



ASSESSMENT OF COFFEE-BASED AGROFORESTRY SYSTEM PERFORMANCE BY PROVINCES IN THE CENTRAL HIGHLANDS OF VIETNAM

[21]

Hoi¹ P.V., Manh¹ N.D. and Vien² T.D.

1- Center for Agricultural Researches and Ecological Studies, Vietnam National Univ., of Agriculture, Hanoi, Vietnam

2- Chairman of the Board of Trustees, Vietnam National Univ. of Agriculture, Hanoi, Vietnam

*Corresponding author: phamhoi@gmail.com

Received 10 June, 2020

Accepted 26 June, 2020

ABSTRACT

Dominated by intensive coffee monocultures for the last 30 years, farmers in the Central Highlands of Vietnam has been increasingly experienced with farming difficulties given resource degradation, market and climate uncertainties. In recent years, a number of farmers have diversified their coffee farms toward the forms of agroforestry: through integrating fruit and other crops into coffee farms. This study, by referring to the existing 10 agroforestry systems and 10 forestry ecological zones identified in the region for its approach, conducted in 20 communes throughout five provinces in the region at the coffee harvesting period in the end of 2018. In total, 249 farmers were identified through snowball sampling technique and successfully interviewed. Five major agroforestry systems are identified with sufficient sample size for statistical analyses. By detailed assessment of inputs used and revenue, this study proves that agroforestry systems strongly enhance farmer's income. However, the success varies among the five studied provinces. Farmer's technical know-how and their choice on 2nd crop made their agroforestry farming profit largely different. Given the fact that large percentage of land in the tropics is too dry, too steep, or too rocky to be classified as arable land which has been further problematic through increasing exposure to erosion resulting from unsustainable farming practices, often driven by intensive monocultures, efforts to promote agroforestry in Vietnam in particular and the tropics in general is thus needed, not only for surviving increasing population but also recovering and pro-

tecting the environment. In the situation of the Central Highlands of Vietnam, together with efforts in promoting agroforestry, a restructure of farming system needs to be considered in accordance with foreseeable difficulties in farming conditions, i.e., more water stress will be happened in certain provinces. These provinces should take a shift more toward less-irrigation dependent crops and reduce their dependence on coffee. These changes will create a better common guarantee for all farmers in coping with future uncertainties

Keywords: The Central Highlands of Vietnam, agroforestry, coffee, risks, profit.

INTRODUCTION

The 2nd Green Revolution-based agriculture has brought into serious impacts to the ecological system, through converting to (market-oriented) monocrop systems with increasing uses of chemical inputs and withdrawing more harvests (in the form of biomass) from the agricultural systems. This has led to pollution and degradation of natural resources, which increasingly damage and threat to agricultural productivity, quality of living environment, and people health (from exposure to pollution and consumption of unsafe foods).

Agroforestry is considered convincing and evidence-based alternatives to the current chemical-based (and mono-driven) agrifood systems. They clearly aim at strengthening innovation capacity of family farms, as well as the recognition of their contribution to food sovereignty, farmer's welfare and environmental protection. Owing to its

biological multi-fuctions, agroforestry is a part of solutions for tackling socioeconomic and ecological problems in the existing intensified agriculture (FAO, 2017).

In the past three decades, agricultural practices have been very much intensified in the Central Highlands. Most of forest has been cut for agriculture. This together with intensified farming practices have driven farmers into troubles with land degradation (Thiennhien.net, 2013). In dry season, fruit crops largely rely on drilled wells for irrigation. Water scarcity and conflicts have been widely happened in the region (DWRM, 2011; Hoan and Trung, 2013). The dry season in 2016 caused thousands of ha of coffee dried because of lack of irrigation (Tran, 2016). Water shortage trouble is forecasted to be intensified in future (CGIAR, 2016).¹ Crop failures caused by widespread diseases on major crops such as coffee and pepper are regularly reported recently (Yen, 2019).

