



# Farm Risks and Strategic Risk Management Options for Building the Resilient Capacity of Smallholder Rubber Farmers in Thailand

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## ABSTRACT

**Background:** This study aims to analyze the risks and management strategies of rubber farms and to identify suitable policy options for risk management in the rubber sector of Thailand.

**Methods:** Data were collected through a nationwide field survey using purposive sampling of 1,079 respondents. Additional information was obtained from structured questionnaires, in-depth interviews with 87 key informants and focus group discussions across four regions. The data were analyzed using factor analysis, risk analysis and descriptive statistics.

**Result:** The findings show eight major farm risk factors. These include market and price risk, climate change and natural hazard risk, financial risk, labor availability and quality risk, market access and middleman risk, farmer group and institutional risk, production and land resource risk and farmer skill risk. Among these, five factors were identified as high-risk. They include market and price risk, climate change and natural hazard risk, financial risk, labor availability and quality risk and market access and middleman risk. The remaining risks were classified as moderate. Effective management of both ex-ante and ex post risks requires a focus on reducing, mitigating and coping strategies. Recommended policy options include the establishment of a farm income stability fund, a rubber insurance scheme, improved financial support for rubber farmers, development of central rubber markets, promotion of sustainable rubber plantations and creation of new rubber farms.

**Key words:** Farm risk, Risk management strategy, Rubber industry, Rubber.

## INTRODUCTION

Natural rubber is vital to Thailand's economic and social development. The rubber industry provides employment, household income, poverty reduction and improved rural livelihoods. It also supports the growth of rubber product manufacturing and related industries (Weerathamrongsak and Wongsurawat, 2013). More than 95.00 per cent of Thailand's rubber output is produced by over 1.70 million smallholder households whose income depends mainly on rubber cultivation (Longpichai *et al.*, 2023). In 2022, the industry generated an estimated economic value of about 600 billion THB. The total plantation area was 24.08 million rai, including 6.21 million rai in the Northeast, 1.54 million rai in the North, 2.46 million rai in the Central region and 13.89 million rai in the South. Total production exceeded 4.82 million tonnes, contributing over 281 billion THB in export value from primary processed rubber (Nguyen *et al.*, 2025; Thai Economic Indicators 2023 and Klaharn *et al.*, 2024).

Natural rubber is a critical raw material for industrial production. It is used in goods such as automobile and aircraft tires, gloves, medical equipment and various industrial components. End users are global corporations with advanced technology, strong financial capacity and efficient management systems that allow them to respond to global market demand (Weerathamrongsak and Wongsurawat, 2013). In contrast, most rubber producers in Thailand are smallholder farmers cultivating less than

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50 rai of land. These farmers face increasing challenges from production constraints, price volatility, climate variation, government policies and shifts in global markets. Longkumer and Sharma (2023) found in their rubber study the marketing channels are the path through which the agricultural commodities move from the producer to the final consumers. The survey revealed two different channels involved in marketing rubber viz; Channel I: Producer-Processor (Rubber Board) and Channel II: Producer-Agent-Processor (Rubber Board). The marketing channel followed by the rubber growers that 100.00

per cent (85+75= 160 respondents) of the respondents followed channel II for selling their produce as they found it more convenient and more profitable than channel I. Rukkhun *et al.* (2021) revealed their study the RRIMFLOW tapping system in young-tapping rubber tree provided significantly highest averaged latex yield per tapping. The average cumulative latex yield was no significant difference comparing with the traditional tapping system. Rubber girth increment had no significant difference among treatments ( $P>0.05$ ). An averaged sucrose distribution in the trunk level of none stimulation treatments were high to very high sucrose values; however, it was medium sucrose values in the stimulation treatments. Inorganic phosphorus distribution in the trunk level showed medium to high values.

New plantations face several natural and economic constraints such as poor soil quality, low rainfall and exposure to drought or cold weather. Farmers in these regions must also cope with higher input costs for land, labor, capital and materials. In traditional rubber areas, mainly in the South and the East, most plantations are in their second or third replanting cycle. Continuous cultivation has caused soil degradation, higher vulnerability to disease and slower tree growth (Vinod, 2012). Climate change further increases these risks. The Intergovernmental panel on climate change (IPCC) projects that by the end of this decade, average air temperature in Southeast Asia will rise by about 2.5 degrees Celsius and annual rainfall will increase by around 7 per cent (McMichael, 2011).

