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An assessment of sustainable agroforestry livelihood of K'Ho Cil minority in Da Nhim Commune, Lac Duong District, Lam Dong Province, Vietnam

Nguyen, T. K. D.[1*], Vo, T. A. D.[1], Tran, T. X.[1], Duong, Q. B.[1], Ton, T. M.[2] and Ho, H. D.[3]

[1]Department of Ecology and Evolutionary Biology, University of Science – VNU HCMC, Vietnam; [2]World Wide Fund for Nature Vietnam; [3] Management Board of Da Nhim Watershed Protection Forest, Lam Dong Province, Vietnam.

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Abstract K'Ho Cil is an indigenous community living in Da Nhim Commune, Lac Duong District, Lam Dong Province. Our research results show that their livelihood was a combination of contracted forest protection and practices of 7 popular farming systems: (1) coffee monoculture (48.7%), (2) coffee intercropped with persimmon (22.5%), (3) coffee-crops polyculture (11.3%), (4) crops monoculture (8.8%), (5) coffee intercropped with persimmon and shiitake (3.6%), (6) persimmon monoculture (2.5%), and (7) shiitake (2.5%). The income from participatory forest protection accounts for 31.6% of household income, which is considered a stable source of livelihood to help minimize negative impacts on forests. Crop income accounted for 37.2% based on medium sustainable farming systems. These farming systems had some negative impacts on the environment or did not meet socio-economic expectations in the face of market challenges and climate change. The shiitake farming system based on a JICA's project is highly appreciated because of its high adaptability to climate change. However, the model is difficult to replicate because of its high initial capital, equipment, and high-tech requirements. To foster the K'Ho Cil's livelihood sustainability and adaptability to climate change, the local government should support diversifying sources of forestry income, strictly control agricultural chemical uses, and strategically develop commercial brands and outputs for local agricultural products. It is suggested that NGOs could engage more to support the people with innovative livelihoods, farming techniques, and initial capital.

Keywords: Agroforestry livelihood, Sustainability, Adaptability, Indigenous people, K'Ho Cil

Introduction

Da Nhim Commune, Lac Duong District, Lam Dong Province is located in the Central Highlands of Vietnam, covered with pine forests of more than

[*] **Corresponding Author:** Nguyen T. K. Dung**; Email:** kimdunguyen@gmail.com

90% of the area (The Commune People's Committee of Da Nhim, 2019). The state has demarcated the forests and allocated the forest management authority to the Management Board of Da Nhim Watershed Protection Forest (MBDNWPF). The Management Board has implemented many different solutions to effectively protect and develop forests, including participatory forest protection and management, which is considered a sustainable solution. However, community participation in forest management, protection, and development is still limited to activities related to contracted forest protection through the government's program of Payment for Forest Environmental Services (PFES). Therefore, the potential that the forest ecosystem in Da Nhim provides is not fully exploited.

The K'Ho Cil ethnic minority community is indigenous people with a long history of attachment to the land of Da Nhim and closely linked their livelihoods with the forests. Following several government policies, the K'Ho Cil people have access to opportunities for livelihood improvement and have become an important force in local forest protection and management. With the support of the local government, the people's lives have gradually improved, changing their livelihoods from shifting cultivation to settlement for stable farms. Today, many of them have contracts with the Management Board of Da Nhim Watershed Protection Forest to protect and manage the forest and develop their farms on their lands with four main crops: coffee, persimmon, cash crops such as artichokes, vegetables, flowers, beans, corns, and shiitake. Our survey in 2020 showed that their main income is from cultivation (37,2%) and forest management and protection (31,6%). Other sources of income come from husbandry, hired laborers, company workers, and small shop retailers. To some extent, K'Ho Cil people remain relied on non-timber forest resources such as firewood, forest vegetable, fish, medical herbs, bamboo shoots, and forest mushrooms for daily use.

Currently, the agro-forestry livelihood of the people is facing some difficulties. The area has a mountainous terrain with steep slopes and receives high average annual rainfall, causing strong soil erosion and leaching nutrients. Agriculture does not bring high interest because farming practices are unscientific and both agriculture and forestry are affected by extreme weather events caused by climate change, such as hoarfrost, storm, and hail. Besides, unstable market prices of agricultural products negatively affect the livelihoods of the K'Ho Cil community as well. In this context, the community need supports to develop models of sustainable livelihoods compatible with the orientation of the Vietnamese government, especially for upland ethnic minority communities like the K'Ho Cill. Sustainable livelihoods are particularly promoted because it is considered an effective solution to adapt to

climate change, limiting adverse impacts on the environment (The Vietnam Ministry of Science and Technology, 2019), and concurrently focusing on local social and economic development (The Vietnam Ministry of Science and Technology, 2019; García-Tejero *et al.*, 2011; Zhen and Routray, 2003). Economically, sustainable agroforestry models focus on economic benefits and an increase in income to the related community. Socially, the models contribute to poverty reduction and hunger eradication, social justice creation, improvements in quality of life, and social security enhancement. And environmentally, the models practice sustainable uses and protection of natural resources, improve environmental quality, and regenerate and rehabilitate natural resources (The Vietnam Ministry of Science and Technology, 2019; Nguyen and Son, 2013; García-Tejero *et al.*, 2011; Gómez-Limón and Riesgo, 2009; Zhen and Routray, 2003).

Currently, the information and understanding of the K'Ho Cil's livelihood are incomprehensive and insufficient to be able to propose development projects related to sustainable livelihoods for this community, especially those livelihoods based on the sustainable use of local forest resources and agricultural production. To get more resources for the above purposes, we evaluated the sustainability of the existing agroforestry livelihood models in Da Nhim Commune, Lac Duong District, Lam Dong Province, and proposed development orientations. This study conducted to understand the extent to which the K'Ho Cil's agroforestry livelihoods practice sustainability, the degrees to which these livelihoods are adaptable to climate changes, the key measures needed, and which stakeholders need to play what roles to promote sustainability and adaptability.

Materials and methods

Conceptual framework

According to researchers, the assessment of agroforestry livelihood models focused on sustainable development indicated by economic, social, and environmental factors. Economically, agroforestry livelihood models should focus on economic benefits and an increase in income to related communities. Socially, the models should contribute to poverty reduction and hunger eradication, social justice creation, improvements in quality of life, and social security enhancement. And environmentally, the models need to practice sustainable uses and protection of natural resources, improve environmental quality, and regenerate and rehabilitate natural resources. The assessment of agroforestry livelihood models not only incorporates the assessment of all the

three factors but also needs to weigh the contribution values of each indicator/criterion in every factor (Nguyen and Son, 2013; Commission on Environment World, n.d.; García-Tejero *et al.,* 2011; Gómez-Limón and Riesgo, 2009; Zhen and Routray, 2003).