Not only experienced with abovementioned problems, but farmers have been also faced with large fluctuation in market demand and price for their agricultural products. For instance, coffee price has been observed with very high in the year 1994, 2008 and 2011 (Hang, 2011), and fluctuated but badly low in 2018 (Hung, 2019); pepper enjoyed high market price in early 2010s (VPA, 2017) and badly fallen down in 2018 (Vuong, 2018). Similar trend is also happened for other crops. Even durian made a number of farmers billionaire in VND in 2018, its market price has recently reduced by about 20% within one week time in early April 2019 (Khanh, 2019). Faced with reduced market price for agricultural crops, it is common that farmers often replaced their crops by others which have more market potential signal (Uyen, 2012)

Recently, a number of farmers have started to diversify their crops by integrating fruit trees into their coffee or peppers (TTXVN, 2018) to take advantage of high market demands on fruits. In addition, farmers increase utilization of single fertilizers instead of NPK which is sometimes blamed for its fake and/or low quality (Sau, 2017; Thinh, 2017).²

¹ A lady in Cu Sue commune (Cu M'Gar district, Dak Lak province) revealed that she has deepen her drill well three times, but water is not as much as in the past. At the present, for one irrigation demand, she has to do twice in a day because not enough water for irrigation for one pumping time. Average she has to do 6-8 irrigation times for her coffee in dry season instead of 2-3 times as 10 years ago (Personal interview on March 23, 2019).

² A farmer also doing fertilizer & pesticide retails said that it is not fluctuated markets for agricultural products but

More farmers pay attention to manure and compost for their soil fertilization (IRC, 2018a;b).

These changes have diversified agricultural crops and farming practices in the Central Highlands, formulating various types of integrated farming systems. This study targets on understanding existing agroforestry farming practices in the Central Highlands of Vietnam. Detailed analyses of farming investments for and profit generated from individual crops will be taken from which factors contributing to success and failure of the farming system, in terms of farmer's income will be elicited. Finally, some thoughts on promoting agroforestry in the Central Highlands of Vietnam will be discussed in the conclusion section.

RESEARCH APPROACH

Given the diverse climate conditions and associated diverse agroforestry practices in the Central Highlands region, the research was counted on the 10 agroforestry models (Sen, 2015) and 10 forestry ecosystem (Lung, Sam et al 2015) identified in the region for selecting sites for the survey with the two major criteria: (1) Diverse existing of agroforestry models; (2) representative for different forestry ecosystem in the region. Based on a group discussion with local researchers and officials³, 10 districts (2 in each province) were selected for the research.

The survey was conducted from December 18 to 31, 2018 with 8 enumerators and 2 supervisors. The first day was for training enumerators and supervisors, including questionnaire content and logistics necessary for the whole survey. In addition, several relevant personal interviews taken in other researches are also used for this paper.

Since the focus of the research is on agroforestry practices, the survey teams had to rely on snow-ball sampling to identify relevant households for interviews with abovementioned criteria. For this, each enumerator was requested to complete surveying three households in daily average. In total, 249 households were interviewed in selected communes in the region. Number of households surveyed is relatively equally distributed among the

fake and low quality of NPK should be the most serious problem in localities since the crop can badly hit by such NPK. Personal interview in Mar 24, 2019 in Cu Sue commune, Cu M'Gar district, Dak Lak province.

³ The group discussion was conducted in Oct 2018 with two representatives of DaLat Agroforestry University, one of Dalat Vocational College; and one of Lam Dong Department of Plant Protection.

5 provinces, from 48 households in Kon Tum to 52 households in Lam Dong province.

RESULTS AND DISCUSSION

1. General information of the Central Highlands

The Central Highlands of Vietnam is well-known for its diversification of ethnic groups, climate and topography. It contains 5 provinces: Dak Lak, Lam Dong, Gia Lai, Kon Tum and Dak Nong. Total natural land area of the region is 5,460,000 ha of which agricultural land area accounts for 44.3% and forestlands for 45.6%. Other land types such as fishpond, nonfarm land, unused land accounts for a small percentage.

