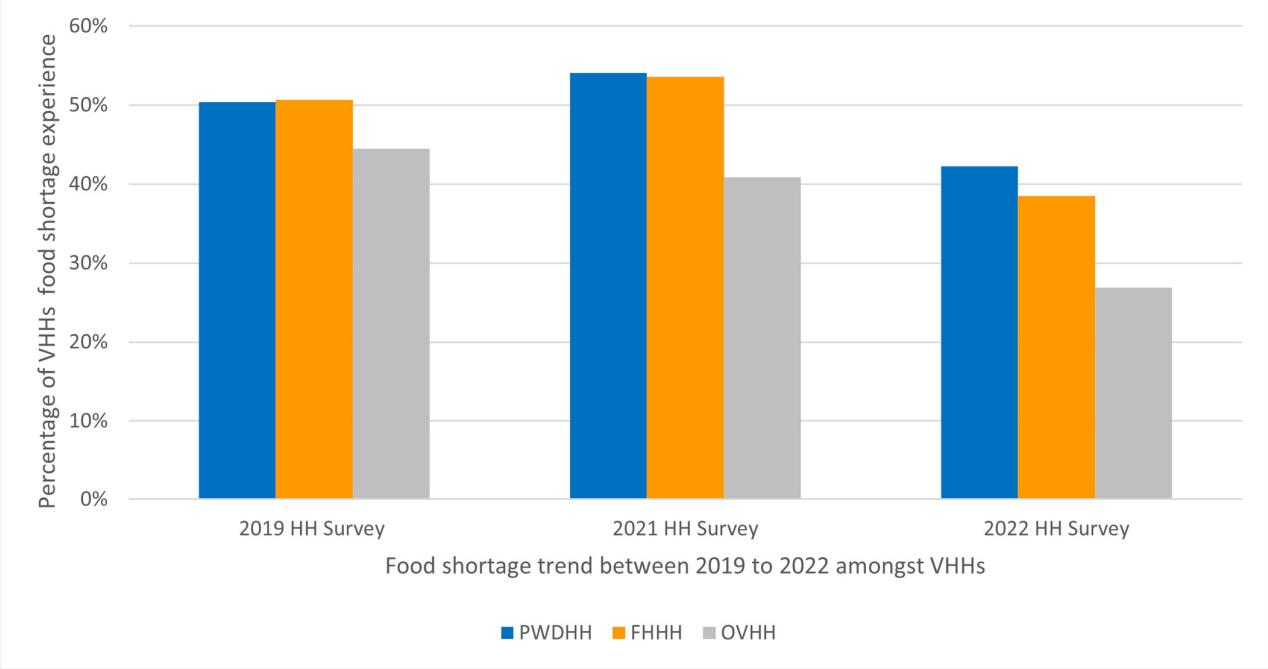

Figure 2. A food shortage reduction trend was noticed between 2019 (n = 504 VHH), 2021 (n = 425), and 2022 (n = 435) among three vulnerable HHs.