In essence, any agro-forestry livelihood model is always highly associated with local land use. Due to differences in soil and ecological conditions, agro-forestry livelihood models vary from place to place. One model may be appropriate to practice in one ecoregion, but not in another (Nguyen *et al.,* 2006). Therefore, the assessment of agro-forestry models must be tied to specific territorial areas. In addition, the impacts of socio-economic conditions, especially markets, policies, and science and technology should also be emphasized. In reality, these factors are constantly changing according to the national and local socio-economic development, contributing to promoting or limiting the formation and development of local agroforestry livelihood models (PanNature, 2017; Pham, 2015). Thus, it is important to take into account changing contexts advocating and impacting on the development of agroforestry livelihood models along the process of assessment (Nguyen *et al.,* 2006). Moreover, local social policies such as programs on rural development, poverty reduction, national defence security, social security, policies on special-use and protection forests in adjacent areas also play important roles in the orientation of developing agro-forestry economic models (The Government of Vietnam, 2012).

Based on the theoretical and practical analysis mentioned above, three indexes for assessing agro-forestry economic models towards sustainable development along with twelve criteria are identified (Table 1) (Nguyen and Son, 2013; Commission on Environment World, n.d.; García-Tejero *et al*., 2011; Gómez-Limón and Riesgo, 2009; Zhen and Routray, 2003).

In the 12 criteria, each criterion is weighted with different scores depending on their importance contributing to the assessed factors. Based on their importance values, three criteria are granted 3 points, four criteria are deserved 2 points, and five criteria are worthy 1 point (**Table 1**) (Nguyen and Son, 2013). Therefore, the maximum total points scored for a model are calculated as (3x3) + (4x2) + (5x1) = 22 points. The sustainability of the agroforestry livelihood model is assessed based on three factors: economic, social, and environmental. The rating scales are as follows with five ranges: Low sustainability (0 – 4.4 points), Medium-Low sustainability (> 4.4 – 8.8 points), Medium sustainability (> 8.8 – 13.2 points), Medium-High sustainability (> 13.2 – 17.6 points) and High sustainability (> 17.6 – 22.0 points).

Table 1. Index for assessing agro-forestry economic models towards sustainable development

Criterion		Variable	Point
A.	**Economic factor assessment**		
1.	Cost	• Total cost • Labor cost • Material cost • Average investment cost per ha per year	1
2.	Income	• Total income for a whole cycle of production • Net income on average per year	2
3.	The output of interest rates		3
B.	**Social factor assessment**		
4.	Satisfaction level of households with the model	• Percentage of contribution to household economic income • Adaptation to climate change	3
5.	Number of households applying model in a village	• Social conditions facilitating in a village	2
6.	Number of villages applying the model in the commune	• Social conditions facilitating in the commune	2
7.	Ability to spread model in terms of scales and reasons	• Model replication	1
8.	Conditions for spreading model	• Economy • Technology • Organization • Policy • Market	1
C.	**Environmental factor assessment**		
9.	The ability of the model to use and protect soil resources effectively and sustainably	• Soil quality improvement • Limit on the use of renewable and non-renewable resources, especially chemical fertilizers • Biodiversity maintenance and enhancement	3
10.	The ability of the model to use and protect water resources effectively and sustainably	• Household use water • Irrigation water	1
11.	The ability of the model to combat environmental pollution	• Waste management	1
12.	The ability to reduce pressures on forest resources in sites and adjacent areas and improve ecological relationships between forests and farming models	• Reduction in negative impacts on forests • Sustainable exploitation of forest resources	2
TOTAL SCORE			**22**

Methods

To assess and compare agroforestry models, several qualitative and quantitative research methodologies are applied (Table 2) (FAO, 2006). The methods included village-based surveys, semi-structured interviews, and participatory observation techniques.

Table 2. Research methods for the assessment of agroforestry economic models and model analysis

Method	Data/Information	Target group	Sample size
Village-based survey/questionnaire	• Twelve economic, social, and environmental criteria for model assessment	K'Ho Cil households	80 (30%, N=263) K'Ho Cil households practicing agroforestry livelihoods
Semi-structure interview	• Clarity of twelve economic, social, and environmental criteria • Structures and practices of models and their advantages and disadvantages • Local socio-economic conditions (especially markets, policies, resources, and science and technology)	Representatives of • Management boards of forest areas • Local authorities • NGOs	2 representatives of the MBDNWPF 2 representatives of Da Nhim Commune People's Committees 1 representative of JICA and SNV
Observation and in-depth interview	• Practices relating to environmental protection factors	Households practicing agroforestry livelihoods	7 K'Ho Cil households

The SWOT/SWOC method are used to be the best visualize the current context and prospects of every agro-forestry livelihood model. SWOT/SWOC stands for Strength (S), Weakness (W), Opportunity (O), and Threat/Constraints (T/C). This method supports the development of planning, action strategies/solutions for each model based on analysis of its internal and external factors. The internal factors determine the strengths and weaknesses of a model and representing its local and current conditions. The external factors determine opportunities and risks that a model might face in the future. They are detailed as follows (PAEX, 2012):

- Strength: conditions, qualities, and resources that promote models for better development.
- Weakness: unfavourable factors and inadequate conditions that hinder model development.
- Opportunity: factors that might optimize conditions for model development and facilitate measures to achieve set goals of models.
- Threat/Constraint (risk and obstacle): unfavourable factors that might produce negative, unintended results that limit or eliminate model development.

Research area

Da Nhim Commune, Lac Duong District, Lam Dong Province is located in the Central Highlands of Vietnam, with an average altitude of 1,500m above sea level and a steep slope of 20^0 - 30^0. With a total area of 23,903 ha, of which forest land is 21,557 ha (90%) (The Commune People's Committee of Da Nhim, 2019), the area belongs to a tropical monsoon climate with distinct rainy and dry seasons and an average annual temperature of 17.9 ^{0}C. The rainy season lasts from May to October and the dry season from November to April next year. Annually, Da Nhim receives an average rainfall of about 1,896 mm. At the beginning of rainy seasons, hails often occur, while in the dry season strong forest fires and hoarfrosts may happen in January, February, and March, damaging forests and reducing crop yield (Constable, 2015). Concerning the soil, it has 2 main soil groups of Ferralic Acrisols (78%) and Humic Acrisols (18%). Ferralic Acrisols have the potential for forest and biodiversity development, while Humic Acrisols are suitable for the development of perennial industrial crops such as coffee, pepper, fruit trees, and also crops (Constable, 2015).