Given the good soil and climate conditions that support diverse crops in the region, a huge migration was happened in the regions in the past decades¹. That was coupled with official allow of Vietnamese governments in agricultural land business have reduced household's farmland as well as widen the gap, especially between migrants and local minority ethnics. In local statistics, roughly 10% of local households owned less than 0.2 ha of agroforestry lands, 14.5% own from 0.2 to 0.5 ha, roughly 52% own from 0.5 to 2 ha, and 24% owned 2 ha or more than 2 ha (**DakLakDOS, 2016, DakNongDOS, 2016, GiaLaiDOS, 2016, KonTumDOS, 2016 and, LamDongDOS, 2016**).

2. Classification of agroforestry system

In average, surveyed households have 2.0 ha of land, and 1.6 ha for agroforestry farming practices. Households having less than 2 ha of land account for nearly 60%, Area for fishpond, annual crops and woody trees accounts for a small area. Forty-four percent of households are growing woody trees and only four reported having forests. Households raising fishes and growing annual crops account for small percentages.

76% of surveyed households growing coffee. Coffee is thus considered as major crops of the households. Pivoted on coffee, 6 major agroforestry systems are identified with number of households involved being large enough for statistical analyses.

For households having grown coffee, roughly 21% having coffee integrated with other fruit crops such as avocado, banana, persimmon, passion...;

nearly 16% with pepper, 14% with litsea and 13% with durian.

Given the lack of detailed information for crops (such as harvests and values of mulberry, grass for livestock, vegetables, cassava...), we thus focus on analysis five farming categories with coffee and integrated crops, such as: Coffee-Durian, Coffee-Pepper, Coffee-Litsea, Coffee-Other fruit crops, Coffee-Others (hereafter AFS1, 2, 3, 4, and 5, respectively).

Provinces are different in AFS adoption. AFS1 is mostly presented in Dak Lak (42% of households surveyed), followed by Lam Dong and very few in other provinces. AFS2 is dominated in Dak Nong (roughly 63% of households surveyed), followed by Dak Lak, and few in other provinces. AFS3 is dominated in Kon Tum (roughly 67% of households surveyed), followed by Gia Lai, and none in other provinces. AFS4 is mainly found in Lam Dong province (more than 57% of households surveyed), followed by Dak Nong, and few in other provinces. AFS5 is more presented in Gia Lai (28% of households surveyed), followed by Dak Lak and Lam Dong and few in Dak Nong (see **Table 1**).

Of the 189 households adopting coffee-based AFS, 8.5% grow Arabica in an area accounting for 3.5% of total AFS area. These households growing Arabica are only presented in Kon Tum and Lam Dong. The rest of households surveyed are all growing Robusta.

Table 1. Coffee-based agroforestry system distribution by provinces

(N=189, %)

AFS	Dak Lak (N=38)	Lam Dong (N=47)	Gia Lai (N=25)	Kon Tum (N=36)	Dak Nong (N=43)
AFS1	42.1	23.4	4.0	8.3	4.7
AFS2	28.9	0.0	8.0	2.8	62.8
AFS3	0.0	0.0	48.0	66.7	0.0
AFS4	7.9	57.4	12.0	5.6	27.9
AFS5	21.1	19.1	28.0	16.7	4.7

Since the unforeseeable and fluctuate market demands for agricultural products, different farmers adopt different farming strategies. Except coffee that farmers can process and store beans at home up to several months before sell, or persimmon fruits can be dried at some extent, other fruits are mainly sold in fresh without storing possibility. In addition, fruit crops often take several years before

¹ Vietnamese statistics estimated that within the period of 2005-2017, there were 58,846 migrant households moved to the region (**Lich, 2019**)

having harvests whilst often requiring more investment to be able to have harvests. Thus, growing fruit crops is considered having more risks for farmers than other woody trees and/or annual crops in the integrated system. It needs to mention that successful durian and/or avocado farmers started their crop about 8-10 years ago when durian and avocado market potential was not clear yet. Taking any changes in commercial farming structure in unorganized and risky markets like in Vietnam, is thus often accompanied with both opportunities and risks. In this sense, farmers in Dak Lak and Lam Dong provinces are likely more risk-taking than those in other provinces, especially Kon Tum.