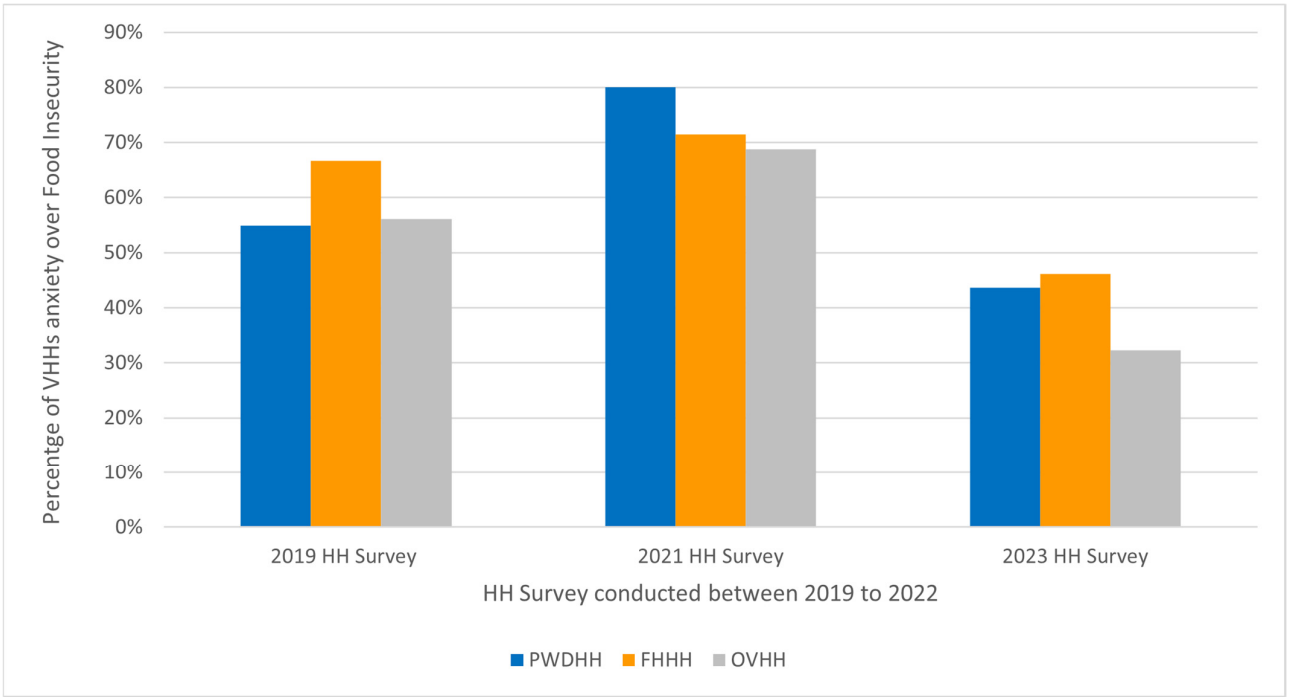

Figure 3. Decreased food shortage anxiety was noticed among three types of vulnerable households in the past 4 weeks at the time of the 2019 (n = 504), 2021 (n = 425), and 2022 (n = 434) household surveys.

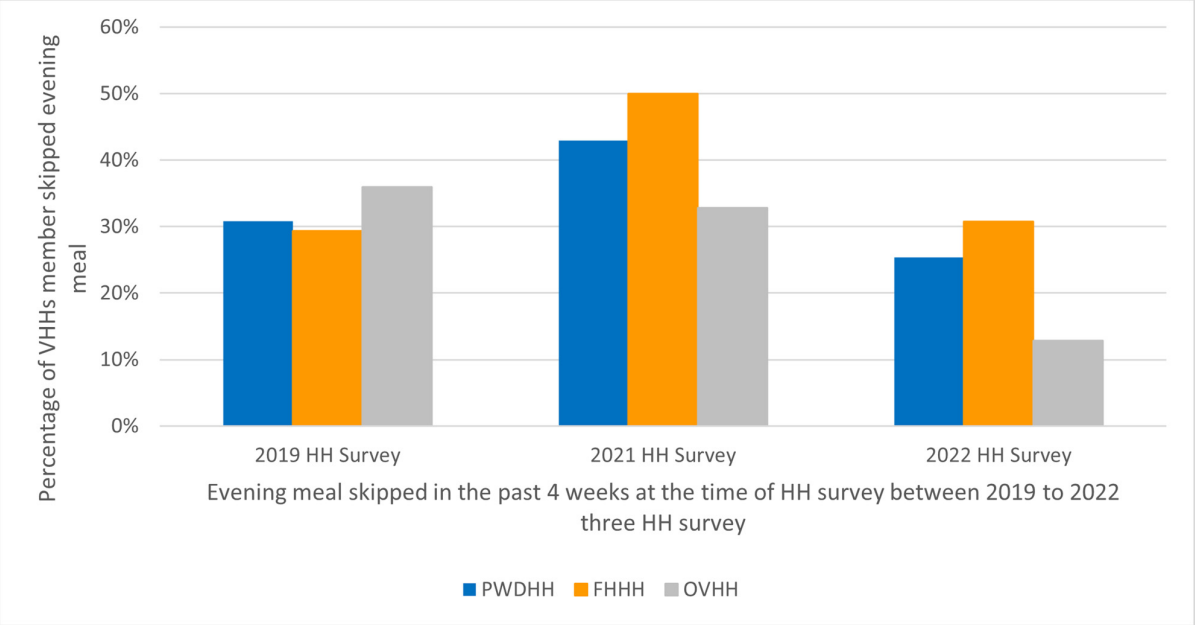

Figure 4. A percentage of household members among the three types of vulnerable households who skipped evening meals and went to bed without eating in the past 4 weeks at the time of 2019 (n = 504), 2021 (n = 425), and 2022 (n = 434) HH surveys. The chart demonstrates the reduction in the number of HH members skipping meals.

3.1.3. Coping Methods to Address Food Insecurity

The findings highlight the diverse range of strategies employed by households to cope with food insecurity, with varying degrees of severity and impact on their food intake (Figure 5). About 17% of FHHHs, 6% of PWDHHs, and 3% of OVHHs reduced the number of meals, reflecting the critical need for immediate intervention and support and indicating the dire circumstances faced by these households. In addition to these measures, 52% of households, with the highest proportion being 59% of PWDHHs, 51% of OVHHs, and 33% of FHHHs, resorted to collecting food from forest areas. This foraging strategy highlights the resourcefulness of these households in accessing alternative food sources when facing food shortages. Furthermore, 43% of households (50% of FHHHs, 44% of PWDHHs, and 43% of OVHHs) sought assistance from other family members. This collaborative approach underscores the importance of social support networks in times of food crisis. Interestingly, 32% of households, including 34% of OVHHs, 33% of FHHHs, and 22% of PWDHHs, opted to sell their livestock.

3.1.4. Households Diet Diversity

We conducted an analysis of the dietary diversity within households over a 24-h period at the time of the survey, with the primary goal of assessing the nutritional quality of food consumed by household members. The results showed that 14% of HHs (17% of FHHHs, 15% of OVHHs, and 11% of PWDHHs) were consuming food from 5 food groups in 2019 compared to a minimum of 41% (67% of OVHHs, 62% of FHHHs, and 41% of PWDHHs) in the 2022 HH survey results (Figure 6). It demonstrates a significant improvement of 48% in food quality and diversity that members were consuming.

