Sustainability of Small-Scale Vegetable Growers in the Context of the Thailand-China Free Trade Agreement: Case Study of Onion, Shallot, and Garlic Production in Chiang Mai Province

Nawan Thinnarach[1], Kamol Ngamsomsuke[2], Benchaphun Ekasingh[3] and Anupong Wongchai[4]
Agricultural Systems program, Faculty of Agriculture,
Chiang Mai University, Chiang Mai, Thailand

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Abstract
This research aims to ascertain the sustainability of small-scale vegetable growers in the context of the Thailand-China Free Trade Agreement, specifically for onion, garlic, and shallot production. The Sustainable Livelihood Framework (SLF) was applied to identify asset ownership, strategy implementation, and outcome. The study concerned the relationship between livelihood assets and livelihood strategies during 2008 – 2018. The sustainable livelihood of vegetable growers in this study is measured by their income change between 2008 - 2018 due to the Thailand-China FTAs.

The results show four variables affecting the sustainable livelihood of vegetable growers in Chiang Mai. They include the age of the household head, adaptation strategy against the impact of China-Thailand FTAs, change in production investment or cost, and amount of credit used in 2018. For overall vegetable growers, the older household heads were able to increase their household income. The same was true for onion and shallot growers. The adoption of adjusting production or marketing strategy against the impact of China-Thailand FTAs could cause all type of vegetable growers to increase or decrease their household income. That is, it caused onion and shallot growers to lose their household income. While such a strategy cause garlic growers to lower their income. Interestingly, an increase in production investment could cause all types of vegetable growers and garlic growers to lose or increase their income, but shallot growers could enjoy a higher income. On the other hand, the amount of credit used in 2018 affected only onion growers' household income to increase.

[1] Ph.D. Candidate, Agricultural Systems program, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand. Correspondent Author: nimnawan@gmail.com

[2] Assistant Professor, Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, 239 Suthep Rd, Chiang Mai, 50200, Thailand.

[3] Associate Professor, Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, 239 Suthep Rd, Chiang Mai, 50200, Thailand.

[4] Assistant Professor, Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, 239 Suthep Rd, Chiang Mai, 50200, Thailand.

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1. Introduction

After China became a member of the World Trade Organization, many countries became aware of China's competitiveness because China could expand its role in the world economy. With the advantage of a large domestic market, China had the largest population and cheaper labor costs compared to other Asian countries. Therefore, China is able to support agricultural production, domestic consumption, and high export potential. Many countries developed their production and government policy to increase competitiveness. The China-ASEAN Free Trade Agreement stipulates that signatory countries can import some groups of products with reduced tariffs before the date issued, which is known as Early Harvest (Kingkorn, 2006; Sapphasri *et al.*, 2013). In the case of international trade, Thai farmers were put on the losing side when negotiators projected the outcome of FTAs, while a number of farmers were anticipated to benefit from lowering trade barriers and wider market access. Their market access and prices continue to depend on middlemen who also have to struggle with increasing competitors in the newly liberalized markets (Prachasan, 2009). Nirathorn (2007) study on the effects of Free Trade Agreements (FTAs) on the livelihood of farmers who grow onions in the Fang district in Chiang Mai province and other stakeholders. The result found that FTAs not only affected the livelihood of farmers but highlighted the chronic problems that have not been solved, some of which originated from government measures. Cost reduction, increased production, and some farmers turned to casual workers were coping with the impacts. The study recommends that the government should have a crucial role in productivity improvement and reduced production costs.

For the bilateral trade agreement, in which tariffs were removed on a significant number of fruits and vegetables traded between the two countries, has created a flood of cheaper imports of fruits and vegetables into Thailand. Consumers have access to more opportunities for consumption because there are more kinds of fruits and vegetables because fruits and vegetables imported from China have an advantage over Thai fruits and vegetables in price, taste, freshness, and quality. Most Chinese fruits and vegetables can substitute for Thai produce and are quite price competitive in Thailand. This would likely have led to the loss of the trade balance with a negative effect on the growers if the consumers changed their behavior and consumed more Chinese fruits and vegetables.

The Sustainable Livelihood Framework (SLF) was used to identify asset ownership, implemented strategy, and achieve an outcome, institution influence, and vulnerability faced by smallholders in sustaining their livelihoods (DFID, 1999: UNDP, 2017). Thus, this paper tried to present the effects of livelihood assets on growers' strategies and outcomes in onion, garlic, and shallot production in the study areas. A livelihood approach looks to promote choice, opportunity, and diversity, which are used to denote a range and combination of activities and choices that people make in order to achieve livelihood goals.

2. Methodology

Study area

This study was conducted in Chiang Mai province, located in the northern region of Thailand. Chiang Mai has important cities, the main agricultural areas that produce

agricultural products for domestic consumption, export, and import, especially for onion, garlic, and shallot, which are exported to other ASEAN countries. Fang, Chaiprakarn, and Mae Wang districts in Chiang Mai were the main study areas in this research.

Sample sizes and data collection

Sample sizes

In this research, the number of samples was calculated from the total number of vegetable growers in Chiang Mai province using of Taro Yamane formula (Yamane, 1973) in the case of vegetable populations. The total number of vegetable growers growing onion, garlic, and shallot in Chiang Mai province included 8,870 households, 2,779 4,555, and 1,536 households for garlic, onion, and shallot growers, respectively. Form field survey collected 262 samples from the growers who are head of household and adapt themselves from FTAs' impact by strategy 1 (production or marketing adjustment) and strategy 2 (Request to postpone import period) in the number of 133, 87, and 42 samples of onion, garlic, and shallot grower respectively.

Data collection

The secondary data identified vegetable production and supply chain systems for evaluating vegetable production in local and regional markets from related documents and government, semi-government, and non- governmental organizations with vegetable production, vegetable market, farmer adaptations, and measurement methods. In addition, related trade policies, especially for FTAs, were collected from related documents and internet websites related to Thailand and China's agricultural trade.

Primary data collection collected supporting data to analyze all objectives through the small-scale vegetable growers in the study area who had an important role and were affected by trade policies such as FTAs. In this study, the data was collected from key informants using the questionnaire for individual interviews and focus groups, which includes the general characteristics of the study areas: socio-economic, demographic data, biophysical characteristics of vegetable production, and their adaptation strategy.

The framework of the study

The sustainable livelihoods approach is a way of thinking about the objectives, scope, and priorities for development activities. It is based on thinking about the livelihood and the importance of policies and institutions. It helps formulate development activities that include people-centered, responsive and participatory, multilevel, conducted in partnership with the public and private sectors, dynamic, and sustainable (Serrat, 2008). The concept of the approach has begun at the United Nations Conference on Environment and Development in 1987 and provides a guide in which to improve people's understanding of livelihood in terms of their assets and the capabilities in the policies, institutions, and processes that enhance their access to capital, may be increasing or decreasing the vulnerability. The approach also examines the risks, shocks, and stresses of households and how their cope and adapt to long-term periods on the effect of a change to the livelihoods in the context of capability, equity, and sustainability, which are mentioned as the fundamental principles to sustainable livelihoods (Chamber and Conway, 1992).