3. Assessment of inputs used for AFSs

Details of AFS farming practices are presented in **Table 2**. Given the differences in soil and climate condition, farming preference and risk taking of farmers among provinces, there are thus a number of significant differences in farming practices of households between and among provinces.

Farmers in Dak Lak adopted largest number of NPK application, largest quantity of manure/ compost, and largest number of irrigation, but lowest in herbicide and pesticide cocktail application. By contrast, farmers in Kon Tum adopted lowest number of NPK application, lowest quantity of manure/compost. Farmers in Lam Dong adopted least irrigation, but largest quantity of herbicides. Pesticide cocktails are more used by farmers in Dak Nong.

Technically speaking, farmers in Dak Lak are more outstanding and better-off than their neighbors that allow them to invest more for their crops especially labor for NPK application, manure/compost and irrigation. Under degraded land condition, more number of application will enhance NPK efficiency. By contrast, farmers in Kon Tum are technically weak and poorer that constraint them for investment on fertilization. Endowed with more rainfall not only positively supporting farmers in Lam Dong to reduce irrigation needed for the crops, but also favoring more weed problem that induces to more herbicide uses in this province.

After Dak Lak, farmers in Lam Dong are technically performing better than farmers in Dak Nong, then Gia Lai.

4. Assessment of production cost of AFSs

Details of AFS farming costs are presented in **Table 3**. There is no difference among provinces in various farming investment cost items such as land preparation, land addressing, single fertilizer and combining utilization, insecticide and fungicide uses...However, there are several investments of statistical difference.

Farmers in Dak Lak spent the largest money for crop pruning practices, fertilization labor, and irrigation. By contrast, farmers in Kon Tum spent least in pruning practices, irrigation, processing, and pesticide spraying cost. Farmers in Gia Lai spent least in fertilization labor, and processing cost. This means that farmers in Kon Tum and Gia Lai province are mainly sell coffee cherry shortly after harvesting. Farmers in Lam Dong spent more on harvesting and processing practices, and pesticide spray labor.

As above presented, farmers in Dak Lak are technically better than their neighbors, followed by farmers in Lam Dong, then Dak Nong, Gia Lai, and Kon Tum. Will the technical capacity drive to financial success of farmers? In next section we will analyze cost-benefit of different AFS systems by provinces

5. Economic assessment of AFS systems

Details of production cost and profit of individual crops and the whole AFS system are presented in **Table 4**. There are several indicators of statistical difference.

Farmers in Lam Dong spent the largest coffee production cost and enjoyed the highest yield of coffee. By contrast, farmers in Gia Lai spent least in coffee production cost, and had lowest coffee yield and net profit from the crop.

Net profit of coffee is highest in Dak Lak, followed by Lam Dong, then Dak Nong, and lowest in Gia Lai. Total revenue from the 2nd crop. Largest in Dak Lak with an average of 263 mil.VND/ha.year, lowest in Lam Dong, of 29 mil.VND/ha.year.¹

¹ X-change rate: US\$=23,000 VND.

Table 2. Details of input used for AFSs by provinces (N=189)

