Determinants of livelihood vulnerability of smallholder tea farmers in Lam Dong province, Vietnam

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Abstract. This study constructed and evaluated the livelihood vulnerability index of small scale tea farming households in Lam Dong Province. It then determined the factors that can increase or reduce their vulnerability. The vulnerability to stresses of weather, climate, production linkages, and product consumption was viewed as a function of exposure, sensitivity, and adaptive capacity. The results showed that most of the households had very high exposure indices to changes in weather, climate, and natural conditions, showing that tea farming activities depended immensely on nature. The sensitivity to pressures of livelihoods, product consumption, or damages from climate variability was moderate. Tea farming households in Lam Dong province had relatively low adaptive capacity indices. The composite vulnerability index was calculated and provided an average of 0.56. The moderately vulnerable group comprised of 71 households (equal to 26.3% of the sample), the highly vulnerable group had 198 households (73.3%), and the extremely vulnerable group had one household (0.4%). The regression model revealed that risk-dependent livelihood, poverty, receiving support from acquaintances or the local government could worsen the vulnerability, while training and production experience can help lessen it.

1. Introduction

Small-scale farming households account for 75% of total agricultural production households globally [1] and 60% of the worldwide agricultural labor force [2]. They supply more than 80% of food consumables in developing countries [3]. According to Cornish [4] and Nagayets [5], small-scale households or smallholders are farming households whose production area less than 10 ha and primarily use family laborers.

Although smallholders play an essential part in the agriculture sector, their livelihoods are exceptionally vulnerable. Small farms’ resources to maintain or expand production are usually limited, and they also have difficulties accessing rural supporting programs [6, 7]. Many farmers are adversely affected by inappropriate land use plans [6], lack of price forecasts of agricultural products, globalization, and agricultural industrialization [8]. Rapid population expansion, climate change, and degraded resources accompanied by poverty and unstable food supply can also affect rural areas [9]. Notably, these impacts are most severe at smallholders whose income-producing activities depend on external factors [10-12].

The vulnerability of agricultural production communities and smallholders under threats of climate change, weather, or fluctuations of agricultural markets needs to be assessed clearly to discover factors
that help mitigate adverse impacts [13]. Therefore, it has become an essential concept in livelihood studies and provides in-depth information to build and orientate rural development programs. Various disciplines such as anthropology, sociology, disaster management, climate science, and sustainable livelihoods have theoretical foundations and approaches to analyze vulnerability [14-22].

In Vietnam, Lam Dong is the province with many advantages for industrial tree plantations such as tea, coffee, and mulberry thanks to its favorable climate conditions. This area is the leading tea producer in Vietnam because it can apply high-tech agricultural farming and serves as a centralized raw material area. However, in Lam Dong, tea production mainly occurs at small-scale farms. These households are susceptible to many factors such as price fluctuation, changes in climatic conditions that lead to diseases, and increased input costs. Climate variations also influence output yields and tea bud quality, which affect prices and competitive capabilities. Besides, the current consumption and export of tea from Lam Dong are disturbed because two big markets in Taiwan and China have been lowered.

There have been several studies for highlands in Asia that analyze the impacts of external variables, mainly natural disasters, on farmer livelihoods [10, 12, 13, 23, 24]. However, there has been limited research done on smallholders in Lam Dong province creating a research gap of studies. Hence, it is necessary to analyze the livelihood vulnerability of smallholder tea farmers. This study aim was to quantify the livelihood vulnerability of small-scale tea producers in Lam Dong and determine factors that can increase or reduce their vulnerability.

2. Methodology

2.1. Livelihood vulnerability assessment framework

Vulnerability is the susceptibility of a community, a system, or a place when being affected by external pressures [17]; it is the degree to which a system cannot cope with adverse impacts [16, 18]. According to IPCC [16], vulnerability is a function of exposure, sensitivity, and adaptive capacity. The components and indicators used to assess the livelihood vulnerability in this study are presented in Table 1.

Exposure is the level of disturbance or stress that the system or the object of analysis has to endure [16, 21]. Exposure often includes variables or indicators related to the environment and climate. Tea production is an activity that heavily depends on many natural factors such as weather, soil, and water availability. Lack of water leads to increasing drought, while excess water creates erosion, flooding, and landslide in production areas. These environmental changes sharply disturb households whose livelihoods mainly involve agriculture [25]. In this study, exposure includes variables reflecting tea producers' dependence on weather or external conditions, the occurrence of soil erosion, and water availability.