This study used the livelihood approach as a framework based on a sustainable livelihoods framework with a focus on livelihood assets and livelihood strategies (Chambers and Conway, 1991, UNDP, 2017). Factors that contribute to households' economic reliance on economic activity in general and on livelihood capital in particular may vary depending upon the type of resource funding, demographic characteristics, economic characteristic,

market situation, the fluctuation of prices, policies, and technology. The livelihood framework is micro/household focused and is able to help them understand the relationship between local institutions and policy (Hussein, 2002). The livelihood framework might be used as a checklist for structuring ideas. It can be applied in the form of a livelihood analysis to assess what development activities are suitable for the livelihood. Livelihood analysis utilized a broad range of conventional methods and instruments, such as Participatory Poverty Assessment (PPA), Participatory Rural Appraisal (PRA), and Good Governance Assessment techniques (Kollmair and Gamper, 2002). Phongchiewboon, Holland, and Farrelly, (2012). Example of research about Socio-ecological perspectives on sustainable livelihood and environmental management in Northern Thailand's national park. Aim to investigate the relationship between sustainable livelihood and natural resource management of communities in the context of enhancing compatibility. The results show that sustainable livelihood activities are related to environmental conservation initiatives, such as annual forest restoration, the establishment of fire breaks, water resources management, and community-based ecotourism, which are vital parts of natural resource management in northern Thailand's national park communities. IFAD (2014) implemented Economic Inclusion Program for Families and Rural Communities in the Highlands, Lowlands and Inter-Andean Valleys in Bolivia. The Economic Inclusion Program would strengthen three types of resilience include agri-environmental resilience (adaptation measures and investments in conservation, restoration, and management of agricultural land and ecosystems), cultural resilience (recovery of local knowledge of agroclimatic prediction), and social and human resilience (development of risk management plans). The program implements Adaptation techniques, including Capacity-building for community-based adaptation and Climate risk management.

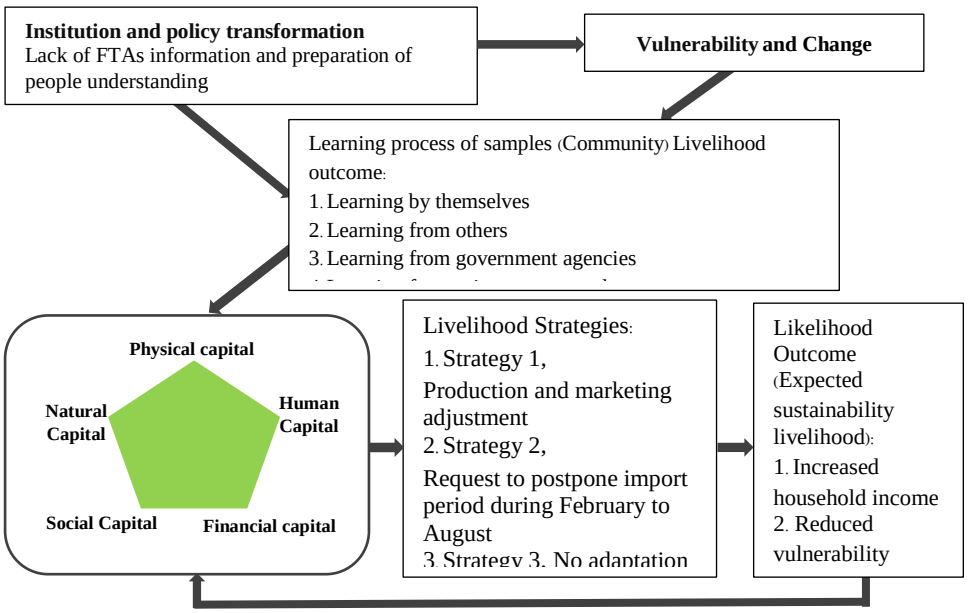

Figure 1 The relationship between income change from the Thailand-China Free Trade Agreement and livelihood strategies

The following process was used to analyze small-scale vegetable farmers' livelihoods under the sustainable livelihoods framework. The overall objective of this study was the determine the effects of livelihood assets on outcomes in onion, garlic, and shallot production in the study areas (Figure 1).

The model used in the study

This study aimed to determine the relationship between income change from the Thailand - China Free Trade Agreement and livelihood strategies. Multinomial logistic regression model is used to study the relationship between a dependent variable and one or more independent variables (Green, 2002). Multinomial logistic regression (MNL) was used to predict categorical placement in the probability of category membership on a dependent variable based on multiple independent variables. To describe the MNL model, let y denote a random variable taking on the values $\{1,2....j\}$ for choices j, a positive integer, and let x denote a set of conditioning variables. Therefore, x represents a number of climate attributes, environmental, socioeconomic characteristics of households, and other factors. Since the probabilities must sum to unity, $P(y=j/x)$ is determined once we know the probabilities for $j = 2...j$. The MNL model has response probabilities:

$$P(y=j/x) = \frac{\exp(x\beta_i)}{1+\sum_{k=1}^{j}\exp(x\beta_k)\, j=1,...,j}$$

Where β_i is k x 1, $j = 1, \dots, j$

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change or probabilities.

The independent variables could be either dichotomous or continuous and necessitate careful consideration of the sample size and examination for outlying cases. A multinomial logit model was fit for the full factorial model, and parameter estimation was performed through an iterative maximum- likelihood algorithm (Greene, 2002; Vanichbuncha, 2005). The model was used by following Hosmer and Lemeshow 2000; Sosina, Holden, and Barrett, 2010; Mustapha, Tanko, and Abukari, 2017, to express the probability of a farmer being in a particular category in the general form of the multinomial Logit model:

$$\Pr(y_i = j) = \frac{\exp(Xi\ \beta j)}{1+\sum_{j=1}^{J}\exp(Xi\ \beta j)} \quad \dots\dots (1)$$

And to ensure identifiability,

$$\Pr(y_i = 0) = \frac{1}{1+\sum_{j=1}^{J}\exp(Xi\ \beta j)} \quad \dots\dots (2)$$

where for the 1th individual,

y_i refers to the observed outcome.

X_i refers to a vector of explanatory variables.

β refers to the unknown parameters.

Testing significance of the coefficients, the Wald test is obtained by comparing the maximum likelihood estimate of the slope parameter, $\hat{\beta}$, to an estimate of its standard error.

The resulting ratio under the hypothesis that $\beta = 0$, will follow a standard normal distribution. Hauck and Donner (1977) examined the performance of the Wald test and found that it behaved in an aberrant manner of the failing to reject the null hypothesis when the coefficient was significant, they recommended that the likelihood ratio be used. Jennings (1986a) has also looked at the adequacy of inferences in logistic regression based on Wald statistics. His conclusions are similar to those of Hauck and Donner.

The Wald statistic, the tests are based on the distribution of the full rank quadratic (Greene, 2002),

$$\text{If x} \sim N_J[\mu, \Sigma], \text{then } (\text{x} - \mu)(\text{x} - \mu)' \Sigma^{-1}(\text{x} - \mu) \sim \text{chi} - \text{squared } [J]$$

In the setting of a hypothesis test, under the hypothesis that $E\ (\text{x}) = \mu$, the quadratic form has the chi-squared distribution. If the hypothesis that $E\ (\text{x}) = \mu$ is false; however, then the quadratic form just given will, on average, be larger than it would be if the hypothesis were true.