Input	Detail	Unit	Dak Lak (N=38)		Lam Dong (N=47)		Gia Lai (N=25)		Kon Tum (N=36)		Dak Nong (N=43)		Sig.
			% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean			
NPK	No. of application	times	95	4.8	89	2.7	80	2.8	64	2.6	98	4.5	.00
	Quantity	kg/ha	95	3,585.2	89	1,938.5	80	1,436.1	64	1,719.1	98	2,671.5	.40
Single fertilizer / combinant	No. of application	times	47	1.1	45	1.1	44	1.0	42	1.2	60	1.2	.98
	Quantity	kg/ha	47	617.6	45	2,213.4	44	454.0	42	488.8	60	760.5	.34
Manure/ compost	No. of application	times	71	1.3	60	1.0	72	1.4	28	0.5	70	1.6	.03
	Quantity	kg/ha	71	5,491.6	60	3,974.6	72	3,500.6	28	992.9	70	3,475.6	.05
Irrigation	No. of irrigation	times	100	6.7	47	1.0	96	4.3	69	3.0	93	4.4	.00
	No. of application	times	82	2.6	66	2.3	80	1.8	56	1.3	63	1.4	.06
Insecticide	No. of application	litter/ha	82	8.9	64	7.9	76	5.5	56	5.0	60	4.9	.18
	Quantity	litter/ha	82	8.9	64	7.9	76	5.5	56	5.0	60	4.9	.18
Fungicide	No. of application	times	47	1.3	30	0.8	28	0.4	19	0.4	49	1.1	.10
	Quantity	litter/ha	42	3.3	28	3.6	28	1.0	19	1.4	49	3.2	.34
Herbicide	No. of application	times	5	0.1	15	0.3	4	0.1	6	0.1	12	0.2	.34
	Quantity	litter/ha	3	0.1	15	1.4	4	0.4	6	0.2	12	0.3	.05
Stimuli	No. of application	times	26	0.5	13	0.3	28	1.0	11	0.3	14	0.3	.21
	Quantity	litter/ha	24	1.6	13	0.4	28	2.3	11	0.6	14	0.6	.06
Cocktail	No. of application	times	5	0.1	28	0.9	12	0.2	17	0.4	37	0.9	.01
	Quantity	litter/ha	5	0.1	28	4.1	12	0.8	17	0.8	37	4.1	.00
Total pesticides	No. of application	times	95	4.5	96	4.6	100	3.5	67	2.5	95	4.0	.05
	Quantity	litter/ha	95	13.9	94	17.3	96	10.0	67	7.9	93	13.2	.01

Note: X-change rate 1 US\$ = 23,000 VND

Table 3. Production cost of AFSs by provinces

(N=189, Unit: '000VND)

Cost item	Dak Lak (N=38)		Lam Dong (N=47)		Gia Lai (N=25)		Kon Tum (N=36)		Dak Nong (N=43)		Sig.
	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	
Land preparation	100	855.0	100	1,000.8	100	780.5	100	765.2	100	502.7	.07
Land addressing	100	7,477.9	100	5,044.5	100	6,728.5	100	11,320.7	100	10,295.1	.69
Seeding	100	601.0	100	798.8	100	583.6	100	1,111.7	100	555.0	.61
Pruning	100	7,358.0	100	6,586.4	100	5,012.6	100	3,988.7	100	5,724.9	.01
NPK	95	20,289.4	89	19,860.2	80	14,267.6	64	15,730.0	98	25,730.6	.25
Single fertilizer/ combinant	47	3,558.1	45	8,263.3	44	2,515.1	42	3,874.3	60	5,720.2	.22
Manure/compost	71	13,169.4	60	13,732.7	72	9,622.7	28	2,605.7	70	8,986.6	.06
Fertilization labor	100	3,014.4	100	2,823.0	100	1,549.8	81	1,563.1	100	2,238.5	.00
Irrigation cost	100	2,389.9	45	1,182.7	96	1,458.5	69	985.4	93	2,114.7	.04
Harvest	100	8,702.9	100	14,662.9	96	7,314.5	100	11,729.2	98	9,251.5	.00
Processing	95	2,685.0	66	3,874.5	32	286.3	6	266.2	98	2,588.5	.04
Insecticides	82	1,138.2	66	1,616.8	80	692.2	56	557.1	63	916.0	.05
Fungicides	42	468.5	30	740.6	28	174.6	19	164.6	49	591.4	.29
Herbicides	3	5.9	15	111.3	4	22.7	6	13.9	12	58.8	.08
Stimuli	26	506.4	13	184.0	28	319.6	11	122.6	14	147.9	.25
Cocktails	5	9.2	28	583.8	12	160.5	17	160.3	37	965.2	.00
Total pesticides	95	2,128.2	96	3,236.5	100	1,369.6	67	1,018.5	95	2,679.2	.00
Total spraying labor	92	2,040.7	96	2,443.2	100	1,488.9	67	996.4	95	1,482.2	.00