Strikingly, seven out of ten food groups under scrutiny are rooted in plant-based crops, which have the potential to be cultivated and harvested right in one's own home garden. While the issue of food insecurity continues to be a pressing challenge within these communities, it is promising to note that there has been a gradual improvement across various criteria related to food security.

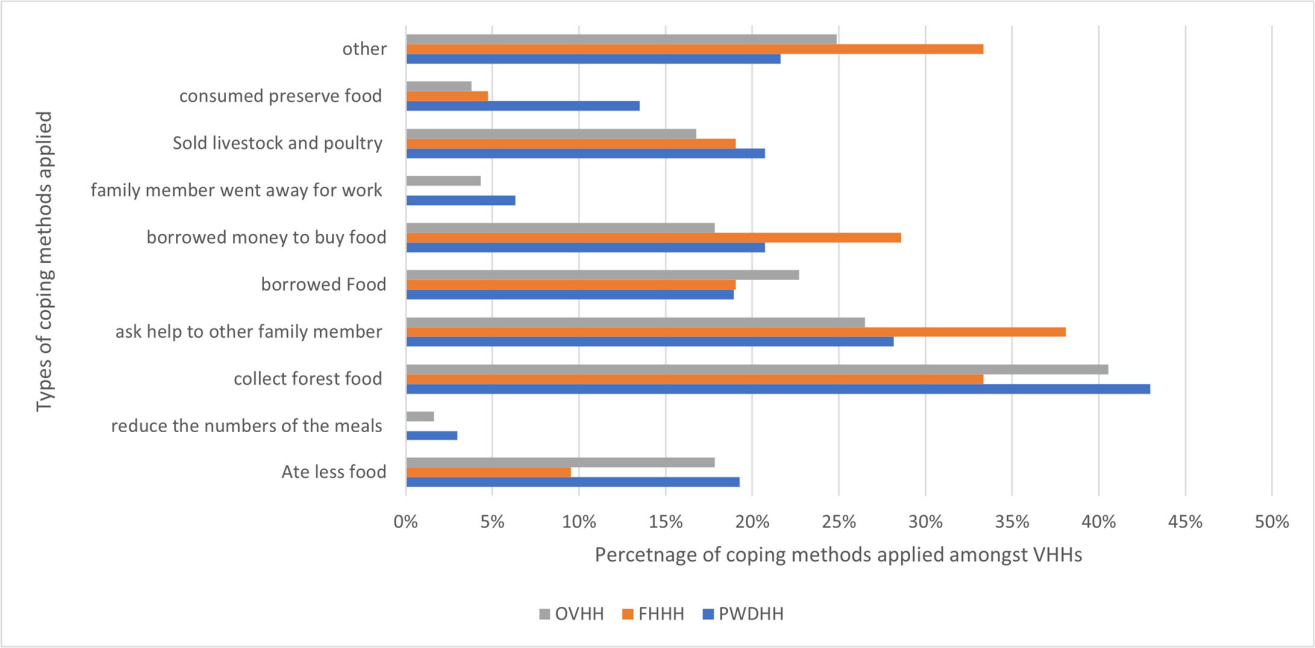

Figure 5. Coping methods applied by three types of vulnerable households that experienced food shortages in the past 4 weeks at the time of the 2022 household survey, (n = 160).