Let $\hat{\theta}$ be the vector of parameter estimates obtained without restrictions, hypothesize a set of restrictions especially,

$$H_0 : \text{c}(\theta) = \text{q}.$$

If the restrictions are valid, then at least approximately θ should satisfy them. If the hypothesis is erroneous, however, then $\text{c}(\hat{\theta}) = \text{q}$ should be farther from **0** than would be explained by sampling variability alone. The device we use to formalize this idea is the Wald test. The independent variables used in the correlation matrix analysis are presented in Table 1.

Table 1 Variables included in the analysis of the change in income from vegetable production due to adaptation strategy

Variables	Description	Data Type
Dependent variable		
Y	Household income change between 2008 and 2018 (100,000 baht)	
	1 = Decreased household income	
	2 = No change in household income	
	3 = Increased household income	
Independent variables		
Overall vegetable growers' model		
X_1	Growers' age as of 2018: Age of household head (year)	Continuous
X_2	Education literacy of the growers as of 2018	
	1 = Primary school	
	2 = Higher than primary school	
X_3	Membership of agricultural cooperative status in 2018:	Nominal
	1 = Being a member of cooperative	
	0 = Not being a membership	
X_4	Farm experience as of 2018 (Years)	Nominal
	Lowest through 20 years	
	21 years through the highest	
X_5	Farm size change between 2008 - 2018	Nominal
	1 = Lowest through 0.080 rai	
	2 = 0.081 rai through the highest	

Variables	Description	Data Type
X_6	Growers' Adaptation strategy during 2008-2018:	Nominal
	Adaptation strategy which the growers choose to cope with the impact of FTAs	Nominal
	1 = Production or marketing adjustment	
	2 = Request to postpone the import period	
	3 = No adaptation	
X_7	Production cost change between 2008 – 2018 (100,000 baht)	Nominal
	1 = Lowest through 0.610	
	2 = 0.611 through the highest	
X_8	Amount of credit used in 2018 (100,000 baht/year)	Continuous
Onion growers' model		
X_1	Growers' age as of 2018: Age of household head (year)	Nominal
	1 = Lowest thru 50 years old	
	2 = 51 years old through the highest	
X_5	Farm size change between 2008 - 2018: Farm size change between 2008 - 2018	Nominal
	1= Lowest through 0.080 rai	
	2 = 0.081 rai through the highest	
X_6	Growers' Adaptation strategy during 2008-2018:	Nominal
	Adaptation strategy which the growers choose to cope with the impact of FTAs	
	1 = Production or marketing adjustment	
	2 = Request to postpone the import period	
	3 = No adaptation	
X_7	Production cost change between 2008 - 2018: Value of agricultural production cost change (100,000 Baht/year)	Continuous
X_8	Amount of credit used in 2018 (100,000 baht/year)	Continuous
Garlic growers' model		
X_1	A Grower's age as 2018: Age of the grower as of 2018: Age of household head (year)	continuous
X_6	Growers' Adaptation strategy during 2008 - 2018:	Nominal
	Adaptation strategy which the growers choose to cope with the impact of FTAs	
	1 = Production or marketing adjustment	
	2 = Request to postpone the import period	
	3 = No adaptation	
X_7	Production cost change between 2008 - 2018: Value of agricultural production cost change (100,000 Baht/year)	Continuous
X_8	Amount of credit used in 2018 (1,000 baht/year)	Continuous
Shallot growers' model		
X_1	Growers' age as of 2018: Age of household head (year)	continuous
X_5	Farm size change between 2008 - 2018	Nominal
	1= Lowest through 0.080 rai	
	2 = 0.081 rai through the highest	
X_6	Growers' Adaptation strategy during 2008 - 2018:	Nominal
	Adaptation strategy which the growers choose to cope with the impact of FTAs	
	1 = Production or marketing adjustment	
	2 = Request to postpone the import period	
	3 = No adaptation	
X_7	Production cost change between 2008 - 2018: Value of agricultural production cost change (100,000 Baht/year)	Continuous

This study focused on the relationship between the Thailand-China Free Trade Agreement impact and livelihood strategies, represented by Y (dependent variable) as the function of independent variables X_1, X_2, X_3, X_4, X_5, X_6, X_7, and X_8.

This study defined the change in household income between 2008 – 2018, which was divided into three groups of income change (100,000 baht). The group of household income change consisted of decreased household income (lowest through -9.530%), no change in household income (-9.529% through 10.530%), and increased household income (10.531% through the highest).

Results

1. Livelihood Assets

1.1 Human capital

Human capital depends on the general characteristics of the study areas, including farm labor, household head education level, and household head gender and status. Regarding education level, 90% of household heads studied in primary school, 3.4% of growers had an undergraduate education or higher, and 2.2% of growers who studied in secondary school. Heads of household had more than 15 years of experience in agriculture. From the field survey, 47.90% of heads of households had 21-30 years of experience growing onion, garlic, or shallot, with 38.70%, 10.70%, and 2.40% of heads of households with 11-20 years, 31-40 years, and 1-10 years of experience, respectively.

For the adaptation strategies used to cope with the impact of FTA in this study, the growers' adaptation strategies were grouped into three adaptation strategies to cope with FTA/s impact based on the field survey: production and marketing adjustment, request to postpone import period during February – August, and no adaptation.

2.2 Natural capital

Natural capital includes total land holding and average planted areas. The households in the study areas have an average total landholding of 8.75 raises, 86.40% of the growers have 1-2 plots for agriculture, 12.60% have 3-4 plots, and 1% have more than five plots. The average household farm size was 5.5 rais. The major crop in Chiang Mai province was annual rice because of the availability of irrigation and intensive care for onion, garlic, and shallot for better prices as economic crops.

2.3 Physical capital

The households in the study areas could get seed for agriculture production from three main sources: agricultural cooperatives for onion seed and other growers' and growers' own seed for shallot and garlic. For onion production, growers used 1 pound for 1.5 rais, and there was an average seed cost of 2,500 baht per rai. For shallot and garlic production, the growers used 75-80 kilograms per rai. The average cost of land preparation found in the study included a machine to prepare land for 1,200 baht per rai and farm labor for 2-3 persons per rai.

2.4 Social capital

The social capital of each community was very important. It included connections to supports to cope with shocks and vulnerability, such as providing subsidies, giving production technologies by extension assistance, and shared labor at the time of growing, weeding, and harvesting seasons. It was found that 80.60% of households were members of

agricultural cooperatives and farmer groups, and 19.40 % were not. Regarding extension and technological assistance in the study areas, it found that there was 17.70% of all households had no extension staff visiting their fields.

2.5 Financial capital

Financial capital refers to the average household income, production cost, and amount of household credit. The results showed that households in the study areas had total incomes of 150,000 – more than 1,000,000 baht. Most households had total incomes of 750,000 – 1,000,000 baht. The main source of income was agricultural production, and off-farm and non-farm activities also contributed to capital. Credit was accessed through the Bank of Agriculture, agriculture cooperatives, village funds, and other sources from other growers. For household credit, 50% of households in the study area could access credit from domestic financial organizations, with an average debt of 138,786.92 baht per year. 65% of household debt comes from the Bank of Agriculture and agricultural and cooperatives, 9.6% from agricultural cooperatives, and 3.6% from village funds. 22% had no total household debt; these households could manage their money for household consumption and agricultural production all year.

Table 2 Livelihood asset of vegetable growers in the study area.