## MATERIALS AND METHODS

### Study area and sampling design

This research employed a multistage sampling approach across the four major rubber-producing regions of Thailand. In each region, two provinces with the largest rubber cultivation areas were purposively selected, except for the Southern region, where three provinces were included due to the higher plantation density. The selected provinces were Songkhla, Trang, Surat Thani, Bueng Kan, Ubon Ratchathani, Chiang Rai and Nan. These areas are characterized by extensive rubber plantations and economies that depend heavily on rubber production.

Within each province, purposive sampling was used to select smallholder rubber farmers who owned plantations of not more than 50 rai and had at least one year of tapping experience. Structured questionnaires were administered through face-to-face interviews. The total sample consisted of 1,079 respondents, including 414 from the South, 259 from the Northeast, 185 from the East and 220 from the North.

### Data collection

Data were obtained through individual interviews using a structured questionnaire validated by experts in agricultural economics and risk management. The questionnaire covered nine dimensions of risk: production, land and

tenure rights, labor and contracts, rubber market, rubber price, finance, climate and natural disasters, policy and institutions and farmer or household conditions (Kongmanee and Ahmed, 2023). Altogether, 97 risk items were identified through document reviews, focus group discussions and in-depth interviews with 120 key informants conducted in September to November 2022. The research worked for this study was carried out in Rubber Authority of Thailand (ROAT).

Each risk item was assessed for its perceived importance and likelihood of occurrence using a five-point Likert scale ranging from 1 (lowest) to 5 (highest). The questionnaire was pilot-tested with 10 farmers from nearby areas to ensure clarity and content validity. Feedback from the pilot test was used to revise the instrument before the main survey.

### Data analysis

Principal Component Analysis (PCA) was used to identify key risk factors. Variables with values below 20 per cent were excluded before conducting the analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was required to exceed 0.50 and Bartlett's test of sphericity had to be significant at the 95 per cent confidence level. The Varimax rotation method was applied to extract factors with eigenvalues greater than 1.0. Variables with correlation coefficients above 0.50 were retained. The internal reliability of each factor was confirmed with a Cronbach alpha coefficient above 0.50 (Dalawi *et al.*, 2025). Following these criteria, the main risk factors were identified and named.

The level of each risk factor was determined using the formula:

$$\text{Risk level} = \text{Impact of risk} \times \text{Likelihood of occurrence}$$

The mean risk score was then used to classify risks into three levels: low (1.00-8.99), medium (9.00-14.99) and high (15.00-25.00).

Policy options for risk management were synthesized by integrating the findings from the risk factor analysis and the magnitude assessment. The synthesis process followed the agricultural risk management frameworks (State of food and agriculture, 2018) and the Organization for Economic Co-operation and Development. These strategic options were further validated and refined through focus group discussions and expert consultations across all regions. The final output consisted of practical, outcome-based policy recommendations for strategic risk management in Thailand's rubber sector.

## RESULTS AND DISCUSSION

### Socioeconomic characteristics of respondents

The study Table 1 found that gender distribution among rubber-farming households was relatively balanced, with 52.40 per cent male and 47.80 per cent female respondents. The average age of respondents was

56 years, indicating that most rubber farmers are middle-aged. In terms of education, 55.70 per cent had completed only primary school, suggesting generally low educational attainment.

Rubber cultivation was the main occupation for 88.00 per cent of respondents. More than half (57.00 per cent) were members of farm groups. The financial profile of households showed an average saving of 111,713.2 baht and an average debt of 385,675.4 baht, reflecting a high debt-to-saving ratio. Family labor played a major role in production, with an average of 3.1 family members involved in farm work. The average household income was 29,047.0 baht per month and 51.40 per cent of that income (14,913.1 baht) was derived from rubber farming.

### Rubber farm risks

An exploratory factor analysis was performed using the principal component method with Varimax rotation to identify the underlying risk factors affecting rubber farms. The Kaiser-Meyer-Olkin (KMO) statistic was 0.856, indicating adequate sampling, while Bartlett's test of sphericity was significant at  $p < 0.01$ . These results confirmed that the data were suitable for factor analysis as shown in Table 2.

Eight major components were extracted, collectively explaining 61.82 per cent of the total variance. All variables loaded above 0.50 on a single factor with minimal cross-loadings, indicating a clear and interpretable structure. Communalities ranged from 0.710 to 0.841, suggesting that the extracted components captured a large proportion

of the total variance in each variable. The results of the factor analysis are summarized in Table 2.

