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Solutions for Conservation and Development of Shan Tea in the High Mountain Regions of Northern Vietnam

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ABSTRACT

Shan tea represents an important indigenous tea genetic resource in Vietnam, valued for its adaptability, high productivity, and superior leaf quality. It is predominantly distributed in high-altitude mountainous regions, where many ancient tea trees have developed under natural forest ecosystems for several centuries. Traditional cultivation practices, characterized by low external inputs and minimal use of synthetic fertilizers and pesticides, support high-quality tea production while helping conserve biodiversity and ecosystem integrity. However, conserving and developing Shan tea in the high mountain areas of Northern Vietnam still faces several limitations, particularly in the naturally distributed Shan tea areas. Issues such as improper harvesting methods, inadequate care leading to poor growth and low yield, spontaneous and fragmented production, and a lack of coordination among stakeholders in production and consumption contribute to these challenges. Additionally, the processed products are not diverse enough, resulting in low value, and many domestic consumers are not fully aware of the value of this rare tea variety, posing a high risk of resource degradation. Based on an analysis of the current situation regarding the conservation and development of Shan tea in the high mountain areas of Northern Vietnam, this paper proposes several solutions aimed at the sustainable development of Shan tea in general and ancient Shan tea trees in particular. These solutions include in situ and ex situ conservation; improved cultivation and management practices (e.g., supplementary organic fertilization, pruning, and plucking); enhanced tea processing technologies; and supportive policy mechanisms.

Keywords: Shan tea, conservation, development, high mountainous regions of Northern Vietnam

INTRODUCTION

Shan tea (*Camellia sinensis* var. Shan) is an indigenous, ancient tea variety cultivated naturally without fertilizers or pesticides (Vietnam Tea Association, 2022). It is a valuable plant resource, primarily found in high mountainous regions and closely associated with forests and the livelihoods of ethnic minority communities in northern Vietnam (Do, V. N. *et al.*, 1998). Additionally, Shan tea provides employment and income for at least 100,000 households, mainly consisting of female laborers and ethnic minorities. Shan tea also offers significant environmental benefits in these high regions (Vietnam Tea Association, 2022). Shan tea has a high bud yield and good quality, and it has become a native crop well suited to the natural conditions, soil, and farming practices of the Hmong people in the high mountainous provinces of Northern Vietnam (Do, V. N., Nguyen, H. L., 2006).

Shan tea serves as both an agricultural crop and a forest plant. Products derived from Shan tea are considered clean tea, and producing Shan tea in a forest-like manner is highly suitable for sustainable agriculture, given the educational level, socio-economic conditions, and farming practices of local ethnic communities in mountainous regions. Expanding Shan tea cultivation contributes to the effective use of land and climate in high mountainous areas while also supporting the national reforestation program, which aims to harness the valuable plant resource of Shan tea (Do, V. N. *et al.*, 1998).

However, highland Shan tea is currently facing a serious decline due to unsustainable exploitation (excessive cutting, improper harvesting techniques, etc.), climate change, limited attention to preserving variety,

and insufficient connections within the value chain. This report presents solutions to preserve and sustainably develop highland Shan tea in the northern mountainous region, contributing to increased value for tea products, job creation, higher incomes, and improved and stabilized livelihoods for ethnic minority communities in the mountains. It also influences policies on poverty alleviation, regional economic development, and environmental protection in Vietnam's highlands.

CURRENT STATUS OF CONSERVATION AND DEVELOPMENT OF SHAN TEA

Distribution characteristics and properties of Shan tea

The Shan tea plant in Vietnam is primarily distributed in the High Mountainous Regions of Northern Vietnam, concentrated in some provinces: Ha Giang, Son La, Dien Bien, Lai Chau, Yen Bai, Lao Cai, Tuyen Quang, etc. The Shan tea plant is found at high altitudes of over 600 meters above sea level, with slopes ranging from 8 to 30 degrees (Do, V. N. *et al*., 1998; Do, V. N., Nguyen, H. L., 2006; Nguyen, Q. V., 2021). The area of Shan tea in five provinces is approximately 25,820.7 hectares, accounting for over 20% of the total tea area in the country (123,000 hectares), with 9,568.7 hectares being the area of ancient Shan tea trees, many of which are hundreds of years old (Figure 1).