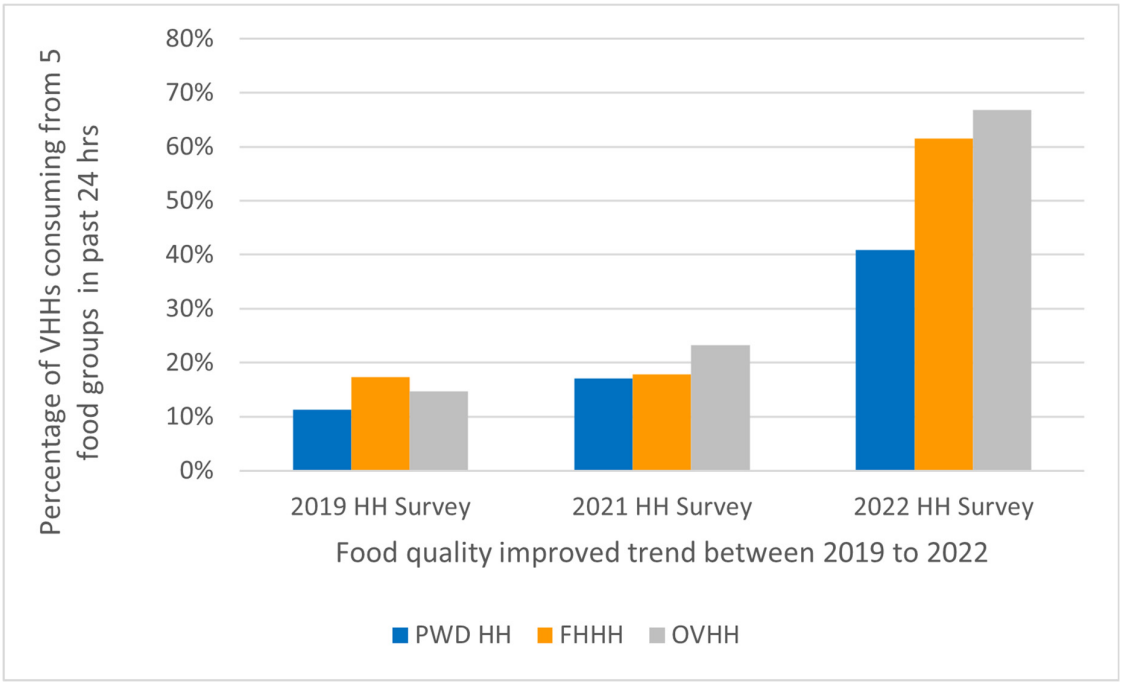

Figure 6. Percentages of households consuming food from a minimum of 5 food groups and household diet diversity intake among three types of vulnerable households at the time of 2019 (n = 504), 2021 (n = 425) and 2022 (n = 434) surveys that measured the quality of food, demonstrating the quality of food improvement among the households.

3.2. Contribution of Home Gardens to Households' Food Security

The study observed a steady increase in home gardening among all vulnerable household groups (VHHs) over time. According to the 2019 household survey, approximately 68% of households engaged in home gardening. By 2021, this figure had risen to 80%, with a 29% increase among OVHHs and FHHHs and a 21% increase among PWDHHs. By the

end of 2022, at least 90% of households were practicing home gardening, with participation rates reaching 94% for PWDHHs, 92% for FHHHs, and 90% for OVHHs.

The study also investigated the utilization of home garden-harvested crops, which revealed a unanimous 100% of VHHs reporting that harvested crops were primarily for household consumption. Nonetheless, 57% of OVHHs, 50% of FHHHs, and 47% of PWDHHs also sold surplus crops. This showed a considerable economic gain from home gardening where families were not only satisfying their own needs but also contributing to their livelihoods by selling excess produce. Additionally, 28% of VHHs (33% of FHHHs, 28% of OVHHs, and 26% of PWDHHs) processed and preserved their crops for future consumption. While household consumption remains the primary use, the combination of selling surplus crops, processing for future use, and seed preservation demonstrates the multifaceted benefits and strategies employed by VHHs in managing their home gardens. Throughout the year, home garden crops were harvested by households, but there were variations in the number of households who were able to harvest (Figure 7). During the 2019 HH survey, all VHH home garden harvests started to decline starting in the month of June, with 47% of households engaged in harvesting and decreasing to 17.6% in August. However, home garden harvesting reached its peak in the month of December with 73.5% of households engaging in crop harvesting. Interestingly, by the end 2022 HH survey, those households were consistently harvesting crops throughout the year, with a minimum of 51% of households engaged in harvesting.

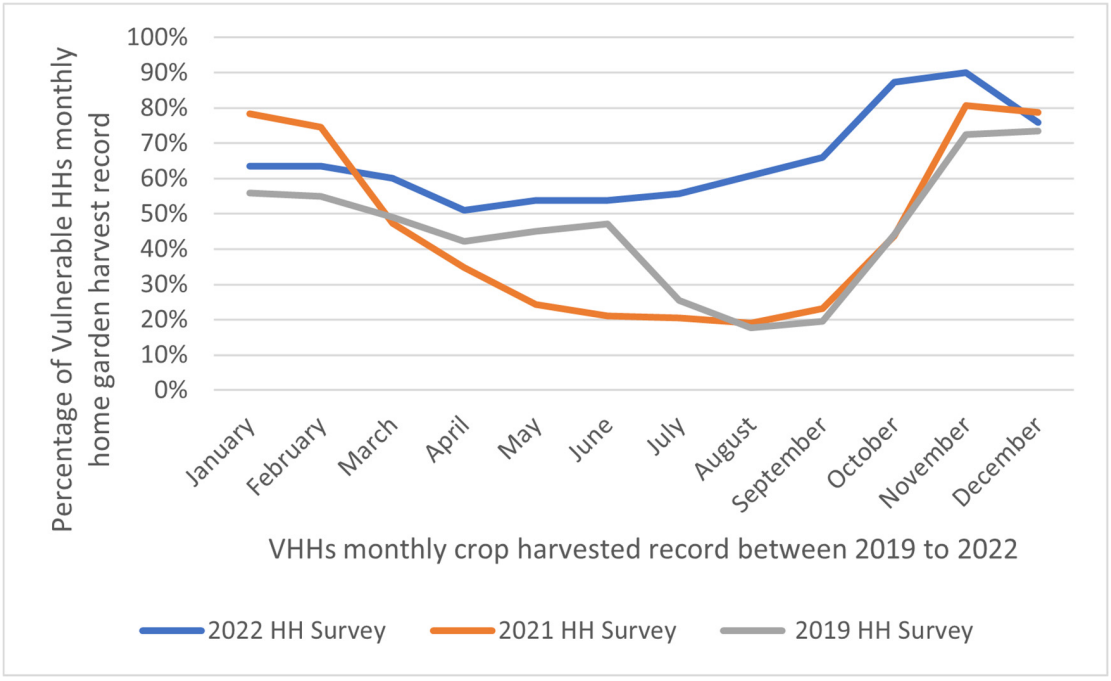

Figure 7. The records of monthly crops harvested in VHH home gardens between 2019 (n = 504), 2021 (n = 425), and 2022 (n = 435) according to the household survey. An increased VHH harvesting crop trend was noticed.