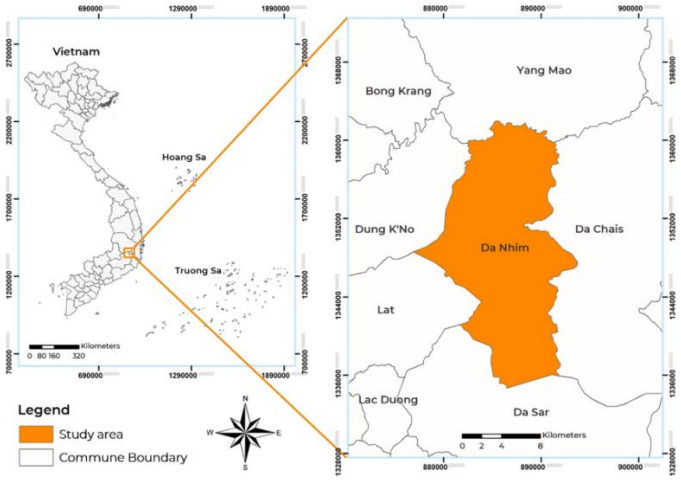

Figure 1. Map of Da Nhim Commune

With favorable soil and climate conditions, Da Nhim has a large forested area with a great potential for forestry development such as afforestation, sustainable exploitation and processing of non-timber forest products, payments for forest environmental services, and ecotourism. Da Nhim forest helps protect upstream water resources of Dong Nai River and provides water for Da Khai and Da Nhim hydropower plants. In addition, the forest here also provides biodiversity, especially bird diversity which is potential for developing bird watching tourism. According to bird surveys in 2020, 55 bird species have been

recorded in Da Nhim, many of which are target birds for birdwatchers worldwide, and thus making it a good birdwatching site (Nguyen *et al*., 2020).

Currently, Da Nhim commune has 5 villages with 1,034 households of 4,961 people, of which 80% (1,004 households of 3,957 people) are the K'Ho Cil ethnic minority (The Commune People's Committee of Da Nhim, 2020). People in working-age account for 60.6% of the population. On average, each household has 2 to 4 people of working ages. Although there is an abundant labor force, the education level of the people is low. The illiteracy rate is 35.9%, primary education is 28.2%, secondary education is 24.4% and high school education accounts for 11.5%. Regarding local socio-economic organizations, 67.5% of the people have never participated in activities with local socio-economic organizations or clubs. The rest participate in associations such as Women's Union (15%), Farmer's Union (11.3%), Veteran's Union (2.5%), Youth Union (2.5%), and Commune Fatherland Front Committee (1.2%). In 2020, there were 263 K'Ho Cil households participated in forest protection through contracts with the MBDNWPF (The Commune People's Committee of Da Nhim, 2020) (together with our survey, 2020).

Results

The study results showed that the agroforestry livelihood model in Da Nhim commune was a combination of contracted forest protection and practices of 7 popular farming systems: (1) coffee monoculture (48.7%), (2) coffee intercropped with persimmon (22.5%), (3) coffee-crops polyculture (11.3%), (4) crops monoculture (8.8%), (5) coffee intercropped with persimmon and shiitake (3.6%), (6) persimmon monoculture (2.5%), and (7) shiitake (2.5%).

In the income structure, participatory forest protection accounts for 31.6% of household income, which is considered a stable source of livelihood to help minimize negative impacts on forests. Crop income accounted for 37.2% based on medium sustainable farming systems. In general, these farming systems had some negative impacts on the environment or did not meet socio-economic expectations in the face of market challenges and climate change. The shiitake farming system based on JICA's project is highly appreciated because of its high adaptability to climate change. However, the model is difficult to replicate because of its high initial capital, equipment, and high-tech requirements.

Livelihoods from forestry

The K'Ho Cil in Da Nhim Commune contracted with MBDNWPF for forest protection through the national program of payment for forest environmental services (PFES). According to Decree 75/2015/ND-CP issued

by the government of Vietnam, ethnic minority and poor Kinh households are eligible for signing contracts of forest protection with state forest owners. The contract period is annual, or under the general plan with a term of 3 years or 5 years. Every year, the contracts are renewed based on positive performance on forest protection of contractees evaluated by the forest owners. To implement PFES in Da Nhim, there was a coordination between the village heads, the MBDNWPF, the Commune People's Committee (CPC), and the Provincial Forest Protection and Development Fund. The village heads, CPC, and the MBDNWPF are altogether responsible for reviewing, selecting, and approving households eligible for participating in forest management and protection following standards of Decree 75/2015/ND-CP such as being responsible, enthusiastic, and committing to forest protection laws. The Provincial Forest Protection and Development Fund provides funds to contractees. In the course of contract performance, commune forest rangers, commune police, commune military, and forest ranger units cooperate with the contractees in patrolling forests, detecting, reporting, and handling violations.

In 2020, Da Nhim CPC cooperated with MBDNWPF and the Management Board of Bidoup Nui Ba National Park to allocate 19,173.75 ha of forest to 613 households for protection. There are 263 of the 613 households who signed contracts with MBDNWPF to protect 7,760 ha of the forest under the MBDNWPF management authority (The Commune People's Committee of Da Nhim, 2020). According to a representative of Da Nhim PFMB, 263 households formed 11 groups with an average of 10-15 people per group to patrol the forest. And, two groups protected the same forest area. In general, contractees who did not participate in forest patrols for 2-3 sessions were recorded and handled by terminating the contracts. In the course of the patrols, the team cooperated with the Management Board to jointly handle forest law violations. In dry seasons, patrol teams also paid special attention to forest fire prevention. Most contractees understood the importance of forests and their tasks and fully committed to forest patrols. However, there were still some people that were unenthusiastic, expecting higher payments. The current contract rate for forest protection in Da Nhim is about US$ 25 (1 USD = 22,800 VND) per ha per year, higher than the provision of Decree 75/2015/ND-CP, which is about US$17.5. Thus, each contracted household had an average income of US$ 526 - 702 per year with an average contracted forest area of 26 ha per household.

Livelihoods from agriculture

In addition to forest protection, the K'Ho Cil also relies on agriculture, mainly farming four popular crops: coffee, cash crops (artichokes, vegetables,

flowers, beans, corn), persimmon, and shiitake. Coffee is the main crop in Da Nhim Commune, accounting for more than half of the local crops (56%), while cash crops blame for a quarter (26%) and persimmon trees and shiitake mushrooms are less common, accounting for 14% and 4%, respectively. Based on specific natural, economic and social conditions, coffee is monoculture, intercropped, or polyculture. Coffee monoculture accounts for nearly half of the farming structure (48.8%). Coffee intercropped with persimmon accounts for 22.5% and coffee-crops polyculture accounts for 11.3%. The remaining systems such as crops (8.8%), shiitake (2.5%), and persimmon monoculture (2.5%) accounted for low percentages (Figure 2).

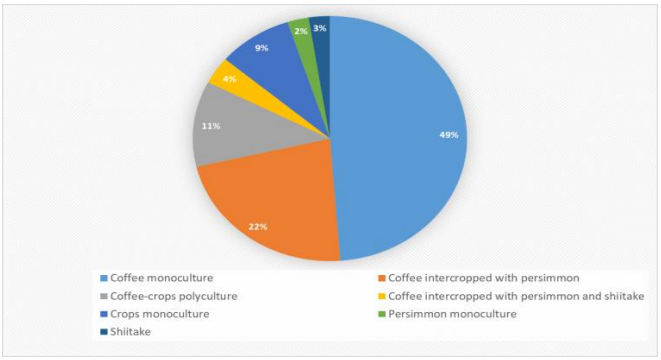

Figure 2. Farming systems in Da Nhim Commune

Economic factors

Cost

Investment costs included initial investment (seedlings, fertilizers, equipment), care, harvesting, and labor. In the first five years, the persimmon farming system had the lowest average investment cost per year, about US$ 395/ha/year. The main coffee farming systems (monoculture, intercropping, and polyculture) had average annual investment costs, ranging from US$ 1,000 to 2,412/ha/year. The coffee intercropped with persimmon system had a higher average investment cost per year than the coffee monoculture and polyculture systems with US$ 440 and 1,300/ha/year, respectively. The farming systems with relatively high average annual investment costs were shiitake mushrooms (over US$ 614,000/ha/year), cash crops monoculture (about US$ 13,200/ha/year), and shiitake combined with coffee and persimmon (about US$ 4,400/ha/year).