Livelihood asset	Decreased household income	No change in Household income	Increased household income	Total
1. Social Capital				
Membership of agricultural cooperative status in 2018				
Being a member of cooperative	72	168	33	273
Not being membership	15	30	17	62
Farm experience as of 2018 (Years)				
Lowest through 20 years	41	77	21	139
21 years through the highest	46	121	29	196
2. Human capital				
Education literacy as of 2018				
Primary school	80	184	49	313
Higher than primary school	7	14	1	22
Adaptation strategy during 2008 - 2018				
Production or market adjusted	42	70	25	137
Request to import period	26	91	8	125
No adaptation	19	37	17	73
Apply post-harvest technology to keep fresh yield before the sale in the market as of 2018?				
No apply post-harvest technology	78	173	50	301
Apply post-harvest technology to keep fresh yields	9	25	0	34
3. Physical capital				
Farm size change between 2008 – 2018				
Lowest through 0.080 rai	52	104	31	187
0.081 rai through the highest	35	94	19	148
4. Natural Capital				
Water available for agriculture production as of 2018				
Arid land	2	12	0	14
Irrigated land	85	186	50	321
5. Financial capital				
Production cost change between 2008 – 2018 (100,000 baht)				

Livelihood asset	Decreased household income	No change in Household income	Increased household income	Total
Lowest thru 0.610	60	164	35	259
0.611 through highest	27	34	15	76
Amount of household credit used in 2018 (Baht per year)				
Lowest through 100,000 baht	45	105	25	175
100,001 baht through highest	42	93	25	160

Source: Field survey 2018

3. Factors affecting household livelihood assets (household income) of vegetable growers

This study used Multinomial logistic regression to analyze the factors influencing the household income change for Thai-China FTAs' impact on small-scale growers. MNL analyzed several variables in this study, and *No change in household income* to FTAs impact was a reference category.

3.1 Overview model (Overall vegetable growers' model)

Table 3 shows the statistical tests for model fitness of factors influencing the change of income of growers under Thailand-China's FTA during 2008-2018. The Likelihood ratio tests, there are 0.001 ($p - value \leq 0.05$), state that the model can estimate the change of household income from the impact of FTAs. The likelihood-ratio test is based on deviance which is the difference between two times the likelihood of empty and overall vegetable growers' model [−2 log likelihood]. The chi-square values were 33.877 with p value in the number of less than 0.001 ($p \leq 0.001$), which was less than 0.05 level of significance.

Table 3 shows that statistical tests for model fitness of factors influencing the change in household income of growers, which there is the statistics test was less than 0.001 ($p < 0.001$) and means that the overall vegetable growers' model statistically significantly predicts the dependent variable better than the intercept-only model alone. There were three Pseudo R-square which consisted of Cox and Snell R-square, Nagelkerke R-square, and McFadden R-square, which were 0.121, 0.145, and 0.071, respectively, represented that the variables explain the variability used in the model for 12.10% 14.50% and 7.10% of the dependent variable respectively.

Table 3 Statistical tests for model fitness of factors influencing the change of income of growers under Thailand-China's FTA during 2008-2018

Model	**Model Fitting Criteria**			**Likelihood Ratio Tests**		
	AIC	**BIC**	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Intercept Only	478.205	485.342	474.205			
Final	464.328	507.148	440.328	33.877	10	<0.001
Pseudo R-Square						
Cox and Snell	0.121					
Nagelkerke	0.145					
McFadden	0.071					

Relationship between independent variables and dependent variable using the likelihood ratio test, which evaluates the overall relationship between an independent and

dependent variable. The overall vegetable growers' model showed the independent variables are statistically significant, which implied that the odds value indicated are related to 2 independent variables that were significant at 5% ($p \leq 0.05$), which had p value equal to <0.001 and 0.005 of growers' adaptation strategy (X_6) and value of agricultural production cost (X_7) respectively. In addition, the result shows that the age of the grower [Growers' age as of 2018 (X_1)] have p value equal to 0.094 is significant at 10 % ($p \leq 0.10$). The likelihood-ratio test is based on deviance which is the difference between two times the likelihood of empty and overall vegetable growers' model [−2 log likelihood]. Table 4 shows statistical tests for model fitness of factors influencing the change in household income of the growers, in which the statistics test was less than 0.001. it means that the overall vegetable growers' model is statistically significant in predicting the dependent variables.

Table 4 Overall statistics testing for factors influencing the change of household income of growers under Thailand-China FTAs.

Effect		Model Fitting Criteria			Likelihood Ratio Tests		
		AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Overall vegetable growers' model							
Intercept		464.328	507.148	440.328[a]	.000	0	.
X_1	Growers' age as of 2018	465.066	500.749	445.066	4.737	2	0.094
X_5	Farm size change between 2008 – 2018	463.693	499.377	443.693	3.365	2	0.186
X_6	Growers' Adaptation Strategy to cope with FTAs during 2008 - 2018	475.274	510.957	455.274	14.945	2	< 0.001
X_7	Production cost change between 2008 – 2018 (100,000 baht/year)	470.743	506.427	450.743	10.415	2	0.005
X_8	Amount of credit used in 2018 (Baht per year)	461.362	497.046	441.362	1.034	2	0.596

Note: The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Table 5 shows that the predicted correctly percentage of the growers who preferred have the household income change in 3 groups, consisting of decreased household income, no change in household income, and increased household income, predicted correctly in the multinomial logistic regression. The predicted correctly percentage of adaptation strategy of the growers was 61.1%.

Table 5 Statistical tests for the predicted accurate percentage of the change in a household of growers in the study area

Observed	Predicted			
	Decreased income	No change	increased income	Percent Correct
1. Decreased household income	5	61	2	7.4%
2. No change in household income	6	154	1	95.7%
3. Increased household income	1	31	1	3.0%
Overall Percentage	4.6%	93.9%	1.5%	61.1%

Table 6 shows the household income change between 2008 – 2018 when consideration of independent variables in parameter estimation is statistically significant ($p \leq 0.05$ and $p \leq 0.10$) when the reference category was no change in household income. Details of the major findings are the change in household income defined in 3 categories in the unit 100,000 baht, consisting of;

1. Decreased household income, which is mentioned on the growers who have income change lowest through – 9.530 %.

2. No change in household income, which is mentioned on the growers who have income change between – 9.529 – 10.530 %.

3. Increased household income, which is mentioned on the growers who have income change between 10.531% through the highest.

Table 6 shows the change of household income with the impact from FTAs when consideration of independent variables in term of parameter estimation are statistically significant ($p \leq 0.05$ and $p \leq 0.10$) when the reference category was no change in household income. Details of the major findings are as follows.

1. In the case of the growers who have increased household income change, the parameter estimation described some factors or independent variables influencing the income change. The result from NML found that growers' adaptation strategy (X_6) of the growers who adapt by production and marketing adjustment and production cost change (X_7) between 2008 – 2018 are statistically significant, the statistic test equal to 0.002 and 0.005 ($p \leq 0.05$), respectively.

2. For the growers who have decreased household income change (Table 7), the result from NML found that production cost change (X_7), and growers' adaptation strategy (X_6) which cope for FTAs impact by production or marketing adjustment are statistically significant, the statistic test equal to 0.008 and 0.018 ($p \leq 0.05$) respectively. While farm size changes (X_5) between 2008 – 2018 lowest through 0.080 rai is statistically significant; the statistic test equals 0.093 ($p \leq 0.10$).