Table 4. Profit of AFSs by provinces (N=189)

Crop	Criteria	Dak Lak (N=38)		Lam Dong (N=47)		Gia Lai (N=25)		Kon Tum (N=36)		Dak Nong (N=43)		Sig.
		% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	% of HH applied	Mean	
Coffee	Total production cost	100	54,349.3	100	73,738.3	96	41,056.0	100	44,848.5	100	55,594.5	.00
	Total material cost	100	27,065.9	100	40,599.9	100	22,092.8	100	19,818.8	100	34,618.3	.00
	Yield	97	2,296.7	100	2,840.4	100	1,716.4	100	1,948.4	98	1,969.9	.01
	Price	97	35.9	100	33.2	100	27.8	100	26.8	98	34.3	.00
	Total revenue	97	82.0	100	96.7	100	49.3	100	55.8	98	68.9	.00
	Net profit	100	28.1	100	23.0	88	9.5	100	11.0	100	15.6	.34
2nd crop	Total production cost	68	19,575.4	60	7,412.4	88	11,136.3	92	10,428.7	84	21,959.6	.08
	Total material cost	68	12,856.1	62	4,100.3	88	6,083.6	92	3,975.3	84	8,820.0	.06
	Total revenue	68	262.9	62	29.0	88	47.3	92	46.6	84	48.9	.00
	Net profit	68	243.3	60	20.5	88	37.7	92	36.2	84	26.9	.00
AFS	Total revenue	100	305.4	100	81.0	96	68.1	100	78.7	100	76.6	.00
	Net profit	100	271.4	98	43.1	92	44.2	100	47.2	100	42.5	.00

This figure is of less than 50 mil.VND/ha.year in other provinces. Having more fruit tree like durian and avocado explains for the largest revenue received by farmers in Dak Lak whilst farmers in other provinces having less value crops such as pepper, litsea, annual crops (**cf. Table 1**).

In combination, net profit from AFSs is largest in Dak Lak with an average of 271 mil.VND/ha.year and lowest in Dak Nong of 42.5 mil.VND/ha.year. However, this figure is of less than 50 mil.VND/ha.year in other provinces.

AFS economic performance is thus not only related to farmer's technical know-how, but also their choice of second crop. High market price for durian and avocado in 2018 made AFS1&4 enjoyed better income whilst low pepper market price in 2018 made AFS2 farmers troubled. Dominated by AFS1 made Dak Lak highest in net AFS profit. By contrast, dominated by AFS2 made Dak Nong lowest in net AFS profit (**cf. Table 1**).

CONCLUSIONS

AFSs have proved their capacity in enhancing farmer's income. Though with a large variation, the 2nd crop has contributed positively to total AFS net profit. Economic successful farmers in Dak Lak proved that difference in farmer's technical know-how and choice of the 2nd crop made a huge difference in farmer's income in 2018.

Given land degradation caused by long-time dominance of monocultures in the Central Highlands of Vietnam that induces to poor soil (water and nutrient) holding capacity. For the same quantity of chemical inputs, more application times will enhance fertilization efficiency. In the Central Highlands situation, lot of fertilizers applied proves ineffective. For instance, in the study of **Thong and Niekdam (2016)** conducted in Dak Lak, the average technical efficiency score is 0.64 and statistically significant, meaning that coffee farmers may have a potential improvement of coffee production of about 36% without increasing input production factors. The combination of more manure/compost utilization and more NPK application times is thus likely factor contributing to success of farmers in the province.

Given the poor market organization in Vietnam (**Hoi, Mol et al 2009**) with small farming scale and market and climate uncertainties, not monocrop but integrated cropping system can provide farmers a more secured markets and better income. In addition, integrated cropping system in appropriate structure and density, or in this research: agrofor-

estry – is a good farming choice to cope with various risks being and will be encountered by small scale Vietnamese farmers in the increasingly risky future - for not only in terms of climate changes and market demands but also other socioeconomic risks like financial and labor availability, and save the environment, especially for biodiversity, soil and water resources.