The first and most dominant factor, representing market and price risk, had the highest eigenvalue of 15.543 and explained 20.29 per cent of the total variance. It captured variations linked to declining rubber prices, increasing input costs, market price volatility and global economic slowdown, particularly due to reduced demand from China. These variables reflect the vulnerability of rubber farmers to market fluctuations and external economic shocks that directly affect farm income. The factor demonstrated high internal reliability with a Cronbach alpha value of 0.837.

### Risk levels of rubber farms

Based on the eight identified factors, five were assessed at a high level of risk, including market and price risk (score = 19.15), climate change and natural hazard risk (17.00), financial risk (15.78), labor availability and quality risk (15.24) and market access and middleman risk (15.21). Three additional factors were assessed at a moderate level: farmer group and institutional risk (14.42), production and land resource risk (14.33) and farmer and farm knowledge risk (14.10). These findings indicate that rubber farms in Thailand face both systemic and structural challenges that interact across production, market and institutional dimensions as shown in Table 3.

The results suggest that farm risks can be broadly grouped into three overarching categories based on their underlying nature and implications for management intervention. The first category, uncertainty-related risks, encompasses market and price risk as well as climate change and natural hazard risk. These risks originate from external and largely unpredictable factors that lie beyond the control of farmers. They cause sudden fluctuations in income and productivity and together account for 31.27 per cent of the total variance, making them the most influential cluster. Their systemic nature, driven by global market dynamics and climatic variability, underscores the need for stabilization mechanisms such as market insurance, price support schemes and climate adaptation measures.

Market access and middleman risk also pose considerable challenges. Concentrated market power, collusion among traders, distant purchasing points and breaches of sales contracts contribute to market inefficiencies and income instability. These problems are especially prevalent in newly established rubber areas in the northern and northeastern regions (Sisay, 2023). Weaknesses in farmer group and institutional capacity further aggravate market and production risks. Many farmers remain unorganized and lack collective representation, reducing their bargaining power and access to shared resources (Shiferaw *et al.*, 2008).

Finally, farmer and farm skill risk is linked to aging farmers, health issues and limited technical capacity. Older farmers face constraints in adopting modern technologies and sustaining productivity. The lack of participation in farmer cooperatives limits opportunities for knowledge

**Table 1:** Socioeconomic characteristics of respondents (n = 1,079).

| Variables                         | Results                                                     |
|-----------------------------------|-------------------------------------------------------------|
| Gender (%)                        | Male 52.4, Female 47.8                                      |
| Average age (years)               | 56.0                                                        |
| Education (%)                     | Primary school 55.7                                         |
| Main occupation (%)               | Rubber farming 88.0                                         |
| Membership in farm groups (%)     | 57.0                                                        |
| Average saving (baht)             | 111,713.2                                                   |
| Average debt (baht)               | 385,675.4                                                   |
| Family labor (persons)            | 3.1                                                         |
| Household income (baht per month) | 29,047.0                                                    |
| Rubber income (baht per month)    | 14,913.1                                                    |
| Total landholding (rai)           | 27.1                                                        |
| Main rubber plot (rai)            | 15.7                                                        |
| Replanting investment (%)         | RAOT scheme 57.0,<br>Self-financed 43.0                     |
| Tapping labor (%)                 | Family 68.0, Hired 32.0                                     |
| Product forms (%)                 | Cup lump 60.0, Field<br>fresh latex 38.0                    |
| Average tapping days (days)       | 134.0                                                       |
| Market channel (%)                | Trader or middleman 60.0,<br>Farm group or cooperative 40.0 |
| Average yield (kg per rai)        | 259.0                                                       |