Table 6 The parameter estimated and associated statistics of factors influencing the change in household income of the growers under the Thailand-China FTA during 2010-2018, where the reference category is no change in household income.

Variables		B	Std. Error	Wald	df	Sig.	Exp(B)
Decreased household income							
Intercept		-0.806	1.376	0.343	1	0.558	
X_1	Growers' age as of 2018	-0.022	0.024	0.839	1	0.360	0.978
X_5	Farm size change between 2008 – 2018						
	Farm size changes lowest through 0.080 rai	0.520	0.309	2.824	1	0.093	1.682
	Farm size change between 0.081 rai through the highest	0[b]	.	.	0	.	.
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018						
	Growers' adaptation strategy to cope with FTAs by production or market adjusted	0.802	0.304	6.936	1	0.008	2.230
	Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_7	Production cost change between 2008 – 2018 (100,000 baht/year)	1.247	0.527	5.587	1	0.018	3.478
X_8	Amount of credit used in 2018 (Bahr per year)						
	Amount of household credit used: lowest through 100,000 baht per year	-0.227	0.301	0.570	1	0.450	0.797
	Amount of household credit used: 100,001 baht per year through the highest	0[b]	.	.	0	.	.
Increased household income							
Intercept		-7.315	2.508	8.505	1	0.004	
X_1	Growers' age as of 2018	0.070	0.043	2.654	1	0.103	1.072
X_5	Farm size change						
	Farm size changes lowest through 0.080 rai	0.454	0.415	1.193	1	0.275	1.574
	Farm size change between 0.081 rai through the highest	0[b]	.	.	0	.	.
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018						
	Growers' adaptation strategy to cope with FTAs by production or market adjusted	1.400	0.447	9.794	1	0.002	4.053
	Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_7	Production cost change between 2008 – 2018 (100,000 baht/year)	1.843	0.650	8.041	1	0.005	6.317
X_8	Amount of credit used in 2018 (Bahr per year)						
	Amount of household credit used: lowest through 100,000 baht per year	-0.346	0.403	0.736	1	0.391	0.708
	Amount of household credit used: 100,001 baht per year through the highest	0[b]	.	.	0	.	.

a. The reference category is: No change in household income.

b. This parameter is set to zero because it is redundant.

3.2 Factors affecting each vegetable's household livelihood assets (household income) of growers.

The statistical tests for model fitness of factors influencing the change in household income of growers, which there is the statistics test was less than 0.001 and means that the overall vegetable growers' model statistically significantly predicts the dependent variable.

For onion growers, there were three Pseudo R-squares which consist of Cox and Snell R-square, Nagelkerke R-square, and McFadden R-square, which were 0.133, 0.165, and 0.088, respectively, represented that the variability is explained by the variables used in the model for 13.30% 16.50% and 8.80% of the dependent variable respectively.

In the case of garlic growers, we found that Cox and Snell R-square, Nagelkerke R-square, and McFadden R-square were 0.265, 0.319, and 0.174, respectively, represented the variability explained by the variables used in the model for 26.50% 31.90% and 17.40% of the dependent variable respectively.

Table 7 Statistical tests for model fitness of factors influencing the change of income of onion, garlic, and shallot growers under Thailand-China's FTA during 2010-2018.

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	**AIC**	**BIC**	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Onion						
Intercept Only	165.978	171.758	161.978			
Final	163.032	191.935	143.032	18.946	8	0.015
Pseudo R-Square						
Cox and Snell	0.133					
Nagelkerke	0.165					
McFadden	0.088					
Garlic						
Intercept Only	158.458	163.389	154.458			
Final	147.635	172.294	127.635	26.822	8	<0.001
Pseudo R-Square						
Cox and Snell	0.265					
Nagelkerke	0.319					
McFadden	0.174					
Shallot						
Intercept Only	56.846	58.560	54.846			
Final	52.143	60.711	42.143	12.703	4	0.013
Pseudo R-Square						
Cox and Snell	0.266					
Nagelkerke	0.361					
McFadden	0.232					

The overall statistics testing for factors influencing the change of household income of the growers, shown in Table 8, found that the adaptation strategies which the growers choose to cope with FTAs impacts influenced the change of household income.

Table 8 Overall statistics testing for factors influencing the growers' household income change under Thailand-China FTAs.

	Effect	Model Fitting Criteria			Likelihood Ratio Tests		
		AIC of Reduced Model	**BIC of Reduced Model**	**-2 Log Likelihood of Reduced Model**	**Chi-Square**	**df**	**Sig.**
	Onion						
Intercept		163.032	191.935	143.032[a]	0.000	0	.
X_1	Growers' age as of 2018	163.838	186.961	147.838	4.806	2	0.090
X_5	Farm size change	162.068	185.191	146.068	3.036	2	0.219

	Effect	Model Fitting Criteria			Likelihood Ratio Tests		
		AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018	164.836	187.959	148.836	5.804	2	0.055
X_8	Amount of credit used in 2018 (baht per year)	167.085	190.208	151.085	8.054	2	0.018
	Garlic						
Intercept		147.635	172.294	127.635[a]	.000	0	
X_1	Growers' age as of 2018	145.955	165.683	129.955	2.320	2	0.313
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018	148.939	168.666	132.939	5.304	2	<0.001
X_7	Production cost change between 2008 – 2018 (100,000 baht/year)	159.156	178.884	143.156	15.521	2	0.111
X_8	Amount of credit used in 2018 (100,000 baht/year)	148.027	167.754	132.027	4.392	2	0.071
	Shallot						
Intercept		52.143	60.711	42.143[a]	.000	0	
X_1	Growers' age as of 2018	54.248	61.102	46.248	4.105	1	0.043
X_5	Farm size change	51.443	58.298	43.443	1.300	1	0.254
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018	56.439	63.294	48.439	6.296	1	0.012
X_7	Production cost change between 2008 – 2018 (100,000 baht/year)	54.513	61.367	46.513	4.369	1	0.037

Note: The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

For onion growers, the independent variables are statistically significant at 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$), which implied that the odds value indicated the amount of household credit used in 2018 (X_8) had p value equal to 0.018, which is statistically significant at 5% ($p \leq 0.05$). There were two independent variables that are statistically significant at 10 % ($p \leq 0.10$) consisting of growers' age as of 2018 (X_1) and growers' adaptation strategy (X_6), which have p-values equal to 0.090 and 0.055, respectively.

For garlic, the result implied that the odds value indicated the amount of household credit (X_8) have p value of 0.071, which is significant at 10% ($p \leq 0.10$). While growers' adaptation strategy (X_6) have p value less than 0.001 which is statistically significant at 5% ($p \leq 0.05$).

For shallot, demonstrated that the shallot grower with the growers' age as of 2018 (X_1), growers' adaptation strategy (X_6), and Production cost change between 2008 – 2018 (X_7) are statistically significant. There are p values equal to 0.043, 0.012, and 0.037, respectively.