The zenith of home garden harvesting occurred in November when an impressive 90% of household members from all three types of households were actively involved in crop harvesting, indicating November as the most effective month for home garden crops. This study finds a positive trend in crop harvesting, with findings showing that all three types of households were able to access more food from their home garden in 2022 compared to the HH project survey of 2019 and 2021. On average, each month, the average types of vulnerable households collected plant-based crops: 28.4 kg for OVHHs, 30.08 kg

for FHHHs, and 34 kg for PWDHHs, highlighting home gardens' significant contribution to food security and nutrition.

The study not only delved into the expansion and growth of home gardens but also meticulously explored the content of these gardens and the evolution of these trends over time. The study also revealed significant improvements in home garden crop diversity when comparing the 2019 and 2022 HH surveys across all three categories of VHHs (Figure 8). We found 83 types of edible plant-based crops distributed among 6 key groups: (1) root vegetables, tubers, and grains; (2) dark green vegetables; (3) legumes and nuts; (4) herbs; (5) fruits; and (6) other vegetables within these home gardens. An astounding diversity of plant varieties was discovered, including 26 different fruit varieties; 19 herb and spice varieties; 13 other vegetable varieties; 9 varieties of dark green vegetables; 8 types of grains, root vegetables, and tubers; and 8 varieties of legumes and nuts. PWDHHs cultivated 66 different varieties, FHHHs managed 55 varieties, and OVHHs maintained an impressive 74 varieties of edible plant-based crops. Interestingly, the two most favored groups of edible plant-based crops among all three types of households were herbs and spices and dark green vegetables. However, it is worth noting that the overall crop composition varied among these households, with OVHH households having the highest number of varieties, comprising 47% of the total, followed by PWDHHs (42.5%) and FHHHs (36%). This indicated that OVHH home gardens contained the greatest variety of products, while FHHH home gardens exhibited slightly fewer varieties compared to PWDHHs and OVHHs.

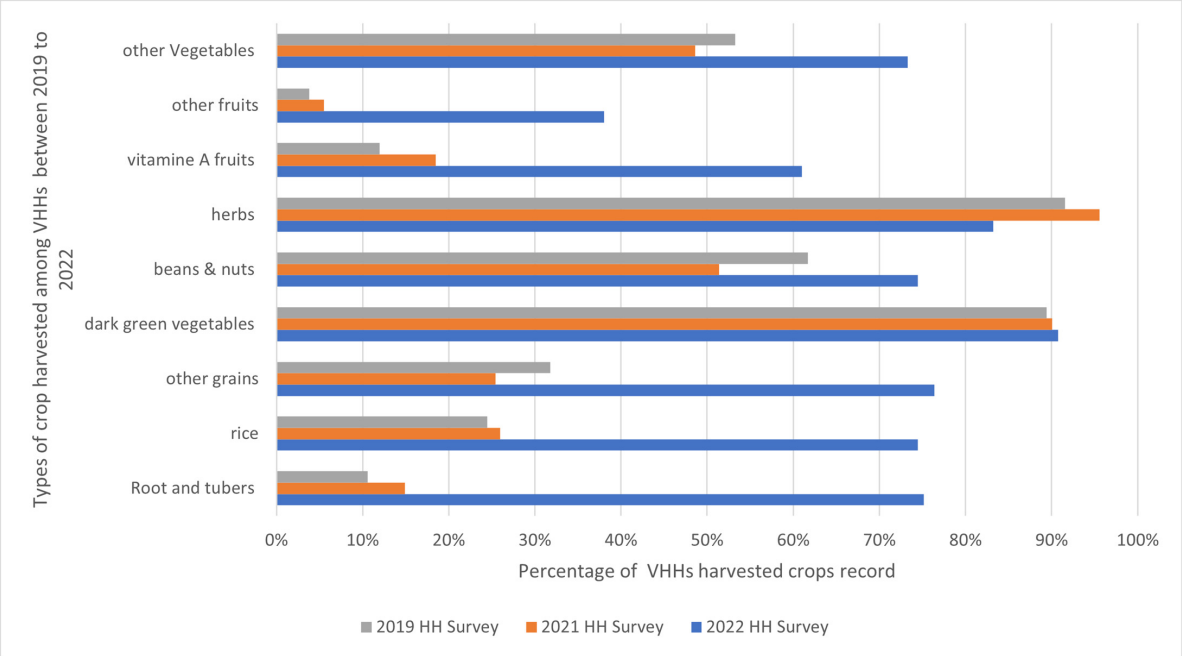

Figure 8. Percentages of plant-based food groups harvested by all three types of vulnerable households at the time of the baseline (n = 504), midterm (n = 425), and end of project (n = 434) surveys, demonstrating changes in HH growing various plant-based crops from key food groups.