Ecologically speaking, systems of more diversified crops will have better resilient capacity under biological (i.e., pests and diseases), climate and market stresses. More than half of all land in the tropics, is too dry, too steep, or too rocky to be classified as arable land (**Bene, Beall et al 1977**). In addition, sloping land which constitutes 60% to 90% of the land resources in Southeast Asian countries, has been extensively affected by soil erosion resulting from unsustainable farming practices, often driven by intensive monocultures (**Craswell, Sajjapong et al 1998**). Promotion of agroforestry in Vietnam in particular and the tropics in general is thus needed, not only for surviving increasing population but also recovering and protecting the environment.

Together with concern on agroforestry development, a restructure of farming system needs to be considered in accordance with foreseeable difficulties in farming conditions, i.e., more water stress will be happened in provinces like Kon Tum, Gia Lai and Dak Lak under climate changes (**cf. CGIAR, 2016**). These provinces should take a shift more toward less-irrigation dependent crops and reduce their dependence on coffee. These changes will create a better common guarantee for all farmers in coping with future uncertainties.

ACKNOWLEDGEMENT

The research is a part of larger project funded by Vietnamese government (Project code: ĐTDL. CN-18/18) implemented in the Central Highlands of Vietnam, from 2018 to 2020

REFERENCES

- Bene, J.G., Beall, H.W. and Cote A., 1977. Trees, Food, and People: Land management in the tropics Ottawa, Canada, IDRC, pp. 1-52.**
- CGIAR, 2016.** The drought crisis in the Central Highlands of Vietnam, CGIAR Research Centers in Southeast Asia. **Assessment Report, 18 - 22 April 2016 Kon Tum, Gia Lai, Dak Lak, Vietnam, pp. 1-35.**