Sensitivity consists of characteristics that make a system weaker to pressures [26]. According to Smit and Wandel [27], sensitivity can be reflected through a household’s demographic or economic properties. In this paper, indicators presenting sensitivity are poverty status, the number of dependent members within a family, the number of livelihoods, difficulty levels of selling output from tea production, and property losses due to climate and weather changes.

Adaptive capacity is the ability or potential of a system to adjust with and adapt to pressures [27]. Selected adaptive capacity indicators describe smallholders’ efforts to cope with adverse weather or tea production activity changes. They are categorized into human capital, financial/economic capital, natural capital, physical capital, and social capital. Human capital consists of education, understanding about VietGap standards (an advanced farming model) in tea farming, the number of agricultural training per year, duration of residence, tea production experience, and primary laborers in the household. Financial capital includes rural credit accessibility and tea production revenue. Physical encompasses investment costs for tea farming and whether if the household implement VietGap standards when farming tea or not. Social capital reflects the participation in tea production linkages, the ability to receive weather warnings, receiving support from relatives and friends, and being supported by local government in finding jobs, solving disputes in production, and preventing illegal production activity.
Table 1. Components and indicators of the livelihood vulnerability

| Components            | Indicators/variables            | Explanation                                                                 | References |
|-----------------------|---------------------------------|-----------------------------------------------------------------------------|------------|
| Exposure              | Risk-dependent                  | Household’s livelihoods depend on risks (climate, weather, diseases) (1=yes, 0=no) |            |
|                       | Erosion                         | There are occurring adverse trends of soil erosion (1=yes, 0=no)            |            |
|                       | Lack of production water        | Lack of water for production (0=enough water, 1=lack of water, 2=no water)  |            |
| Sensitivity           | Single livelihood               | The household only has one single livelihood (1=yes, 0=no)                  | [28, 29]   |
|                       | Poverty                         | 0=no, 1=near poor, 2=poor family                                           |            |
|                       | Sell difficulties               | 1=very easy, 2=easy, 3=normal, 4=difficult, 5=very difficult               |            |
|                       | Dependents                      | Number of dependents (people)                                              | [21, 30, 31]|
|                       | Property losses                 | There are property losses due to climate change (1=yes, 0=no)               | [28]       |
| Adaptive capacity     | Education                       | Number of years going to school                                            | [17, 32]   |
|                       | VietGap understanding           | Understanding levels about VietGap standards (1=don’t know, 2=a little, 3=average, 4=understand, 5=clearly understand) |            |
|                       | Training                        | Number of attended agricultural training (times/year)                       | [32, 33]   |
|                       | Duration of residence           | Number of years living in the area (years)                                 |            |
|                       | Production experience           | Tea farming experience (years)                                             | [34, 35]   |
|                       | Primary laborers                | Number of primary laborers in the family (people)                           | [31]       |
|                       | Credit accessibility            | Be able to access rural credit (1=yes, 0=no)                               | [13]       |
|                       | Tea revenue                     | Revenue from tea production (1000 VND/Year)                                | [13]       |
|                       | Production area                 | Production area (ha)                                                       | [13]       |
|                       | Water source                    | Water source (1: ponds, lakes, rivers, 2: wells, 3: others)                 |            |
|                       | VietGap implementation          | Applying VietGap (1=yes, 0=no)                                             |            |
|                       | Investment costs                | Investment costs for tea production (million VND)                          |            |
|                       | Production linkages             | Participation in tea production linkages (1=yes, 0=no)                     |            |
|                       | Weather warnings                | Receiving warnings and information about bad weathers (1=yes, 0=no)        | [36]       |
|                       | Job support                     | Local government support finding jobs (1=yes, 0=no)                        | [35]       |
|                       | Support                         | Receiving support from relatives and friends (1=yes, 0=no)                 | [35]       |
|                       | Preventing violations           | Local government prevent illegal production activities (1=disagree, 2=disagree, 3=neutral, 4=agree, 5=agree) |            |
|                       | Solving disputes                | Local government help solve disputes in the area (1=agree, 2=disagree, 3=neutral, 4=agree, 5=agree) |            |

2.2. Data collection
This study used primary data collected using structured interviews conducted in households in Lam Dong province. There were 270 tea farming households selected to be surveyed. The questionnaire contained five parts: demographic information, tea farming costs, information about the environment, information about linkages in tea production, and questions related to the household’s livelihoods.