4. Discussion

The study highlights a critical issue wherein the majority of VHHs primarily rely on agriculture for their livelihoods. Despite this heavy dependence on agriculture, a troubling trend persists: these households continue to grapple with food insecurity. Interestingly, our research revealed a gradual reduction in the prevalence of food insecurity among all three VHHs. While this is certainly a positive development, it is important to note that a portion of the population still faces food insecurity challenges. To delve deeper into this

issue, our discussion has explored the nature and severity of food insecurity within these households. Additionally, light has been shed on the role of home gardens as a potential solution to reducing food insecurity. Findings suggest that home gardens play a crucial role in alleviating food scarcity and establish themselves as a vital source of sustenance in research areas. This constitutes a novel contribution to the research field as it provides evidence of improved food security across all types of vulnerable households in rural farming settings.

4.1. Food Insecurity Severity Among the Vulnerable Households

In the 16 villages, all 3 vulnerable household (HH) types faced varying degrees of food insecurity. They struggled with food shortages, inconsistent access to food supplies, extreme coping mechanisms, and reduced dietary diversity, collectively rendering them food insecure [61]. The baseline survey revealed that less than half of vulnerable HHs considered themselves food secure. Many experienced food shortages over the past several months, with some periods emerging as critical times of severe food insecurity.

Analysis of these findings highlights that female-headed households (FHHHs) suffered the most from food insecurity, followed by persons with disabilities-headed households (PWDHHs) and older vulnerable households (OVHHs). When asked about the reasons behind this disparity, qualitative responses pointed to various factors: "Our stored food supplies, especially rice, were running extremely low at that time". Others explained, "We were occupied with work in the rice paddies and shifting cultivation fields, leaving us with little time to cultivate crops in our home gardens". Additionally, environmental challenges exacerbated food insecurity: "Excessive rainfall made it difficult to plant crops in our home gardens due to waterlogged conditions". Some HHs also highlighted a lack of support, stating, "I have minimal assistance and am responsible for both farming and household chores; without support from my extended family, it's tough to meet our HH's food needs". Such concerns were frequently echoed among FHHHs.

The study found that food-insecure HHs adopted various coping strategies, including "borrowing food", "seeking help from other family members", "borrowing both money and food", and "foraging for food in the forest and river". Some took drastic measures such as "reducing meal portions and frequency". Typically, food-insecure HHs employed a combination of consumption- and asset-based coping strategies, such as consuming lower-quality or less expensive foods and receiving donations from relatives or friends [62]. Notably, severe coping mechanisms like "eating less and reducing the number of meals" were prevalent during the baseline survey but had declined by the project's end.

The study also assessed food quality using the minimum diet diversity proxy indicator [45]. Findings revealed that only 14% of vulnerable HHs (17% of FHHHs, 15% of OVHHs, and 11% of PWDHHs) met the minimum diet diversity criteria at the start of the project—defined as consuming at least five out of ten food groups. Research has shown that cultivating home gardens (HGs) can improve access to nutrient-rich foods, particularly in developing countries [63–66]. This study supports that claim as dietary habits significantly improved by the project's end, with minimum diet diversity increasing to 41% (67% of OVHHs, 62% of FHHHs, and 41% of PWDHHs).

While overall food quality improved, PWDHHs and FHHHs saw the least progress. Despite reductions in food insecurity, some vulnerable HHs continued to experience anxiety, stress, and adjustments in HH food management, often resorting to measures like "eating less" and reducing meal frequency. Achieving adequate dietary diversity remains a challenge.

Food insecurity has far-reaching negative impacts beyond access to food, affecting education, economic stability, and health. These challenges can perpetuate cycles of poverty,

further disadvantaging vulnerable HHs [5]. Women and persons with disabilities are particularly susceptible due to systemic disadvantages and limited opportunities. Various global initiatives aim to bridge these disparities [67–69].

In conclusion, while food insecurity among vulnerable HHs declined compared to baseline levels, significant disparities persisted, with FHHHs and PWDHHs remaining the most affected. Additional support is essential to fully eliminate food insecurity in these study villages. However, project interventions, particularly the expansion of HGs and plant-based crop production, have contributed to positive changes in food security.

4.2. Home Garden's Role in Improving Food Security Among Vulnerable Households

Home gardens (HGs) play a vital role in improving access to, availability, utilization, and stability of food among three types of vulnerable households (VHHs). The study finds HGs to be an instrumental food source as their number increased significantly across 16 villages during the project. This increase led to improved access to fresh produce for vulnerable HHs, and the importance of HGs was repeatedly emphasized. Participants described HGs as "a source of food and fresh vegetables that taste good and provide vitamins to our body", "we don't have to buy or ask for food from others", "a regular supply of food", and "we have vegetables all year round, contributing to our food security". Numerous studies support this, showing that HGs help reduce food insecurity [41,65,70].