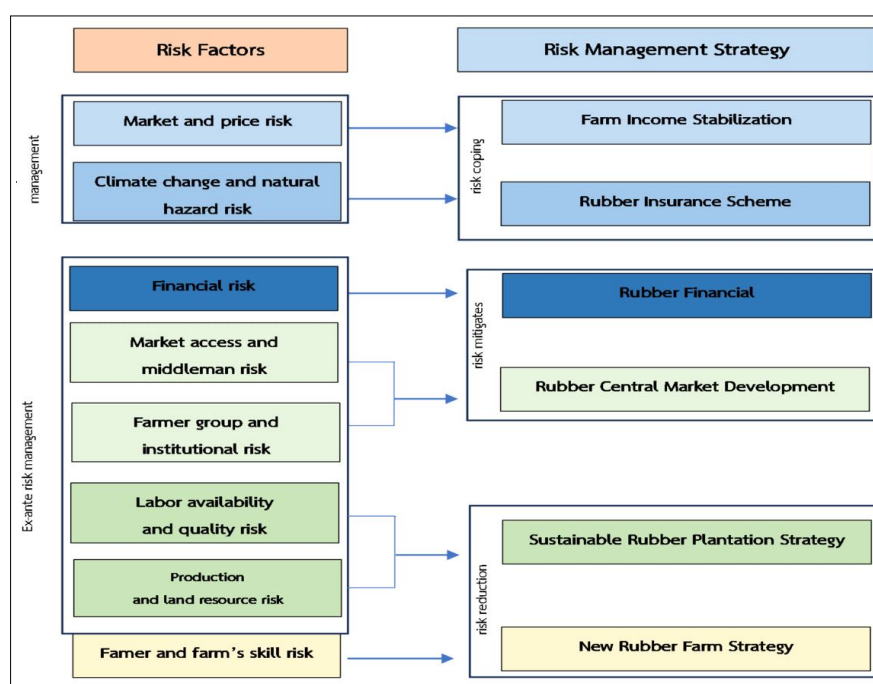
**Table 2:** Results of factor analysis using varimax orthogonal rotation method of risk perception.

| Risk factors                                                                                           | R1    | R2    | R3    | R4    | R5    | R6    | R7    | R8 | Communality |
|--------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|----|-------------|
| Decline in rubber price or low price                                                                   | 0.837 |       |       |       |       |       |       |    | 0.730       |
| Increase in production input price                                                                     | 0.827 |       |       |       |       |       |       |    | 0.712       |
| Price volatility in the rubber market                                                                  | 0.751 |       |       |       |       |       |       |    | 0.711       |
| Global economic slowdown or<br>China's low demand for rubber                                           | 0.749 |       |       |       |       |       |       |    | 0.671       |
| Storms and strong winds                                                                                |       | 0.849 |       |       |       |       |       |    | 0.753       |
| Flooding                                                                                               |       | 0.797 |       |       |       |       |       |    | 0.722       |
| High number of rainy days or<br>irregular rainfall pattern                                             |       | 0.782 |       |       |       |       |       |    | 0.691       |
| Drought and water shortage                                                                             |       | 0.739 |       |       |       |       |       |    | 0.661       |
| Rubber leaf fall disease outbreak,<br>along with an upward trend in pests<br>and plant diseases        |       | 0.692 |       |       |       |       |       |    | 0.663       |
| Decline in household income                                                                            |       |       | 0.797 |       |       |       |       |    | 0.711       |
| Increase in household expenditures                                                                     |       |       | 0.760 |       |       |       |       |    | 0.705       |
| High levels of debt                                                                                    |       |       | 0.690 |       |       |       |       |    | 0.682       |
| Rising interest rate of loan                                                                           |       |       | 0.644 |       |       |       |       |    | 0.670       |
| Strict borrowing requirements and<br>limited bank or financial institution<br>access to credit         |       |       | 0.534 |       |       |       |       |    | 0.654       |
| Shortage of tapping-labor                                                                              |       |       |       | 0.798 |       |       |       |    | 0.778       |
| Low-quality work (cheating, theft<br>and dishonesty) or lack of tapping skill                          |       |       |       | 0.744 |       |       |       |    | 0.729       |
| Shortage of temporary hired labor                                                                      |       |       |       | 0.721 |       |       |       |    | 0.718       |
| Decline in family labor availability                                                                   |       |       |       | 0.711 |       |       |       |    | 0.716       |
| Enhanced negotiating leverage of<br>hired workers in contract negotiations                             |       |       |       | 0.683 |       |       |       |    | 0.683       |
| Price suppression by traders or<br>middleman or collusion among traders                                |       |       |       |       | 0.810 |       |       |    | 0.702       |
| Purchase sites of farm groups are<br>either located far from plantations<br>or are difficult to access |       |       |       |       | 0.744 |       |       |    | 0.690       |
| Noncompliance with sales agreements<br>by traders or processing factories                              |       |       |       |       | 0.731 |       |       |    | 0.660       |
| Lack of information about rubber<br>prices and markets                                                 |       |       |       |       | 0.656 |       |       |    | 0.659       |
| Absence of participation in farmer<br>groups or cooperatives                                           |       |       |       |       |       | 0.775 |       |    | 0.785       |
| Weaknesses of farmer groups unable<br>to compete in the market                                         |       |       |       |       |       | 0.762 |       |    | 0.727       |
| Inadequate farm groups' facilities<br>or infrastructure                                                |       |       |       |       |       | 0.670 |       |    | 0.725       |
| Unsuitable land for rubber cultivation                                                                 |       |       |       |       |       |       | 0.753 |    | 0.761       |
| Soil degradation, erosion and poor<br>soil management                                                  |       |       |       |       |       |       | 0.732 |    | 0.732       |
| Decline in rubber yield                                                                                |       |       |       |       |       |       | 0.715 |    | 0.729       |
| Less or no application of fertilizers                                                                  |       |       |       |       |       |       | 0.688 |    | 0.684       |
| Rubber tree tapping before it reaches<br>the 50 cm standard girth                                      |       |       |       |       |       |       | 0.660 |    | 0.671       |