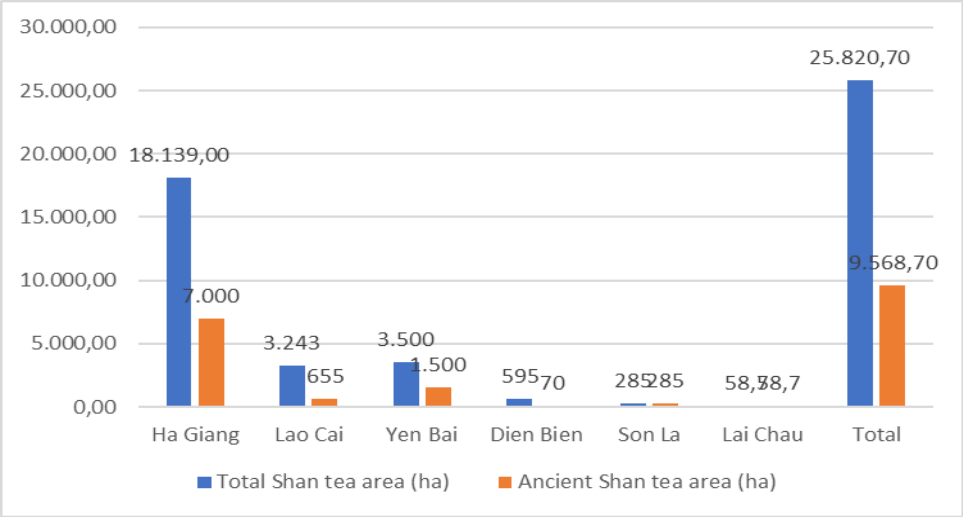


Figure 1. Area of Shan tea in some provinces of the northern mountainous region in Vietnam
Data sources: The DARD of the provinces until 2024

Current status of conservation and development of High Mountain Shan tea

Ancient Shan tea is naturally distributed in high-altitude mountain forests of northern Vietnam, where it has been maintained under traditional low-input management systems for centuries. However, increasing anthropogenic pressures have posed significant challenges to conserving these indigenous tea resources. Unsustainable harvesting, forest degradation and land-use change, together with increasing market demand and premium prices for Shan tea, have accelerated the exploitation of natural tea populations. Consequently, many ancient Shan tea trees have been damaged, removed, or have declined naturally, resulting in a gradual reduction in their distribution area. Field surveys indicate that the area of ancient Shan tea stands in the northern mountainous provinces has declined by approximately 2 – 5% annually. Despite recent conservation initiatives, the protection and sustainable development of Shan tea resources in several northern mountainous provinces continue to face major constraints, including:

1) Inappropriate cultivation and management practices remain one of the major constraints to the conservation of ancient Shan tea resources. Excessive or improper pruning, including severe pruning of the main stem and cutting at inappropriate positions, together with incorrect harvesting practices that damage young shoots and growing points, reduces plant vigor and increases susceptibility to decline and mortality. In some production areas, branches are cut to facilitate bud harvesting, while insufficient application of organic

fertilizers and inadequate soil nutrient management further accelerate the deterioration of tree health, resulting in reduced productivity and threatening the long-term sustainability of ancient Shan tea populations.

2) Tea processing technologies in many Shan tea production areas remain largely traditional and lack adequate process control. The continued use of conventional processing equipment, such as cast-iron pans and wood-fired stoves, results in poor temperature regulation, leading to uneven heat treatment, degradation of aroma compounds, and inconsistent product quality. Moreover, standardized processing protocols for different tea products (e.g., green, black, white, and yellow teas) are insufficiently developed or applied, particularly during critical stages such as withering and fermentation. These limitations reduce the consistency and quality of Shan tea products, hinder the full utilization of their unique sensory characteristics, and ultimately constrain product value addition and market competitiveness.