HGs provide fresh food daily, and each vulnerable HH type (PWDHH, FHHH, OVHH) has yielded substantial quantities of produce for their own consumption. While some HHs harvested crops every month, others struggled. However, as HG numbers increased, so did the ability of vulnerable HHs to harvest regularly, confirming that HGs provide steady access to fresh and diverse food. Primarily used for HH consumption, many vulnerable HHs also sold surplus produce, saved seeds, and preserved excess crops for future use. This suggests that HGs not only contribute to food security but also offer income-generating potential, though this varies by HH type and location [39].

The study identified remarkable crop diversity within HGs, with 83 edible plant species recorded. HGs are one of the most natural and diverse food production systems, enhancing access to a wide variety of domesticated crops [31,32]. Despite having smaller gardens, PWDHHs planted the most varieties and harvested the most crops, while FHHHs planted and harvested the least. This diversity contributed to a wide range of food groups, including root vegetables, grains, dark green vegetables, legumes, herbs, and fruits, improving diet quality and nutrition [33,34]. Research participants often described HG produce as "healthy, tasty, and nourishing".

Access to diverse fresh plant-based foods improved significantly over the project. Even during the least productive periods, a notable increase in food access was observed, and at peak harvest times, access improved further. This highlights the positive impact of HGs as all three HH types accessed a greater quantity and variety of food than at the project's start.

There were also significant shifts in crop varieties between the baseline survey and the project's later stages, aligning with changes in food intake. This points to increased cultivation, harvesting, and consumption of a wider array of crops, supporting findings from studies on the role of HGs in enhancing food and nutritional security [41,71]. These studies confirm that HGs serve as a crucial food source, primarily for family consumption, while also increasing dietary diversity. In this way, HGs contribute significantly to nutrition, food security, and the livelihoods of subsistence-farming HHs, aligning with prior research [39,72–76].

The study underscores HGs' success in improving access to fresh plant-based foods for vulnerable HHs, reinforcing broader research on their role in food security, dietary diversity,

and overall well-being. HGs are not just about quantity but also quality, enhancing nutrition and resilience against food insecurity.

Beyond nutrition, HGs foster social connections. Many vulnerable HHs shared surplus produce with family, friends, and neighbors, strengthening social capital [76]. Additionally, HG crops were preserved for extended periods, providing a buffer during food shortages or emergencies. Preserving crops minimizes waste, prolongs food availability, and maintains dietary diversity, which is crucial during periods of scarcity.

Despite their benefits, challenges remain. Some HHs still experience food shortages, highlighting the complexity of food insecurity. About 35% of HHs cannot regularly harvest from their HGs, indicating the need for further support through training, resources, and assistance. Enhancing production capacity could significantly reduce food insecurity among vulnerable HHs.

In conclusion, HGs are a valuable asset in combating food insecurity, offering immediate sustenance, long-term resilience, and opportunities for income generation, social cohesion, and food preservation. Supporting and enhancing HG initiatives can further improve food security and the well-being of vulnerable communities.

4.3. How to Further Reduce Food Insecurity Among the Three Types of Vulnerable Households

Home gardens (HGs) play a crucial role in food security initiatives, significantly contributing to the sustenance and dietary diversity of vulnerable households (HHs). HGs provide an invaluable source of fruits, vegetables, and herbs rich in essential minerals and vitamins. Aid organizations and government bodies recognize their role in combating hunger and food crises, while vulnerable HHs themselves emphasize their importance, often stating, "It is our primary food source". HGs also lead to cost savings by reducing the need for market purchases, benefiting entire families.

However, despite these advantages, approximately 35% of vulnerable HHs still experience food shortages, with 15% facing severe food insecurity, leading to reduced meal frequency and quantity. The findings indicate significant potential for enhancing plant-based crop production. Currently, only 65% of vulnerable HHs harvest monthly, leaving room for improvement among the remaining 35%. Strengthening HG practices could substantially mitigate food insecurity. As some HHs noted, "We save money since we don't have to buy from the market". Addressing food shortages during the most challenging period, particularly from August to October, requires targeted strategies.

While HGs contribute significantly to food security, sole reliance on them will not eliminate food insecurity among vulnerable HHs. Most HHs depend on agriculture for their livelihoods yet continue to struggle with food shortages. This presents an opportunity to explore livelihood diversification, enabling HHs to generate income through alternative means beyond agriculture.

Despite the presence of 83 edible crop varieties, the highest crop diversity is observed among OVHHs. Promoting and facilitating the exchange of crop diversification practices could help mitigate risks associated with crop failures and market fluctuations. While HGs are indispensable in enhancing food security, they should be integrated into a broader strategy that includes livelihood diversification and knowledge-sharing on crop diversity. This comprehensive approach offers a more sustainable solution to the complex challenges of food insecurity among vulnerable HHs.