Income

The average annual income in 7 farming systems was quite different. The farming systems that provided high average annual income are mushrooms and

crops. The shiitake cultivation system can bring an average annual income of over US$ 920,000/ha/year, while US$ 52,630/ha/year for crops. Two medium-income farming systems were coffee intercropped with persimmon and shiitake and coffee-crops polyculture. Meanwhile, coffee combined with persimmon and shiitake had an average income of US$ 6,580/ha/year, twice as high as that of coffee-crops polyculture with an income of over US$ 3,500/ha/year.

Unlike the mushroom and crop farming systems that has appeared recently in Da Nhim commune, traditional farming systems such as coffee monoculture, coffee intercropped with persimmon, and persimmon monoculture have been practiced for a long time and bring about low income due to several obstacles of climate change and markets. The average annual income from these systems ranges from US$ 835 to 1,755/ha/year, in which the intercropping form gives the average annual income almost twice higher than the monocultures.

Output interests

The three farming systems that do not generate interest include coffee monoculture, intercropping coffee, and shiitake combined with coffee and persimmon. The other four systems with high interest rates include shiitake about US$ 300,000/ha/year, crops about US$ 39,500/ha/year. In particular, the system of coffee-crops polyculture and persimmon monoculture brings low average annual interest rates, ranging from US$ 700 to 2,240/ha/year, of which persimmon monoculture has the lowest interest rate of about US$ 700/ha/year due to the sharply dropped price of persimmon.

Social factors

People's satisfaction with farming systems

People's satisfaction with the farming system is based on the satisfaction degree of crop productivity and the ability of the system to contribute to the general income of the household (Table 3). Among 7 farming systems, the system of shiitake cultivation and shiitake in combination with household gardens of coffee and persimmon were highly appreciated for good productivity and contributes over 80% of total household income, significantly improving K'Ho Cil's livelihoods. The systems of cash crops and coffee polyculture were also good at crop productivity and the ability to contribute to the household's overall income (from 65% to 80%). The remaining three systems (coffee monoculture, coffee intercropped with persimmon, and persimmon monoculture) were unpopular because of low crop yields as well as low-income generation (from 28% to 38% of total household income).

Table 3. Satisfaction degrees of farming systems

Farming systems	Numbers of practiced households (*n=80*)	Satisfaction degree of crop production (max.10 points)	Ability to contribute to household income (%)
Coffee monoculture	39	5.44	28.58
Coffee intercropped with persimmon	8	5.38	38
Coffee intercropped with persimmon and shiitake	3	8.67	87.33
Coffee-crops polyculture	19	6.42	65.63
Crops monoculture	7	7.86	80.71
Persimmon monoculture	2	1.50	32
Shiitake	2	8.00	100

Frequency of villages and households adopting farming systems

Faced with the demands of socio-economic development and adaptation to climate change, the systems of crops, shiitake, and shiitake in combination with household gardens were borned with many prospects to be replicated in the community by bringing in high income and good output interest rates. The traditional persimmon monoculture may be abandoned in the future because without providing a good source of income. The survey showed that coffee monoculture was most popular in Da Nhim Commune and widely distributed in all five villages with 49% of households practicing. The three least common systems are shiitake, shiitake in combination with household gardens, and persimmon monoculture. These systems had a narrow distribution, occurring in only one or two villages and having only 2.5% to 3.8% of households participating (Table 4).

Table 4. Possibility to expand the existing farming systems

Farming systems	Numbers of practiced households (n=80)	Numbers of practiced villages (max. 5 villages)	Expectation to expand farming systems (%)
Coffee monoculture	39	5	28.2
Coffee intercropped with persimmon	8	4	25
Coffee intercropped with persimmon and shiitake	3	1	100
Coffee-crops polyculture	19	4	26.3
Crops monoculture	7	3	28.6
Monoculture persimmon	2	2	0
Shiitake	2	2	100

Possibility to expand the existing farming systems

The systems of shiitake monoculture and shiitake in combination with household gardens were preferable to be replicated due to contributing to improve household livelihoods. However, the scalability of the systems is

influenced by many factors such as economic conditions (capital sources), farming techniques, organizational conditions (land and human resources), and objective factors such as policy and market. Inefficient coffee and persimmon farmers wanted to switch to other systems with higher productivity and income such as artichokes, vegetables, or macadamia. While crop systems brought high productivity and income, the scalability was still not high because of the barriers of legally owning arable land (80%), capital (60%), and human resources (40%) (Table 5).

Table 5. Conditions for scaling up the farming systems

Farming systems	Numbers of practiced households (n=80)	Economy		Technology	Organization	
		Shortage in the capital (%)	Low productivity (%)	Inefficiency (%)	Unavailable land (%)	Shortage in human resources (%)
Coffee monoculture	39	63.2		5.3	76.3	23.7
Coffee intercropped with persimmon	8	85.7			85.7	14.3
Coffee intercropped with persimmon and shiitake	3	66.7	100		33.3	
Coffee-crops polyculture	19	58.8	5.9	5.9	64.7	17.6
Crops monoculture	7	60			80	40
Persimmon monoculture	2	50			50	
Shiitake	2	100	100			

Conditions for scaling up the farming systems

A prerequisite for replicated cultivation systems is capital. The transformation or development of the crops system required a huge initial investment. To flatten the high lands suitable for growing crops, households needed to invest from US$ 22,000 to 26,300 per ha. This was unaffordable for most K'Ho Cil farmers. In addition, owning legal arable land for farming system expansion had critical since 80% of the people could not overcome this obstacle. At present, they only managed to shift one cultivation system to another affordable or to increase the productivity of current farming systems. In addition, 40% of crop farmers, 24% of coffee monoculture, and 17% of coffee polyculture reported they did not have enough human resources to ensure stable development of the cultivation systems (Table 5). Since 2018, the shiitake farming system has been piloted locally with JICA's supports to assess the potential for livelihood improvement and replication in the K'Ho Cil community. The farming system brought in high interest to the farmers.

However, in 2020, shiitake farmers encountered yield and profit loss due to the unstable qualities of shiitake spawns provided by contracted suppliers. The farmers had suspended the production because of lacking capital to reinvest. For shiitake cultivation, it did not need a large piece of land or many human resources, instead of reliable shiitake suppliers who commited to provide good qualities of shiitake spawns.