Table 9 Statistical tests for the predicted accurate percentage of the change in households of onion, garlic, and shallot growers in the study area

Observed	Predicted			
	Decreased Household income	No change in household income	Increased income	Percent Correct
Onion				
Decreased household income	0	32	0	0.0%
No change in household income	0	89	1	98.9%
Increased household income	0	8	3	27.3%
Overall Percentage	0.0%	97.0%	3.0%	69.2%
Garlic				
Decreased household income	19	16	0	54.3%
No change in household income	7	39	0	84.8%
Increased household income	5	1	0	0.0%
Overall Percentage	35.6%	64.4%	0.0%	66.7%
Shallot				
No change in household income	-	21	4	84.0%
Increased household income	-	6	10	62.5%
Overall Percentage	-	65.9%	34.1%	75.6%

Table 9 shows that the predicted percentage of the growers who preferred have the household income change in 3 groups, consisting of decreased household income, no change in household income, and increased household income, predicted correctly in the multinomial logistic regression. The predicted accurate percentage of the change in a household of onion, garlic, and shallot growers in the study area are 69.2%, 66.7%, and 75.6% of onion and garlic growers and shallot growers, respectively.

Table 10 shows the parameter estimated and associated statistics of factors influencing the change in household income. In the case of onion growers who have decreased household income change, growers' age as of 2018 (X_1) is an independent variable influenced by the change in household income. There is p value equal to 0.066, which is statistically significant at 10% ($p \leq 0.10$).

While the increased household income change found that the parameter estimation described some factors or independent variables influencing the income change. The result from NML found that growers' adaptation strategy (X_6) and the amount of household credit (X_8) are statistically significant ($p \leq 0.05$), the statistic test equal to 0.037 and 0.012, respectively. While Growers' age as of 2018 (X_1) is statistically significant, the statistic test equal to 0.059 ($p \leq 0.10$).

Table 10 The parameter estimated and associated statistics of factors influencing the change in household income of onion growers under the Thailand-China FTA during 2010-2018.

Variables	B	Std. Error	Wald	df	Sig.	Exp(B)
Decreased household income						

Variables		B	Std. Error	Wald	df	Sig.	Exp(B)
Intercept		11.728	5.600	4.387	1	0.036	
X_1	Growers' age as of 2018	-0.176	0.096	3.371	1	0.066	0.839
X_5	Farm size change						
	Farm size changes lowest through 0.080 rai	-0.820	0.801	1.048	1	0.306	0.440
	Farm size change between 0.081 rai through the highest	0[b]	.	.	0	.	.
X_6	Growers' adaptation strategy to cope with FTAs during 2008 - 2018						
	Growers' adaptation strategy to cope with FTAs by production or market adjusted	-0.999	0.795	1.577	1	0.209	0.368
	Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_8	Amount of credit used in 2018						
	Amount of household credit used: lowest through 100,000 baht per year	1.142	0.773	2.178	1	0.140	3.132
	Amount of household credit used: 100,001 baht per year through the highest	0[b]	.	.	0	.	.
Increased household income							
Intercept		12.840	5.488	5.474	1	0.019	
X_1	Growers' age as of 2018	-0.177	0.094	3.559	1	0.059	0.838
X_5	Farm size change						
	Farm size changes lowest through 0.080 rai	-1.195	0.762	2.458	1	0.117	0.303
	Farm size change between 0.081 rai through the highest	0[b]	.	.	0	.	.
X_6	Growers' adaptation strategy						
	Growers' adaptation strategy to cope with FTAs by production or market adjusted	-1.576	0.755	4.360	1	0.037	0.207
	Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_8	Amount of credit used in 2018						
	Amount of household credit used: lowest through 100,000 baht per year	1.845	0.737	6.264	1	0.012	6.330
	Amount of household credit used: 100,001 baht per year through the highest	0[b]	.	.	0	.	.

a. The reference category is: No change in household income.

b. This parameter is set to zero because it is redundant.

For garlic growers, the parameter estimation described some factors or independent variables influencing the income change (Table 11). The result from NML of the growers who have decreased household income found that growers' adaptation strategy (X_6) in terms of growers' adaptation strategy to cope with FTAs by production or market adjusted and production cost change (X_7) are statistically significant ($p \leq 0.05$), the statistic test equal to 0.027 and 0.002, respectively. In the case of the growers who have increased household income, it found that production cost change (X_7) is statistically significant, the statistic test equal to 0.007 ($p \leq 0.05$).

Table 11 The parameter estimated and associated statistics of factors influencing the change in household income of garlic growers under Thailand-China FTA during 2010-201 where reference categories are no change in household income.

Variables	B	Std. Error	Wald	df	Sig.	Exp(B)
Decreased household income						
Intercept	0.750	2.309	0.106	1	0.745	
X_1 Growers' age as of 2018	-0.050	0.039	1.642	1	0.200	0.951
X_6 Growers' adaptation strategy						
Growers' adaptation strategy to cope with FTAs by production or market adjusted	1.211	0.549	4.871	1	0.027	3.357
Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_7 Production cost change (100,000 baht)	2.798	0.890	9.871	1	0.002	16.406
X_8 Amount of credit used in 2018 (100,000 baht/year)	-0.232	0.180	1.659	1	0.198	0.793
Increased household income						
Intercept	1.080	4.306	0.063	1	0.802	
X_1 Growers' age as of 2018	-0.089	0.075	1.390	1	0.238	0.915
X_6 Growers' Adaptation Strategy						
Growers' adaptation strategy to cope with FTAs by production or market adjusted	0.940	1.008	0.870	1	0.351	2.561
Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_7 Production cost change (100,000 baht)	4.087	1.521	7.218	1	0.007	59.573
X_8 Amount of credit used in 2018 (100,000 baht/year)	-0.879	0.575	2.339	1	0.126	0.415

a. The reference category is: No change in household income.

b. This parameter is set to zero because it is redundant.

Table 12 shows the parameter estimates of the relationship between the income change and influenced independent variables in the increased household income group for shallot growers. The result found that growers' age as of 2018 (X_1), and production cost change (X_7) with the increased household income are statistically significant at 10% ($p \leq 0.10$). There are p values equal to 0.074 and 0.051, respectively. While growers' adaptation strategy (X_6) which copes for FTAs by production and marketing adjustment have p value equal to 0.022, which is statistically significant at 5% ($p \leq 0.05$).

Table 12 The parameter estimated and associated statistics of factors influencing the change in household income of shallot growers under the Thailand-China FTA during 2010-2018, where reference categories are no change in household income.

Variable	B	Std. Error	Wald	df	Sig.	Exp(B)
Increased household income						
Intercept	-19.757	9.425	4.394	1	0.036	
X_1 Growers' age in the study area as of 2018	0.267	0.149	3.201	1	0.074	1.306
X_5 Farm size change	0.944	0.839	1.264	1	0.261	2.570
X_6 Growers' Adaptation Strategy						
Growers' adaptation strategy to cope with FTAs by production or market adjusted	1.974	0.863	5.237	1	0.022	7.202
Growers' adaptation strategy to cope with FTAs by Request to postpone the import period	0[b]	.	.	0	.	.
X_7 Production cost change (100,000 baht)	2.718	1.393	3.807	1	0.051	15.146

a. The reference category is: No change in household income.

b. This parameter is set to zero because it is redundant.

Conclusion

From the analysis of this study, the growers could adapt themselves by using various adaptation strategies to sustain their livelihood production based on their resources and in terms of the change in income from the impact of the free trade agreement. It is concluded that the adaptation strategy of onion, garlic, and shallot growers has influenced the household income change when considering period from 2008 to 2018, at the statistically significant of multinomial logistic regression.