5. Conclusions

A comprehensive effort involving aid agencies and governments worldwide, particularly in Lao PDR, is being undertaken to enhance home gardens as part of agricultural initiatives aimed at tackling food insecurity and malnutrition. This study highlights the

pivotal role of home gardens as a significant food source to combat food shortages and enhance dietary intake in vulnerable households of rural upland villages in Lao. This study also suggests that as the number of home gardens (HGs) increased from 2019 to 2022, access to a diverse range of fresh crops also grew, subsequently improving eating habits and dietary diversity among all vulnerable households, with some households earning extra cash from selling surplus crops. The study also provides clear evidence that HGs lead to a 19% decline in food insecurity from the baseline to the project end (2019–2022). However, 33% of vulnerable households still face seasonal food insecurity, underscoring the need for further investigation and targeted interventions. HGs alone cannot fully address food insecurity. While some support is provided by the government and civil society, local agricultural extension services lack the necessary resources and skills to effectively assist vulnerable farmers.

This research offered valuable insights to policymakers and practitioners regarding the importance of rural upland Laos home gardens and the evidence supporting their promotion and support in reducing food insecurity, irrespective of the household's vulnerability level. Based on the study's findings, the following key recommendations are made for food security through home garden practices:

Support for Home Garden Expansion: Continued support should be provided to VHHs to increase the prevalence of home gardens as this contributes significantly to reducing food insecurity among this demographic.

Crop Diversity in Home Gardens: Efforts should focus on increasing crop diversity within home gardens and enhancing dietary diversity by offering a variety of crops that improve the overall nutritional quality of the food consumed by VHHs.

Addressing Seasonal Food Insecurity: Seasonal food insecurity, notably from August to October, requires targeted interventions to alleviate its severity among VHHs.

Specific Support for FHHH and PWDHH: Female-headed households and people with disability households experience the highest levels of food insecurity, necessitating tailored support to address their specific needs and vulnerabilities.

Training and Resources: The provision of additional training, knowledge, and resources can help VHHs maximize their monthly crop harvest.

Diversifying Livelihood Opportunities: Investigating and implementing the diversification of livelihood opportunities for VHHs will help generate alternative sources of income and food security.

Finally, although our study is based on a robust sample of $\geq$425 households across 16 villages, all are confined to upland regions, limiting the generalizability of our findings to other parts of the country. A more extensive study with a larger sample size and broader geographical coverage would improve the applicability of these results.

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Data Availability Statement: The datasets presented in this article are not readily available because they were obtained from an ongoing project, and most importantly, sharing is restricted due to the terms and conditions of our human ethics clearance. However, all the data used (or needed) for this paper are presented in either tabular or graphical form, making them clear and accessible. Requests to access the datasets should be directed to Mr. Suraj Shrestha, the lead author of the paper.

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Appendix A Key Informant Interviews Questionnaires

1. Home Garden Characteristics
    a. How do you characterize the home garden in your province/district/village? Tell us some of the key characteristics of the home garden.
    b. How do you define a good home garden and how do you define a poor home garden?
    c. Who is responsible for home garden management?
    d. Are there different methods and practices among different communities, and if you have noticed the difference, what are those differences and why?
    e. What are some of the challenges faced by HH in relation to their home garden function, management, and usage?
2. Home Garden and Nutrition/Food security
    a. Does your province/district/village face undernutrition among children and women?
    b. If yes, what approaches/initiatives are taken to address these challenges in your experience and understanding?
    c. Does your province/district/villages face food insecurity- food shortage issues?
    d. If yes, what approaches/initiatives are taken to address these challenges in your experience and understanding?
    e. What role do you think a home garden plays in relation to household nutrition and food security?
3. Home Garden and Climate-Smart Agriculture
    a. Have you noticed changes in weather patterns that may have affected your home garden?
    b. What are those changes you have noticed (weather, rainfall, temperature, drought, flood, soil, etc.)?

c. How do these changes have impacted home gardens in your area?
d. What actions are community members taking to address these challenges?
e. How vulnerable do you think your area is to climate change and provide some examples of vulnerability?

4. Government Incentives and Support
   a. What program, incentive, policies, or resources are there to mitigate climate change impact for home gardening in your area?
   b. Can you tell me if there are any other sectors or agencies that support or promote home gardens in your province/district?
   c. Is there any opportunity or initiative that you think could improve and adapt to climate change?

Appendix B Focus Group Discussion Questionnaires

1. Home Garden Characteristic
   - How do you characterize a home garden in your district? Tell us some of the key characteristics of the home garden.
   - Are there any challenges or barriers identified in relation to your home garden? If yes, what are they?
   - Who is responsible for taking care of the home garden? Who decides what to grow? Who decides what to do with the crops that are produced in the home garden?
2. Home Garden and Food Security and Nutrition
   - What is nutrition and what is food security?
   - How do you see the connection between the home garden and food security and nutrition?
   - How important is your home garden to you and why?
   - Do any agencies or government departments support home garden development or improve food security in your village?
3. Home Garden and Climate-Smart Agriculture
   - How this has impacted their home garden and food security and nutrition?
   - What are you doing to mitigate such problems and what adaptive measures should we take? What are new and traditional methods?
   - How have those changes impacted the home garden in your district?
   - Do any agencies or government departments support making your community climate resilient in your village and if yes, what are they doing?

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