Table 2: Continue...

**Table 2: Continue...**

|                                                                                                          |        |        |        |        |        |        |        |        |
|----------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Only cup lumps or field latex are produced                                                               |        |        |        |        |        | 0.615  |        | 0.656  |
| Old aged of household head                                                                               |        |        |        |        |        | 0.802  |        | 0.767  |
| Health issues within the family member                                                                   |        |        |        |        |        | 0.770  |        | 0.736  |
| Lacking farm skills and latex tapping capabilities of family member                                      |        |        |        |        |        | 0.753  |        | 0.702  |
| Absence of participation in cooperatives or farm groups                                                  |        |        |        |        |        | 0.595  |        | 0.698  |
| Lack of scientific understanding, relying instead on traditions in farm management of rubber plantations |        |        |        |        |        | 0.528  |        | 0.680  |
| Eigenvalues                                                                                              | 15.543 | 5.086  | 4.081  | 3.310  | 2.978  | 2.781  | 2.520  | 2.021  |
| % total of variance                                                                                      | 20.286 | 10.983 | 8.802  | 5.894  | 4.503  | 3.872  | 3.964  | 3.515  |
| % Cumulative of variance                                                                                 | 20.286 | 31.269 | 40.071 | 45.965 | 50.468 | 54.340 | 58.304 | 61.819 |
| Cronbach's alpha                                                                                         | 0.837  | 0.841  | 0.797  | 0.783  | 0.715  | 0.757  | 0.802  | 0.710  |

**Fig 1:** Rubber farm risks and risk management strategies.

exchange and innovation. Risk management strategies should encourage youth participation in farming, promote technology adoption and mechanization and expand access to health and social protection programs. The establishment of training centers for tapping and plantation management, coupled with incentives for cooperative membership, can strengthen knowledge transfer and long-term competitiveness (Kongmanee and Ahmed, 2023).

Overall, the findings demonstrate that market volatility, climatic uncertainty, financial fragility and labor shortages remain the most pressing challenges in the Thai rubber sector. Effective mitigation requires an integrated risk management framework that combines market stabilization, financial resilience, human capital

development and institutional strengthening to support sustainable and resilient smallholder livelihoods in the long term (Pinitjitsamut and Duangmanee, 2024).

#### Analysis of strategic options for rubber risk management in Thailand

The prioritization of rubber farm risks forms the foundation for designing comprehensive and adaptive risk management strategies. The risk management framework for Thailand's rubber sector can be viewed through two complementary dimensions, as illustrated in Fig 1.

The Rubber Financial Strategy targets household-level financial stability to reduce risks linked to income volatility, indebtedness and poor financial management. Its core