Environmental factors

The ability of the farming system to use and protect land resources efficiently and sustainably

In Da Nhim, shiitake cultivation did not use fertilizers and agrochemicals, while most of the remaining farming systems use fertilizers (96.2%), pesticides (74.3%), and herbicides (66.7%). The K'Ho Cill households use a lot of chemical fertilizers (64.7%), a small number of organic fertilizers (31%), and rarely use microbiological fertilizers (4.3%).

Coffee farmers use a lot of chemical fertilizers, an average of 7.73 tons/ha/year for coffee-crops polyculture and 3.89 tons/ha/year for intercropping coffee (Table 6). Persimmon monoculture uses fewer chemical fertilizers (50% of households) with an average of 0.81 tons/ha/year. Pesticides and herbicides are commonly used in most farming systems except for shiitake cultivation. The crop farming system used the highest amounts of pesticides and herbicides with an average of 8.7 liters of pesticides per ha per year (85.7% households used) and 10.7 liters of herbicides (71.4% of households used). Coffee farming systems use fewer those agrichemicals but with a high frequency. On average, each household of intercropping coffee used 5.0 - 6.0 liters of pesticides per ha per year and the coffee monoculture household used about 3.0 liters/ha/year. For herbicides, an average of 5.0 liters/ha/year was used for monoculture and intercropping coffee systems and 2.5 liters/ha/year for polyculture coffee systems. Crop farming systems used more organic fertilizers than others with an average of 11.92 tons/ha/year (100% of households used), while the coffee farming systems were 2-3 tons/ha/year. Microbiological fertilizers are not used popularly in Da Nhim. About 35% of households used microbial fertilizers for coffee and crop systems with an average of 2.5 tons/ha/year. Coffee monoculture and polyculture systems rarely used microbial fertilizers only with 1.67 and 0.2 tons/ha/year, respectively. Through the above numbers, it can be seen that farming systems in Da Nhim had big impacts on the environment, especially crop farming systems that used large amounts of pesticides and herbicides every year.

Table 6. Type and dosage of fertilizers used in the farming systems

Farming systems	Number of practiced households (n=80)	Chemical fertilizers (N, P, K)		Organic fertilizers		Microbial fertilizers		Pesticides		Herbicides	
		%	Amount (tons/ha/year)	%	Amount (tons/ha/year)	%	Amount (tons/ha/year)	%	Amount (litters/ha/year)	%	Amount (litters/ha/year)
Coffee monoculture	39	97.4	1.98	38.5	2.74	2.6	1.67	64.1	3.17	53.8	5
Coffee intercropped with persimmon	8	100	3.89	57.1	2.14	0	0	57.1	6.33	75	5.50
Coffee intercropped persimmon and shiitake	3	100	1.95	66.7	10	33.3	2.50	66.7	2	66.7	0
Coffee-crops polyculture	19	100	7.73	64.7	4.41	5.3	0.2	64.7	4.8	89.5	2.50
Crops monoculture	7	85.7	2.15	100	11.92	28.6	2.51	85.7	8.67	71.4	10.67
Persimmon monoculture	2	50	0.81	0	0	0	0	50	0	50	1
Shiitake	2	0	0	0	0	0	0	0	0	0	0

The ability of cultivation systems to use and protect water efficiently and sustainably

The phenomenon of drought and domestic water shortages in the dry seasons has been recorded in the Da Nhim Commune. The people observed that the water resource in the area has changed in a bad direction. Previously, wells were drilled at 70m in depth to get groundwater, but recently up to 130m in depth to reach groundwater. Besides, the number of wells is also increased significantly in the area. Shiitake farming systems depended entirely on spring water and groundwater. Crop cultivation systems also used these water resources at a high rate with 87.5% of households exploiting them. Coffee cultivation systems had moderate impacts on natural water resources in the region because only approximately 45% of households using them. The remaining households used rainwater mainly (Table 7), especially entirely persimmon cultivation households only using rainwater for cultivation.

Table 7. Water use in farming and household activities

Farming systems	Number of practiced households (n=80)	Farming use			Household use		
		Springwater and groundwater (%)	Rainwater (%)	Tap water (%)	Springwater and groundwater (%)	Rainwater (%)	Tap water (%)
Coffee monoculture	39	14	83.7	2.3	42.6	29.8	27.6
Coffee intercropped with persimmon	8	11.1	77.8	11.1	54.5	27.3	18.2
Coffee intercropped with persimmon and shiitake	3	100	0	0	100	0	0
Coffee-crops polyculture	19	45.5	50	4.5	54.5	13.6	31.9
Crops monoculture	7	0	100	0	50	25	25
Persimmon monoculture	2	40	60	0	33.3	0	66.7
Shiitake	2	87.5	12.5	0	100	0	0

Risk of environmental pollution during cultivation

The sustainability of farming systems is also assessed on the ability to manage agricultural waste such as fertilizer packaging and bottles/containers of pesticide/herbicide. Most farmers in Da Nhim had not practiced sustainable agricultural waste management. More than 69% of households dispose of

agricultural waste by burying, burning, or leaving it in the farming area, especially those belonging to the coffee and persimmon farming systems. This form of treatment, in the long run, will accumulate toxic substances in the soil and water. The other cases in mostly crop farming households, and handle agricultural waste were more sustainably by reusing packaging or by collecting, transporting, and treating according to the state waste management system. These households had more convenient access to the state system of waste collection and transportation than persimmon and coffee farming households because of their cultivation land location. Shiitake farming systems did not generate toxic waste and their spawn waste can also be used as organic fertilizers.

The ability to reduce pressure on forest resources

Besides the main livelihoods from agriculture and contracted forest protection, K'Ho Cil households also exploited non-timber forest products such as firewood, honey, medicinal plants, orchids, aquatic products, rattan, forest mushrooms, and wild vegetables to serve the household's needs. The extent of the impact on forest resources depended in part on the household income from the farming systems they practice. Most of the surveyed households had an impact on natural resources, except shiitake farming households (Table 8). These regulations motivated the farmers to protect forests and stopping encroaching on forest for cultivation land. And thus, the shiitake farming system with strict regulations helped to reduce pressure on forest resources, showing its superiority over other farming systems in Da Nhim.

Table 8. Degree of impacts on forest natural resources

Farming systems	Numbers of practiced households (n=80)	Degree of impact (%)
Coffee monoculture	39	48.7
Coffee intercropped with persimmon	8	75
Coffee intercropped with persimmon and shiitake	3	0
Coffee-crops polyculture	19	68.4
Crops monoculture	7	100
Persimmon monoculture	2	0
Shiitake	2	42.9

Evaluation of farming systems

The sustainability of farming systems is based on three factors: economic, social, and environmental. Research results (Table 9) showed that the sustainability of farming systems in Da Nhim is medium sustainable (> 8.8 – 13.2 points) to medium-high sustainable (> 13.2 – 17.6 points). The

intercropping coffee system is rated the lowest because it was not effective in terms of productivity and income, help to create stable livelihoods and minimized the impact on forest resources. The shiitake system is ranked medium-high because it brought high income and reduced negative impacts on forest resources. However, this system has not achieved a high level of sustainability due to the high investment capital, the difficulty of replication in the community, and the unsustainable use of water resources.