The relationship between the change of household income and independent variables in the model.

From the result of MNL analysis, the household income change of onion, garlic, and shallot growers have influenced by the adaptation strategies which the growers choose to cope with FTAs' impact at the statistically significant ($p \leq 0.05, p \leq 0.10$). The independent variables had influences with the dependent variable: Y when divided by the grouping of the household income change into three groups consisting of increased household income change, no change in household income, and decreased household income change which is described as follows.

1. For the overall model, the change of household income with the impact from FTAs when consideration of independent variables in terms of parameter estimation is statistically significant ($p \leq 0.05$ and $p \leq 0.10$) when the reference category was no change in household income. Details of the major findings are as follows. In the case of the growers who have increased household income change, the parameter estimation described some factors or independent variables that are influencing the income change. The result from NML found that growers' adaptation strategy (X_6) of the growers who adapt by production and marketing adjustment and production cost change (X_7) between 2008 – 2018 are statistically significant, the statistic test equal to 0.002 and 0.005 ($p \leq 0.05$), respectively. For the growers who have decreased household income change (Table 7), the result from NML found that production cost change (X_7), and growers' adaptation strategy (X_6) which cope for FTAs impact by production or marketing adjustment are statistically significant, the statistic test

equal to 0.008 and 0.018 ($p \leq 0.05$) respectively. While farm size changes (X_5) between 2008 – 2018 lowest through 0.080 rai is statistically significant. The statistic test is equal to 0.093 ($p \leq 0.10$).

2. For onion growers, the independent variables are statistically significant at 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$), which implied that the odds value indicated the amount of household credit used in 2018 (X_8) had p value equal to 0.018, which is statistically significant at 5% ($p \leq 0.05$). There were two independent variables that are statistically significant at 10 % ($p \leq 0.10$) consisting of growers' age as of 2018 (X_1) and growers' adaptation strategy (X_6), which have p-value equal to 0.090 and 0.055, respectively. Onion growers who have decreased household income changed growers' age in the study area as of 2018 (X_1) influenced by the change of household income, there is p value equal to 0.066 at 10% (($p \leq 0.10$). The parameter estimation of increased household income change described that growers' adaptation strategy (X_6) and the amount of household credit (X_8) are statistically significant ($p \leq 0.05$), the statistic test equal to 0.037 and 0.012, respectively. While Growers' age in the study area as of 2018 (X_1) is statistically significant, the statistic test equal to 0.059 ($p \leq 0.10$).

2. Household income change of garlic growers found that the parameter estimation described some factors or independent variables influencing the income change. The result from NML of the growers who have decreased household income found that growers' adaptation strategy (X_6) in terms of growers' adaptation strategy to cope with FTAs by production or market adjusted and production cost change (X_7) are statistically significant ($p \leq 0.05$), the statistic test equal to 0.027 and 0.002, respectively. In the case of the growers who have increased household income, it found that production cost change (X_7) is statistically significant, the statistic test equal to 0.007 ($p \leq 0.05$).

3. The result demonstrated that shallot growers with the growers' age in the study area as of 2018 (X_1), growers' adaptation strategy (X_6), and Production cost change between 2008 – 2018 (X_7) are statistically significant. There are p values equal to 0.043, 0.012, and 0.037, respectively. The two independent variables consist of the growers' age (X_1), and production cost change (X_7) with the increased household income are statistically significant at 10% ($p \leq 0.10$). There are p values equal to 0.074 and 0.051, respectively. While growers' adaptation strategy (X_6) which copes for FTAs by production and marketing adjustment have p value equal to 0.022, which is statistically significant at 5% ($p \leq 0.05$). The finding from field survey found that assistance from government agencies and related organizations would play an important role in supporting their sustainable livelihood production.

Many types of research on sustainable livelihood and multinomial logistic regression were applied in many agricultures sector research in many countries. For example, the research of He and Ahmed (2022) found that, in the poor areas of Southwest China, a large number of farmers lacked livelihood resources, and there were still some constraints on their sustainable livelihoods. Whether the sustainable livelihood capacity of farmers can be improved is related to whether a rural revitalization strategy can be effectively implemented. The logistic regression model was used to conduct an empirical investigation of the relationship between livelihood capital and livelihood strategies. The relationship between the livelihood strategy and their asset shown in Juniour, John, and Onwonga (2017) found

that household size had a positive and statistically significant effect. This implies that households with large families were better off employing more livelihood strategies, likely due to the availability of diverse labor and skills from different family members. Ding *et al.* (2018) studied the influence of livelihood capitals on livelihood strategies, which evaluated the different livelihood capitals of herders across the five ecological types consisting of meadow, typical, desert, sandy, and desert steppe in Inner Mongolia region of China, and using the sustainable livelihood framework approach. The result found that long distances to input markets as physical capital decreased the likelihood of adaptation, and the stocks of human and social capital were higher, while those for natural, physical, and financial capitals were lower. Luseno *et al.* (2003) found that market access is an important factor in determining technological adoption choices among farmers. In Thailand, Somboonsuke, *et., al.* (2003) studied applying a sustainable livelihood framework in the sustainable livelihood of small-holding rubber-fruit tree framing system in Kao Phra Community, The Southern Thailand. The analysis defined sustainable livelihood of small holding rubber-base farming and suggested farmers development for sustainability. The result shows that the small holders in four systems of rubber-fruit tree farm try to decrease their vulnerabilities and risk of management in aspect of economics and sustainability. They should try to decrease their vulnerability and limitations set by concerned organizations for maintaining sustainable livelihood of small holding rubber-fruit tree farming system. Similarly for rosella farmers, sustainable livelihood framework is important to formulate sustainable livelihood strategies for rosella farmers in the face of price fluctuations. The price of rosella commodity fluctuates, has an impact on the rosella farmers low income. Rosella commodity fluctuations are influenced by the low bargaining position of farmers and the absence of market price guarantees from the government (Putra, D. F.R., Setiawan, B. and Andriani, D. R., 2022).

On the other hand, Jasmine E. B, *et., al.* (2021) reveals that in an integrated livelihood and well-being framework to understand northeastern Colorado ranchers' adaptive strategies paper, this research mentioned seven factors emerged as inputs for producers' livelihood strategies consisting of financial, natural, social, human, physical, political, and cultural. The results found that producers vary in access to cultural and political factors and emphasize the ubiquitous role of diversification as a livelihood strategy. Livestock producers' varying decision-making approaches emphasize the need to extend producers' lived experiences. The emergent integrated livelihood and well-being framework illustrates how livestock owners draw upon seven factors to assemble livelihood strategies for improved well-being.

Recommendation

To help the growers sustain their farm production, they need to employ various adaptation strategies to cope with the change of household income and also get some assistance from the Thai government and related no government agencies. The agricultural cooperative and related government organizations should be aware of the sustainability of onion, garlic, and shallot production and support growers' access to knowledge and important trade information. If they don't bargain and compete with others who have lower production costs and vegetable prices, they can incur losses from their vegetable production for many years, which can force them to change to other vegetables or crops and can be led to a lack of sustainability of their production livelihood. Increase livelihood capital and expand livelihood capital stock. For natural capital, it is necessary to reasonably adjust the structure

of agriculture and forestry, improve the quality of cultivated and forest land, and improve farmland irrigation facilities and road traffic.