**Table 3:** Analysis of risk levels of risk factors.

| Risk factors                                                                                  | Risk level | Risk factors                                                                                               | Risk level |
|-----------------------------------------------------------------------------------------------|------------|------------------------------------------------------------------------------------------------------------|------------|
| <b>1. Market and price risk</b>                                                               | 19.15      | <b>5. Market access and middleman risk</b>                                                                 | 15.21      |
| - Decline in rubber price or low price                                                        | 19.79      | - Price suppression by traders or middleman or collusion among traders                                     | 15.87      |
| - Increase in production input price                                                          | 18.93      | - Purchase sites of farm groups are either located far from plantations or are difficult to access         | 15.31      |
| - Price volatility in the rubber market                                                       | 19.31      | - Noncompliance with sales agreements by traders or processing factories                                   | 14.89      |
| - Global economic slowdown or China's low demand for rubber                                   | 18.57      | - Lack of information about rubber prices and markets                                                      | 14.77      |
| <b>2. Climate change and natural hazard risk</b>                                              | 17.00      | <b>6. Farmer group and institutional risk</b>                                                              | 14.42      |
| - Storms and strong winds                                                                     | 17.44      | - Absence of participation in farmer groups or cooperatives                                                | 13.80      |
| - Flooding                                                                                    | 16.50      | - Weaknesses of farmer groups unable to compete in the market                                              | 14.64      |
| - High number of rainy days or irregular rainfall pattern                                     | 18.80      | - Inadequate farm groups' facilities or infrastructure                                                     | 14.82      |
| - Drought and water shortage                                                                  | 15.40      |                                                                                                            |            |
| - Rubber leaf's fall disease outbreak, along with an upward trend in pests and plant diseases | 17.10      |                                                                                                            |            |
| <b>3. Financial risk</b>                                                                      | 16.23      | <b>7. Production and land resource risk</b>                                                                | 14.33      |
| - Decline in household income                                                                 | 17.68      | - Unsuitable land for rubber cultivation                                                                   | 16.23      |
| - Increase in household expenditures                                                          | 15.64      | - Soil degradation, erosion and poor soil management                                                       | 14.42      |
| - High levels of debt                                                                         | 16.52      | - Decline in rubber yield                                                                                  | 15.02      |
| - Rising interest rate of loan                                                                | 15.46      | - Less or no application of fertilizers                                                                    | 13.83      |
| - Strict borrowing requirements and limited bank or financial institution access to credit    | 15.84      | - Rubber tree tapping before it reaches the 50 cm standard girth                                           | 13.42      |
| <b>4. Labor availability and quality risk</b>                                                 | 15.24      | - Only cup lumps or field latex are produced                                                               | 13.05      |
| - Shortage of tapping-labor                                                                   | 16.29      | <b>8. Farmer and farm's skill risk</b>                                                                     | 14.10      |
| - Low-quality work (cheating, theft and dishonesty) or lack of tapping skill                  | 16.10      | - Old aged of household head                                                                               | 15.13      |
| - Shortage of temporary hired labor                                                           | 14.29      | - Health issues within the family member                                                                   | 14.22      |
| - Decline in family labor availability                                                        | 15.39      | - Lacking farm skills and latex tapping capabilities of family member                                      | 14.10      |
| - Enhanced negotiating leverage of hired workers in contract negotiations                     | 14.12      | - Absence of participation in cooperatives or farm groups                                                  | 13.52      |
|                                                                                               |            | - Lack of scientific understanding, relying instead on traditions in farm management of rubber plantations | 13.55      |

components include financial counseling services to assist households facing economic stress, targeted financial literacy programs to strengthen understanding of income management and debt restructuring mechanisms supported by state subsidies (Albers *et al.*, 2025).

The Sustainable Rubber Plantation Strategy serves as a proactive approach to mitigating production, land and labor-related risks by promoting efficiency, environmental stewardship and social responsibility

(Langenberger *et al.*, 2017; Kibrom, 2023). Its main objectives include increasing productivity, reducing production costs, restoring degraded land and strengthening long-term sustainability.

The New Rubber Farm Strategy focuses on nurturing a new generation of rubber farmers and agribusiness entrepreneurs equipped with modern skills, scientific knowledge and entrepreneurial capability (Thomas and Lukose, 2024).

## CONCLUSION

The analysis reveals that rubber farmers in Thailand face multiple and interrelated risks that affect every dimension of their production systems. Market and price volatility represents the most critical risk, followed by climate variability and financial constraints. These factors highlight the vulnerability of household income to fluctuations in global demand, extreme weather events and limited access to credit. Labor shortages, weak farmer institutions, limited market access, agronomic constraints and gaps in technical skills further compound production challenges and operational vulnerabilities within the sector. The results suggest that systemic uncertainties form the most significant risk cluster in Thailand's rubber sector. However, the compounding effects of vulnerability and exposure amplify the overall risk burden faced by smallholder farmers. This interconnected risk structure demonstrates the importance of integrated, multi-level policy responses that address both immediate and structural challenges. A coordinated approach can improve productivity, enhance resilience and support sustainable development within the rubber industry.

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## Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect loss resulting from the use of this content.

## Informed consent

There are no animal procedures for experiments during data collection of this study.

## Conflict of interest

The authors declare no conflicts of interest.

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