SWOT analysis of the agroforestry livelihood model

Forest protection activities contribute to improving the livelihoods of the K'Ho Cil. Income from forest protection contracts is relatively stable, helping them overcome difficulties when crop yields fail and agricultural product prices drop. When protecting the forests, their awareness of forest protection is also gradually improved. According to Da Nhim CPC, in 2019 the number of violations were decreased (13 cases in 2019) compared to 2018 (18 cases). While patrolling, the people discovered violations such as grazing cows in planted forests, exploiting non-timber forest products, and illegal encroachment of forest land, and jointly handled the cases with the state forest rangers of MBDNWPF and local authorities.

The Government of Vietnam is promoting further development of agroforestry livelihood models to contribute to reducing pressure on natural resources, which is specified in Decision No. 995/QD-TTg dated August 9, 2018. Forestry activities related to this issue include allocating land associated with forests, ensuring forests having '*real owners'*, clearly defining the rights and long-term interests of forest land users and forest owners, promoting the economic potential of forests, and developing policies to generate revenue for forest management such as PFES, especially in the context of climate change (Trieu *et al.*, 2020). In addition, in line with forestry worldwide, in the period 2020 - 2050, Vietnam pays special attention to sustainable forest management, encouraging the participation of all parties, especially the private sector and communities, empowering local communities, improving the role of the forestry sector in poverty reduction, rural development, climate change adaptation and mitigation, and social security (Pham *et al.*, 2020). In the Da Nhim case, forestry has played a certain role in the local sustainable livelihood. However, this livelihood has not yet diversified and fully exploited the potential of the Da Nhim forest ecosystem. Eco-tourism, especially bird watching with 56 unique bird species recently discovered by scientists, and forest resources such as edible forest mushrooms, medicinal herbs, and honey are those of the potentials to local sustainable livelihoods.

Table 9. Scoring the sustainability and advantages of farming systems in Da Nhim Commune

Factor	Index	Max. score	Coffee monoculture	Coffee intercropped with persimmon	Coffee intercropped with persimmon and shiitake	Coffee-crops polyculture	Crops monoculture	Persimmon	Shiitake
Economic	Cost	(1)	**(0.86)****	(0.57)	(0.43)	**(0.71)***	(0.29)	**(1.00)*****	(0.14)
	Income	(2)	(0.29)	(0.86)	**(1.43)***	(1.14)	**(1.71)****	(0.57)	**(2.00)*****
	The output of interest rates	(3)	(1.29)	(0.43)	(0.86)	**(2.14)***	**(2.57)****	(1.71)	**(3.00)*****
Social	Satisfaction level of farmers with the economic model	(2)	(0.57)	(0.57)	**(2.00)*****	(1.14)	**(1.43)***	(0.29)	**(2.00)*****
	Number of households applying model in a village	(3)	**(3.00)*****	**(2.57)****	(0.43)	**(2.57)****	(1.71)	(1.29)	(1.29)
	Number of villages applying the model in the commune	(2)	**(2.00)*****	**(1.43)***	(0.86)	**(1.71)****	(1.14)	(0.57)	(0.57)
	Ability to spread model in terms of scales and reasons	(1)	(0.57)	(0.29)	**(1.00)*****	(0.43)	**(0.71)***	(0.14)	**(1.00)*****
	Conditions for spreading model	(1)	**(0.71)***	(0.43)	(0.29)	**(0.86)****	(0.57)	**(1.00)*****	(0.29)
Environmental	The ability of the model to use and protect soil resources effectively and sustainably	(3)	(1.71)	(0.86)	**(2.14)***	(1.29)	(0.43)	**(2.57)****	**(3.00)*****
	The ability of the model to use and protect water resources effectively and sustainably	(1)	**(0.86)****	(0.57)	**(0.86)****	(0.43)	(0.29)	**(1.00)*****	(0.14)
	The ability of the model to combat environmental pollution	(1)	(0.29)	(0.14)	(0.57)	**(0.71)***	**(0.86)****	(0.57)	**(1.00)*****
	The ability of the model to reduce pressures on forest resources in sites and adjacent areas and improve ecological relationships between forests and farming models	(2)	(1.14)	(0.57)	**(2.00)*****	(0.86)	**(1.43)***	(0.29)	**(2.00)*****
Scores of advantages in total			**(11)***	**(3)***	**(13)***	**(9)***	**(9)***	**(11)***	**(21)***
Scores of sustainability in total		**(22)**	**(13.29)**	**(9.29)**	**(12.87)**	**(13.99)**	**(13.14)**	**(11.00)**	**(16.43)**

*Note: * – Advantages ranging from 1-3 (*) for three top system*

Advantages and disadvantages of farming systems

The shiitake system is a new livelihood introduced by a JICA's project, focusing not only on livelihood but also climate adaptation and forest resource protection. It requires participatory households to follow forest laws such as not to encroach on forest land and exploit forest resources. Besides, private companies assure to consume shiitake outputs through contracts. However, this system costs high investment when needing an initial investment of about US$ 4,390 to build a cultivation room with shelves on an area of 50-100m^2. Many of the K'Ho Cil people are unaffordable with this cost. Those requirements can be obstacles for many poor households with low education and illegal land in Da Nhim.

The coffee farming system had advantages of popularity, low investment costs, and sustainable use of water resources. Currently, this system is challenged with unstable coffee markets and extreme weather events caused by climate change such as hoarfrost, drought, and pests. As a result, the system of coffee-crops polyculture can help the K'Ho Cil people maintain their livelihoods made up of high interest from crops. However, the biggest drawback of the crop farming system is its flattening lands and changing the topography of the area. According to the Da Nhim CPC, the local government orients coffee as the main crop in Da Nhim and doesn't support the conversion to crop cultivation to avoid the negative impact on the local landscape and ecological environment.

Opportunities and challenges of the farming systems

Opportunities

The development of the farming systems depended largely on the socio-economic development orientation of the local government through institutions, policies, and market demand for agricultural products (Table 10). According to the agricultural policy of Da Nhim Commune, coffee is encouraged to develop but not brings about livelihood efficiency as expected. Under Decision No. 1462/QD-TTg by the Prime Minister and Decision 116/QD-UBND by the People's Committee of Lam Dong Province on the Master Plans for Socio-Economic Development of Lam Dong Province and Lac Duong District through 2020, innovative farming systems are encouraged to improve the people's livelihoods. Since 2018, the project "Natural Resource Management System" has been implemented by the Japan International Cooperation Agency (JICA) and the Ministry of Agriculture and Rural Development (MONRE) in collaboration with a private shiitake company to pilot the shiitake farming system with 2 first households in Da Nhim Commune. By early 2020, the

system has been replicated to 18 households with 25 shiitake farming rooms in 3 villages of Darahoa, Da Tro, and Da Blah of Da Nhim commune.