2.3. Calculating the livelihood vulnerability index
A composite vulnerability index was calculated based on selected indicators, and the approach of Sujakhu, Ranjitkar [13]. This method estimates the vulnerability index by combining data of indicators in Table 1. Firstly, the database was normalized using the formula of UNDP [37] because the original values were various in term of units and scales:

\[
normalized_{Si} = \frac{S_i - S_{\text{min}}}{S_{\text{max}} - S_{\text{min}}}
\]

where normalized\(_{Si}\) is the normalized value of an indicator, Si is the actual value of that indicator, and S\(_{\text{min}}\) and S\(_{\text{max}}\) are the min and max values, respectively, of the same indicator. After this step, all of the data had values range from 0 to 1.
Secondly, the normalized values were averaged to provide sub-indices of exposure, sensitivity, and adaptive capacity. These sub-indices were then combined to provide the composite vulnerability index by using the following formula:

$$V = \frac{E + S + (1 - AC)}{3} \quad (2)$$

Where V is the vulnerability index; E, S, and AC is the sub-indices of exposure, sensitivity, and adaptive capacity, respectively. For analysis, the indices were divided into four categories: low (0-0.25), moderate (0.25-0.5), high (0.5-0.75), and very high (0.75-1).

2.4. Analyzing determinants of livelihood vulnerability

The composite index consists of multiple indicators; however, each has a different influence on tea farmers’ vulnerability. For policymakers to design appropriate plans to lower the vulnerability and make tea producers’ livelihood more sustainable, it is necessary and useful to know which variables are most important to explain the vulnerability. To achieve this objective, we employed an ordered logistic regression [38]. The model was identified as:

$$\text{Pr}(Y \leq j) = \ln \left( \frac{\sum \text{Pr}(Y \leq j | X_i)}{1 - \sum \text{Pr}(Y \leq j | X_i)} \right) = \alpha_j + \beta_1 X_1 + \cdots + \beta_i X_i \quad (3)$$

where Y is the smallholders’ livelihood vulnerability (on a scale of 4: low = 1, moderate = 2, high = 3, and very high = 4); \(\alpha\) is a threshold; \(\beta_i\) are estimated coefficients; and \(X_i\) are indicators in the assessment framework.

Before conducting the regression, we used Pearson’s correlation test to examine multicollinearity between explanatory variables of vulnerability. SPSS software was used for analysis.

3. Results and discussion

3.1. The composite livelihood vulnerability index

The estimation revealed that tea farming households’ average exposure was 0.72, indicating that tea producers in Lam Dong province are particularly exposed to external factors. Specifically, there were 175 households whose exposure indices were very high, 29 households had high exposure, 59 households had moderate exposure, and only 7 had low exposure.

Concerning sensitivity, the average index was 0.24, which is relatively low. The number of smallholders in the low, moderate, high, and very high sensitivity groups were 171, 82, 16, and 01, respectively. The majority of the surveyed households did not fall into poor or near-poor groups. Also, many families had secondary livelihoods besides tea farming. Moreover, most of the farmers had signed contracts with companies and purchasing agencies, so the consumption of tea farming outputs were remarkably favorable. Signing consumption and production contracts help people feel rest assured and focus more on farming, given that their income has become stable and risks are lowered. This finding highlights that the encouragement and facilitation of farmers joining production linkages should be a priority policy in tea farming development.

The adaptive capacity of tea farmers needs to be concerned as the average value was only 0.29, indicating that smallholders will face many challenges dealing with climate extremes or production difficulties. Only 11 households had high sub-index values, 137 had moderate, and 122 had low adaptive capacities.

From the calculated sub-indices, smallholders’ composite livelihood vulnerability was estimated and provided an average value of 0.56. The moderately, highly, and extremely vulnerable households were 71, 198, and 01, respectively. There was no family whose vulnerable index was low. Such findings highlight that small-scale tea farmers in the Lam Dong province are genuinely vulnerable to outside
threats and pressures. The composite livelihood vulnerability of tea farming households is presented in Figure 1.

![Graphs showing exposure, sensitivity, adaptive capacity, and vulnerability with frequency distribution](image-url)

**Figure 1.** Composite livelihood vulnerability of tea farming households

Determinants of the livelihood vulnerability

Before running the ordered logistic regression, we used Pearson’s correlation test to examine multicollinearity between explanatory variables of vulnerability. The test revealed several variables that were intercorrelated with each other, so they were removed from the original model. The final model contained 15 explanatory variables and vulnerability as the dependent variable. The estimation showed that support received from relatives and friends was highly significant ($p<0.01$). Training, poverty status, and the risk dependence of tea farmers were significant at $p<0.05$. Production experience and jobs supported by the local government were significant at $p<0.1$.