Moreover, the government should perfect the system of land distribution and circulation to improve the utilization efficiency of natural capital. For physical capital, the quality of livestock should be improved, large-scale breeding and characteristic breeding should be carried out according to market demand, agricultural production materials and fixed assets should be increased, and labor productivity should be improved. Further research about the sustainability index of livelihood asset needs to develop to reveal the sustainability of their products in the whole kingdom because onion, garlic, and shallot will have important vegetables for domestic consumption and international trade.

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References

Bruno, J. E., Fernandez-Gimenez, M. E., & Balgopal, M. M. (2021). An Integrated livelihoods and well-being framework to understand northeastern Colorado ranchers' adaptive strategies. *Ecology and Society, 26*(4), 27. Retrieved from https://doi.org/10.5751/ES-12754-260427

Chambers, R., & Conway, G. (1991). *Sustainable rural livelihoods: practical concepts for the 21st century.* IDS Discussion Paper 296, 296 Retrieved from http://opendocs.ids.ac.uk/opendocs/handle/123456789/775

Department for International Development. (1999). *Sustainable Livelihoods Guidance Sheets.* London: Department for International Development. Retrieved from http://www.livelihoods.org/info/info_guidancesheets.html

DFID. (2000). *Sustainable Livelihoods Guidance Sheets.* Department for International Development. Retrieved from http://www.livelihoods.org/info/info_guidancesheets.html

Ding, W., Jimoh, O. S., Hou, Y., Hou, X., & Zhang, W. (2018). The Influence of livelihood capitals on livelihood strategies of Herdsmen in Inner Mongolia, China. *Sustainability*, 10, 3325. Retrieved from www.mdpi.com/journal/sustainability

Greene, W. H. (2002). Econometric Analysis (5th ed.). New Jersey: Prentice Hall. pp.720-723.

Hair, J. F. (2010). *Multivariate data analysis : A global perspective.* New Jersey: Peason Prentice Hall.

He, Y. & Ahmed, T. (2022). Farmers' Livelihood Capital and Its Impact on Sustainable Livelihood Strategies: Evidence from the Poverty-Stricken Areas of Southwest China. *Sustainability*, 14, 4955. https://doi.org/10.3390/su14094955

Hosmer D. W., & Lemeshow, S. (2000). *Applied Logistic Regression.* New York: Wiley.

Hussein, K. (2002). *Livelihoods approaches compared: a multiagency review of current practice.* Department for International Development, London, UK. Retrieved from https://www.researchgate.net/profile/Karim-Hussein-4/publication/278405226_Livelihoods_Approaches_Compared_A_Multi-Agency_Review_of_Current_Practice

Juniour S. A., John B., & Onwonga R. (2017). Sustainable Livelihood Approach for Assessing Household Adoption to Eviction: Mau Forest, Kenya. *International Journal of Scientific & Technology Research, 6*(08), 378-383.

Kollmair, M. & Gamper, St. (2002). *The Sustainable Livelihood Approach. Input Paper for the Integrated Training Course of NCCR North-South.* Retrieved from https://www.alnap.org

Lim, L. C. (2013). *The Importance of International Trade, Trade Rules and Market Structures.* Trade and Environment Review 2013. Retrieved fromhttps://unctad.org/en/PublicationChapters/ditcted2012d3_ch5_en.pdf

Luseno, W. K., Mcpeak, J. G., Barrett, C. B., Little, P. D., & Gebru, G. (2003). Assessing the Value of Climate Forest Information for Pastoralists: Evidence from Southern Ethiopia and Northern Kenya. *World Development, 31*(9), 1477-1494. http://doi.org/10.1016/S0305-750X(03)00113-X

Myint, M. K. (2011). Analysis of farmers' strategies in post-monsoon Cotton production systems using Sustainable Livelihoods Framework in Rainfed Upland of Central Myanmar. (Master Thesis). Chiang Mai University.

Narintarakul, K. (2006). *Thai-China Free Trade Agreement: For Whose Benefit? in Asia-Pacific Network for Food Sovereignty.* Regional and Bilateral Trade Agreements: Implications on Food Sovereignty and Development. Philippines: APNFS.

Nirathorn, N. (2008). Economic Integration and Adaptive Strategies of Farmers: How Garlic Farmers in Chiangmai Coped with FTA. *GMSARN International Journal, 2*(2008), 157 – 162. Retrieved from http://gmsarnjournal.com/home/wp-content/uploads/2015/08/vol2no4-4.pdf

Putra, D. F. R., Setiawan, B., & Andriani, D. R. (2022). Sustainable Livelihood Asset-Based Strategy for Rosella Farmers in Pagung Village, Semen District, Kediri Regency. *HABITAT*, *33*(2), 166-176.

Sapphasri, C., Sothitorn, M., Sonprawim, M., & Thanee, C. (2013). *The Impact of ASEAN-China free trade agreement*. (Final report). Bangkok: Faculty of Economics, Chulalongkorn University.

Sharma, R. (2001). *Strengthening Agricultural Support Services for Small Farmers, report of the APO Seminar on Strengthening Agricultural Support Services for Small Farmers, Japan*. Retrieved from http://www.apo-tokyo.org/publications/project_report/Strengthening-Agricultural-Support-Services-for-Small-Farmers/

Singh, S.P., Singh, R.J., Chauhan, J.K., Ram Singh., & Hemochandra, L. (2018). Multinomial Logistic Regression Model in Identifying Factors of m4agriNEI in CSA Innovations. *Indian Journal of Hill Farming, 31*(2), 344-347. Retrieved from http://www.kiran.nic.in/pdf/IJHF/Vol_31_2/23%20Edited.pdf

Somboonsuke, B., Prommee, P., Cherdchom P., & Petcharat, J. (2003). The Sustainable Livelihood of Rubber Small Holder: A Case Study of Rubber- Fruit Tree Farming System in Kao Phra Community, The Southern Thailand. *Kasetsart J. (Soc. Sci), 24*(2003), 156 - 168.

Sosina, B., Holden, S., & Barrett, B.C. (2010). Activity Choice in Rural Non-farm Employment (RNFE): Survival versus accumulative strategy. *MPRA Paper*, No. 55034. 2014. Retrieved from https://mpra.ub.uni-muechen.de/55034/

The Energy and Resources Institute. (2019). *Assessment of Sustainable Livelihood Opportunities for Fiji. Prepared for the Ministry of Environment, Government of Fiji under the UNDP-GEF Ridge to Reef Project*. New Delhi. India. Retrieved from www.teriin.org.

United Nations Development Programme. (2017). *Application of the Sustainable Livelihoods Framework in Development Projects*. Retrieved from https://www.undp.org/content/dam/rblac/docs/Research%20and%20Publications/Poverty%20Reduction/UNDP_RBLAC_Livelihoods%20Guidance%20Note_EN-210July2017.pdf

Vanichbuncha, K. (2005). *Advanced Statistics Analysis by SPSS for Windows* (4th ed.). Bangkok: Dharmasarn Printing Company Limited.

Yamane, T. (1973). *Statistics: An Introductory Analysis* (3rd ed.). New York: Harper and Row. Retrieved from https://www.gbv.de/dms/zbw/252560191.pdf