At the same time, crop farming systems appear to help local people overcome the low income of farming coffee. According to Resolution No.52/NQ-HDND dated December 21st, 2018, of the Da Nhim People's Council on the tasks of socio-economic development in 2019, the local government advocates sustainable agricultural development specialized in vegetable, flower, and strawberry farming systems associated with the processing industry, post-harvest preservation, and high-quality value chain development. Because farming crops causes negative impacts on the local landscape and environmental ecology, the government requires coffee farmers to ask for governmental permission before shifting to crop farming, avoiding freely breaking local agriculture planning. Illegal shifting will get fines according to regulations.

In addition, traditional farming systems such as coffee intercropped with persimmon also receive supports from international NGOs. Since 2019, coffee farmers have received supports from the project "Agroforestry coffee and forest quality improvement for REDD+ in Lam Dong Province" (CAFÉ-REDD) carried out by Netherlands Development Organisation (SNV) in sponsorship with the International Climate Initiative under the German Ministry of Environment, Nature Conservation, and Nuclear Safety. The project has worked with a private coffee import-export company (in Lam Ha District, Lam Dong Province) to buy coffee with higher prices than those of the markets (from US$ 0.18–0.26/kg). In return, the farmers must participate in training on harvesting techniques and strictly comply with the company's standards for coffee farming, harvesting, and storage to ensure product quality. The project's coffee farming standards include intercropping coffee with perennials such as persimmon and macadamia to create shade for coffee trees to grow, prevent soil erosion, and restore the landscape, using organic fertilizers in cultivation, and collecting only ripe fruit. In addition, the project builds cooperative groups in which the households can exchange labor in coffee care or harvesting activities, helping to reduce labor costs for the farmers.

According to a bird diversity study, Da Nhim Commune is home to about 59 unique bird species, opening up opportunities for eco-tourism activities, especially bird-watching tourism. Some typical rare bird species include the Golden-throated Barbet (*Psilopogon auricularis*), White-cheeked Laughingthrush (*Lanthocincla vassali*), Vietnamese Cutia (*Cutia legalleni*), Vietnamese Greenfinch (*Chloris monguilloti*) with great potential for servicing eco-tourism in Da Nhim Commune and promoting the development of local livelihoods.

To support forest restoration and promote sustainable livelihoods for indigenous communities, the project “Use of Ectomycorrhizal fungi on reforestation of pine forest in Vietnam” with the sponsorship of The Mushroom Initiative Limited has been implemented in Da Nhim Commune. The project aimed to restore pine forests by using domestic ectomycorrhizal in both nursery and field. When the pine forests are gradually restored, people will have more income from livelihood opportunities from non-timber forest products, especially from the high-priced edible wild mushroom, and the ecotourism business. The project also organizes annual seminars to bring knowledge and experience to the people about afforestation. The project wishes not only to restore the pine forest, diversify sustainable agroforestry livelihoods for the community but also to help raise people's awareness of sustainable forest development.

In addition to the support of international NGOs, the local government also supports poor households who own legally certified land to improve farming systems, diversify livelihoods and reduce poverty, following the National Program on Sustainable Poverty Reduction. From 2016 to 2018, the government had supported poor households with seedlings, fertilizers and pesticides, and local endemic cows for breeding. Our survey shows that 33.8% of K'Ho Cil people received support with plant varieties, 13.5% with fertilizers and pesticides, and 1.4% with livestock breeds. Moreover, local authorities also organized training on effective farming techniques for 71.6% of households.

In summary, Da Nhim Commune has gradually improved inefficient farming systems through policies on hunger eradication, poverty alleviation, participatory forest protection and restoration, and sustainable agriculture. International NGOs and stakeholders support piloting new farming systems, creating value chains in production, contributing to improving livelihoods and sustainable agriculture in Da Nhim. However, the livelihood models in Da Nhim are also facing many challenges mentioned in the next section.

Challenges

Most of the farming systems in Da Nhim Commune faced many challenges due to their dependence on weather and the market for agricultural products (Table 10). In the first 6 months of 2020, natural disasters such as pests, hoarfrost, drought, and the Covid-19 pandemic happened and caused many damages to agriculture production. Hoarfrost damaged 293.26 ha of 508 households, in which 90% of coffee, 9.5% of crops, and about 0.5% of perennial fruit trees. In addition, pests and diseases also outbroke and damaged coffee trees, drastically reducing the productivity and income of the K'Ho Cil people. The coffee farmers said the average coffee yield decreased by nearly half from 15 tons per ha per year to about 7 tons per ha and they lost about US$

2,566 per ha. Under the impact of hoarfrost, they could only cut off the trees about 20cm above the ground so that the tree could regrow or they have to plant new trees taking years to have new harvestings.

It is expected that the farming system of intercropping coffee with persimmon can deal with hoarfrost because persimmon shades and protects the coffee from hoarfrost. However, according to a representative of Da Nhim CPC, the system has declined sharply for 10 years due to the low price of persimmon. In 2020, the price ranged from US$ 0.13 to 0.53 per kg. Besides, pests also damaged persimmon fruits dropping the yield. According to our survey, the persimmon farming systems bring only about US$ 702 per ha per year.

Besides, farming systems in Da Nhim depend on the market for agricultural products. Many farmers asserted that they lack capital for production investment and often borrow money or buy first and pay later for agricultural materials at agro-supply stores with higher prices. When harvesting agricultural products, they have to sell the products to store owners at below-market prices to pay their debts. On the other hand, farmers also sell fresh coffee beans directly at a much lower price than dried beans because of lacking a drying yard or a drying machine to dry the beans. Moreover, the coffee is harvested in the rainy season (October and November), also making it very difficult to dry the beans.

Table 10. Opportunities and challenges of the farming systems

Farming system	Policy/Project	Market
Coffee monoculture	Local support under the National Poverty Reduction Program	Unstable coffee output
Coffee intercropped with persimmon	Local support under the National Poverty Reduction Program and SNV project since 2019	• The SNV project builds up a coffee supply chain. • Low price of persimmon
Coffee-crops polyculture	Local support under Resolution No.52/NQ-HDND	• Unstable coffee output • Good price of crops
Crops monoculture	Local support under Resolution No.52/NQ-HDND	Good price of crops
Persimmon monoculture	Local support under the National Poverty Reduction Program	Low price of persimmon
Shiitake	Governmental and international support under JICA project	Guaranteed consumption by a private company

To sum up, the shiitake farming system is the most superior among the farming systems in Da Nhim today because of its dealing well with extreme weather events and the consumption markets. On the contrary, coffee farming systems are unable to deal with harsh weather and unstable markets. Intercropping coffee with persimmon and/or crops helps overcome obstacles of

local climate and markets but under agricultural development plans of local government. Ensuring outputs for coffee and other agricultural products and developing the coffee processing industry requires more attention from the authorities to improve the farming systems. The model of agroforestry livelihood introduced by the JICA project likely provided a lesson about the effectiveness and importance of connecting livelihood, forest protection, and value chain development in Da Nhim so that K'Ho Cil people can benefit a lot from the livelihood.