- Craswell, E.T., Sajjapongse, A., Howlett, D.J.B., and Dowling, A.J. 1998. "Agroforestry in the management of sloping lands in Asia and the Pacific " *Agroforestry Systems* 38, 121-137.
- DakLakDOS 2016. *Statistical Year Book*. D.O. Statistics. Dak Lak: Vietnam, Dak Lak Department of Statistics, pp. 1-43.
- DWRM 2011. "The Central Highlands: Ground water is increasingly reduced-an important issue." Retrieved May 12, 2019, from http://www.nawapi.gov.vn/index.php?option=com_content&view=article&id=847:tay-nguyen-nuoc-ngam-ngay-cang-sut-giam-van-de-dang-quan-tam&catid=3:tin-trong-nuoc&Itemid=7&lang=vi.
- FAO 2017. "Agroforestry." Retrieved June 6, 2019, from <http://www.fao.org/forestry/agroforestry/en/>
- GiaLaiDOS 2016. *Statistical Year Book*. D.O. Statistics. Gia Lai: Vietnam, Gia Lai Department of Statistics.
- Hang, N. 2011. Coffee market: the three historical marketing marks. Retrieved July 3, 2019, from <http://cafef.vn/hang-hoa-nguyen-lieu/thi-truong-ca-phe-3-moc-lich-su-dang-nho-20110314023922407.chn>.
- Hoan, C. and Trung, D. 2013. "The Central Highlands faced with exhausted groundwater." Retrieved June 3, 2019, from <http://www.sggp.org.vn/tay-nguyen-kiet-nguon-nuoc-ngam-149578.html>.
- Hoi, P.V., Mol A.P.J. and Oosterveer P.J.M. 2009. Market governance for safe food in developing countries: the case of low-pesticide vegetables in Vietnam." *J. of Environmental Management* 91(2), 380-388.
- Hung, C.Q. 2019. The lowest record of coffee price: farmers faced loss. Retrieved July 3, 2019, from <https://www.msn.com/vi-vn/news/newsother/gi%C3%A1-c%C3%A0ph%C3%AA-xu%E1%BB%91ng-th%E1%BA%A5p-k%E1%BB%B7-l%E1%BB%A5c-khi%E1%BA%BFn%C3%B4ng-d%C3%A2n-thua-l%E1%BB%97-n%E1%BA%B7ng/ar-AABaFmR>.
- IRC 2018a. The first independent assesemt on the level technological adoption by coffee farmers in Kon Tum province. Hanoi, Vietnam, Indochina Research & Consulting Vietnam.
- IRC 2018b. The first independent assesemt on the level technological adoption by coffee farmers in Lam Dong province. Hanoi, Vietnam, Indochina Research & Consulting Vietnam.
- Khanh, V. 2019. "Durian market price strongly reduced." Retrieved July 3, 2019, from <http://baodansinh.vn/gia-sau-rieng-giam-manh-d95683.html>.
- KonTumDOS 2016. *Statistical Year Book*. D.O. Statistics. Kon Tum: Vietnam, Kon Tum Department of Statistics.
- LamDongDOS 2016. *Statistical Year Book*. D.O. Statistics. Lam Dong: Vietnam, Lam Dong Department of Statistics.
- Lich, K. 2019. The Central Highlands suffered from migrants." Retrieved June 3, 2019, from <http://cand.com.vn/Phong-su-tu-lieu/Tay-Nguyen-gong-minh-ganh-dan-di-cu-tu-do-537450/>.
- Lung, N. N., Sam, D.D., et al. 2015. *Viet Nam Forest Ecological Stratification Report*. Hanoi: Vietnam, UN-REED.
- Sau, N. 2017. "Crops are destroyed after utilization of fake chemical fertilizers." Retrieved June 4, 2019, from <http://m.baodaknong.org.vn/toa-soan-va-ban-doc/tieu-ca-phe-chet-vi-phan-rong-vang-hay-rong-den--57806.html>.
- Sen, P.T. 2015. Overview of agroforestry in Vietnam. *Agroforestry: the way forward*. New Delhi, India.
- Thiennhien.net 2013. "Land degradation is exegerated in the Central Highlands." Retrieved June 3, 2019, from
- Thinh, H. 2017. *Dak Nong: the crop was destroyed after utilization of NPK.* Retrieved June 4, 2016, from <https://baomoi.com/dak-nong-cay-trong-chet-sau-khi-duoc-bon-phan/c/22020501.epi>.
- Thong, H.Q. and Niekdam, T. H. 2016. "Labor Dependence, Income Diversification, Rural Credit, and Technical Efficiency of Small-Holder Coffee Farms: A Case Study of Cu M'gar District, Dak Lak Province, Vietnam." *Journal of Economic Development* 23(4), 22-41.
- Tran, D. 2016. "The Central Highlands badly hit by droughts". Retrieved June 3, 2019, from <https://vnexpress.net/thoi-su/tay-nguyen-oan-minh-trong-dai-han-lich-su-3378492.html>.
- TTXVN 2018. "Increased integration of fruit crops into coffee farms ". Retrieved June 3, 2019, from <https://bnews.vn/trong-xen-can-h-cay-an-qua-o-at-trong-vuon-ca-phe-o-dak-lak/83394.html>.
- Uyen, P. 2012. "Coffees are cut and replaced by coffee." Retrieved June 3, 2019, from <https://nongnghiep.vn/dua-nhau-chat-ca-phe-trong-tieu-post94287.html>.

VPA 2017. "Peper exports: lesson for sustainable market." Retrieved July 3, 2019, from <http://peppervietnam.com/xuat-khau-ho-tieu-bai-hoc-ve-binh-thi-truong/>.

Yen, T.V. 2019. "Massive pepper death in the Central Highlands: farmers falt into debt trap." Retrieved June 3, 2019, from <https://tintaynguyen.com/ho-tieu-tay-nguyen-chet-hang-loat-nguoi-trong-roi-vao-vong-xoay-no-nan/860665>