The determinants of smallholders’ livelihood vulnerability can be seen in Table 2.

For every one unit increase on risk-dependent livelihood, there is a predicted increase of 1.449 in the log odds or 4.261 in the odds of being in a higher vulnerability category. Among surveyed families, there was only 6% who answered tea production does not depend on risks, 94% believed that tea farming has to rely on risk-containing factors.

Although the number of near-poor and poor households is minor in this study, poverty is the variable that positively contributes to vulnerability. One unit increase in this factor creates an increase of 2.378 in the log odds of being more vulnerable. In this study, we only found several families that stay at or under the poverty threshold, and most of them had high or very high vulnerability indices.
Table 2. Determinants of smallholders’ livelihood vulnerability

|                        | Coeff. | Sig.  | Exp(B) |
|------------------------|--------|-------|--------|
| Education              | -0.064 | 0.271 | 0.938  |
| Training               | -0.259 | 0.041 | 0.772  |
| Duration of residence  | -0.014 | 0.220 | 0.986  |
| Production experience  | -0.031 | 0.088 | 0.970  |
| Primary laborers        | 0.010  | 0.947 | 1.010  |
| Credit accessibility    | 0.253  | 0.620 | 1.288  |
| Production area         | 0.084  | 0.532 | 1.088  |
| Weather warnings        | 0.685  | 0.186 | 1.984  |
| Job support             | 0.854  | 0.069 | 2.350  |
| Water source            | 0.197  | 0.400 | 1.217  |
| Support                 | 0.878  | 0.008 | 2.407  |
| Risk-dependent          | 1.449  | 0.034 | 4.261  |
| Erosion                 | 0.578  | 0.103 | 1.783  |
| Poverty                 | 2.378  | 0.013 | 10.784 |
| Dependents              | -0.228 | 0.123 | 0.796  |

From the regression, if the household receives support from their relatives or friends or needs assistance from the local government in finding jobs, there are predicted increases of 0.878 and 0.854, respectively, in the log odds of having a higher level of vulnerability. According to Rufat [35], social capital does not always function as a positive force to reduce vulnerability. The more support a household need to stabilize their livelihoods, the lesser their capabilities to cope with and adapt to risks and pressures. Up to 72.6% of the surveyed families reported that they demand support from local authorities, and 48.5% received help from their acquaintances.

There are two variables confirmed to help reduce the livelihood vulnerability, which are training and production experience. The regression coefficients indicate predicted decreases of 0.259 and 0.031 in the log odds of being in a higher vulnerability level for every one unit increase in training or production experience. Attending training will provide tea producers with advanced farming techniques and more efficient methods to prevent diseases or cope with climate variations. Moreover, the experience reflects the accumulated knowledge that people have after years of farming. Most of the surveyed families had been engaging in tea production for 10 to 20 years and 36.67% of them had more than 20 years of production experience.

4. Conclusion

The calculation showed that most of the households are highly exposed to natural threats, confirming that tea production is an activity that heavily depends on natural conditions. Conversely, the average sensitivity is low thanks to the livelihood diversification and production linkages formed in the area. The adaptive capacity of tea farmers was relatively low. The combination of the three components created the composite vulnerability index. In addition, the estimation showed that risk-dependent livelihood, poverty, and support from acquaintances or the local government are the main drivers of vulnerability while training and production experience can help reduce livelihood susceptibility.

Based on our findings, we propose some recommendations for tea farmers in Lam Dong province:
1) Development plans for tea production should be suitable for natural conditions and water and soil resources; 2) Investing capital in upgrading and renovating irrigation systems and creating conditions for people to access water in production and living; 3) It is necessary to facilitate participation in the linkages and need to have agricultural promotion programs and training courses. Additional funding and financial support policies are needed to encourage farmers and support those who want to transition from traditional models to linked tea farming models; 4) Strengthening information and communication on new science and technology knowledge. Diversifying information provision channels such as radio speakers, local television, and newsletters at village/nest cultural houses; 5) Companies and purchasing...
agencies need to publish their long-term plans to help farmers have a precise orientation. Local government should attempt to create regional supply chains by forming cooperation with neighboring areas and provinces.

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