Discussion

The agro-forestry livelihood model in Da Nhim is characterized by a combination of forest protection and crop cultivation, especially coffee. In Da Nhim, the ownership of agricultural lands is private both legally and illegally, while the forest belongs to the state and the people, and MBDNWFP on behalf of the state and the people manage the forest resource for environmental protection purposes. According to the Vietnamese forestry policy, several permitted activities for environmental protection forest like Da Nhim forest include contracting for forest protection and sharing benefits, planting and developing forests to ensure ecological functions and environmental protection, collecting non-timber forest products, except rare and precious species protected by law, intercropping endemic trees, thinning, salvaging and utilizing the timbers developing ecotourism, doing scientific research, education and training, and implementing payment for forest environmental services. Crop cultivation in protected forests is not permitted by law. In addition, the local policies on agricultural development orient coffee as the main crop in the area because of its compatibility with the local ecology and providing specialties with unique coffee favors. The policies restricting the conversion of farming coffee and persimmon to cash crops aim to protect the ecological landscape. Therefore, the policies and institutions have oriented the development of agroforestry livelihood models in Da Nhim, creating interdependence and intersectionality between the local community and forest natural resources in unique Da Nhim landscapes.

To what extent the K'Ho Cil's agroforestry livelihoods practice sustainability

The farming systems in Da Nhim gain moderate sustainability due to constraints in bringing about good income, spreading across the community, and practicing friendly environmental farming. The challenges of climate change and pest outbreaks are also putting a lot of pressure on the farming systems. Value chains in the production and processing of agricultural products

and connections with other economic partners inside and outside the locality are underdeveloped. The cultivation techniques and processing technology of agroforestry products are still very backward. Besides, policies on stable prices for agricultural products and outputs for local agricultural products are also in short of governmental attention. Socio-economic organizations such as cooperatives and farmer unions, which play a very important role in supporting farmers to work together, building commercial brands for local agricultural products, and unifying to connect with other partners, are still very weak and unable to mobilize the participation and cooperation of the K'Ho Cil community. This also causes great obstacles in sharing knowledge and experiences, and especially setting up economic cooperation, and exchanging social resources among and between communities. In addition, environmental protection issues in the farming practices of the K'Ho Cil people are still inadequate, especially the excessive use of agrochemicals or the flattening of cultivation lands, which is causing negative impacts on the soil, water, and landscapes in the region. Local authorities need to introduce more sustainable livelihood practices, encourage and monitor the people to practice to protect the environment of the area.

Are these livelihoods adaptable to climate changes?

Climate change is expected to strongly affect Vietnam and its agriculture in the coming years. The research results from Da Nhim show that the ability to adapt to climate change has been underdeveloped and unimplemented in practice. In the face of climate change, some initiatives for crop transformation and livelihood development are piloted and encouraged in Da Nhim such as mushroom cultivation which is unaffected by weather phenomena, and restoration of traditional coffee farming systems by intercropping coffee with perennial plants with high economic value (macadamia) to protect coffee and soil and create a good income. These initiatives are all proposed by international organizations, supporting initial climate change adaptation in Da Nhim. The policies on climate change adaptation have been implemented in many places across Vietnam such as the Mekong Delta, but no specific activities reaching the community.

To promote sustainability and adaptability what are key measures needed and which stakeholders need to play what roles?

Under Vietnam's forestry legislation, the government allows forest owners (MBDNWPF) to conduct a wide range of activities in cooperation with community partners, private sectors, and scientists in services such as eco-

tourism (birdwatching), sustainable exploitation, and development of non-timber forest products (edible forest mushrooms, honey, medicinal plants, and wild vegetables) (Trieu *et al.,* 2020; Kimdung *et al.,* 2013; KimDung *et al.,* 2017). However, at present, these legal activities have not been implemented effectively to fully exploit the potentials of Da Nhim forests. To diversify the livelihoods of people based on the forest, cooperation with the mentioned partners should be focused on and promoted more (KimDung *et al.,* 2016a). In addition, the research results also show the role of international organizations such as JICA and SNV in promoting the development of K'Ho Cil people's livelihood. JICA has brought up the idea of combining new livelihoods with priorities of significantly improving people's income, focusing on connecting people with materials suppliers for production and product consumers, ensuring stable output and prices of agricultural products for the people, introducing new farming techniques to the people, helping them to gradually access science and technology and improve the quality of their livelihood, linking livelihood models with commitments to forest protection and environmental protection, promoting people's awareness on forest protection and reducing their dependence on forest resources. For SNV, its project helps restore traditional farming patterns that are successfully resistant to extreme weather events and are compatible with the ecological landscape of the region. Coffee and perennial crops not only help stabilize the livelihood of the K'Ho Cil people but also help protect crops and protect cultivating land in Da Nhim, which has a steep slope, easy to erode and wash away nutrients.

Policies for ethnic minorities and poverty reduction are very important in improving people's livelihoods (Asian Development Bank, 2002; Ngo, 2019). Local authorities, especially at the commune level, play an important role in implementing these policies locally. In addition, the cooperation with state forest owners in contracting for forest protection and monitoring farming activities in terms of sustainably using agrochemicals also plays an important role. However, as mentioned, the agroforestry livelihood model in Da Nhim was formed due to the orientations from the policy and directed by the competent authorities. Therefore, to make strides in innovation and develop a better K'Ho Cil livelihood, it is necessary to have innovative guidelines and policies from the central and provincial levels of state on livelihood issues in Da Nhim (OECD, 2015). In addition, to innovate the livelihood model, an engagement of many other stakeholders is needed and effective coordination to promote stakeholders (state, private, public, international, scientists) cooperation is the very key. To do so, the levels with the authority to coordinate are none other than the central and provincial governments (The Government of Vietnam, 2012; KimDung *et al.,* 2016b).

Although the current farming systems in Da Nhim are aimed at economic stability and climate change adaptation and have achieved moderate levels of sustainability, most systems are less environmentally sustainable. People still abuse chemical fertilizers and inappropriately manage agricultural waste. In this context, forest protection contracts play an important role in local agroforestry livelihoods. Although this livelihood practice has not yet brought a high income to the K'Ho Cil, the stability of the income helps people overcome difficult times when the income from agriculture is still unstable. Livelihoods from forest protection contracts have motivated people to keep forests and raise awareness of the importance of forests. To strengthen participatory forest conservation and development, the government of all levels should focus on empowering indigenous communities, giving them opportunities for livelihood development, and supporting them to access farming science and technology. This would not only help to stabilize local livelihoods, security, and social development but also effectively promote environmental protection and biodiversity. The effective cooperation and connection through development projects between the governments, indigenous people, and international organizations will ensure sustainable local livelihoods and reduce negative impacts on forest resources. Every effort is valuable because of contributing to sustainable natural conservation and development. The success of this effort brings about benefits not only on the local and regional scale, but also spillovers on the national and international level, and even for future generations.

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