3) Although several national and provincial policies promote organic agriculture, rural development, and specialty crop production, policy interventions specifically targeting the conservation and sustainable utilization of indigenous High Mountain Shan tea genetic resources remain inadequate. Existing programs primarily emphasize production development, whereas comprehensive measures integrating genetic resource conservation, sustainable cultivation, value-chain development, and market incentives have yet to be established.

4) The sustainable development of High Mountain Shan tea is further constrained by the absence of well-defined production zoning and weak integration across the value chain. Limited coordination among tea growers, cooperatives, enterprises, researchers, and local authorities has hindered the adoption of standardized production practices, technology transfer, product commercialization, and market development, thereby reducing the competitiveness and value addition of High Mountain Shan tea products.

Taken together, these constraints demonstrate the need for an integrated conservation and development strategy for indigenous High Mountain Shan tea. Such a strategy should combine scientific research, technological innovation, supportive policy frameworks, and market-oriented value-chain development to ensure the long-term conservation of Shan tea genetic resources while improving the livelihoods of highland communities.

SOLUTIONS FOR THE CONSERVATION AND DEVELOPMENT OF HIGH MOUNTAIN SHAN TEA

Solutions for conserving High Mountain Shan tea

In situ conservation of High Mountain Shan tea refers to conserving indigenous tea genetic resources within their natural habitats, minimizing genetic erosion and maintaining the genetic diversity needed for the continued evolution and future use of these valuable resources. Conservation strategies include the protection of ancient Shan tea trees in their original habitats through the establishment of conservation zones and tree identification systems; restoration of tree vigor through appropriate pruning, harvesting, and nutrient management; community-based monitoring and stewardship involving local households and communities; sustainable harvesting integrated with livelihood development; and the preservation of traditional ecological knowledge and indigenous cultural values associated with Shan tea production. Collectively, these integrated measures contribute to the long-term conservation, sustainable utilization, and resilience of High Mountain Shan tea genetic resources.

For many years, the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) has coordinated with local authorities to conserve and develop the genetic resources of highland Shan tea: in the 2001–2005 period, in-situ conservation covered 207.5 ha, new planting models were established on 245.0 ha, and ex-situ conservation of highland Shan tea germplasm was carried out in Phu Tho on 0.5 ha (Do, V. N., Nguyen, H. L. *et al.*, 2009); in the 2010–2024 period, 9,568.7 ha of Shan tea were conserved and more than 3,303.6 ha were newly planted, with Ha Giang having the largest area of preserved ancient Shan tea—7,000 ha across five districts: Xin Man, Hoang Su Phi, Bac Quang, Quang Binh and Vi Xuyen (Ha Giang Provincial People's Committee, 2024). It is evident that local authorities, residents and research institutes in the highland Shan tea regions of the northern mountains have shifted their awareness regarding conservation and development of Shan tea—from allowing trees to grow naturally to propagating them by seed and stem cuttings to preserve this valuable tea variety.

Table 1. Results of High Mountain Shan tea conservation and development in several provinces of the Northern mountainous region

No	Target	Some Northern mountainous provinces in Vietnam						Total
		Hà Giang	Lào Cai	Yen Bai	Dien Bien	Son La	Lai Chau	
1	Period 2001 - 2005							
-	The area of in-situ preserved Shan tea (ha)	1,5	-	200	3	3	-	207,5
-	Number of Shan tea planted (ha)	86	-	5	149	5	-	245
2	Period 2010 - 2024							
-	The area of in-situ preserved Shan tea (ha)	7.000	655	1.500	70	285	58,7	9.568,7
-	Number of Shan tea planted (ha)	> 1.500	81	600	> 300	214	608,6	3.303,6

Data source: Collected from 2001 – 2024

For elite High Mountain Shan tea trees, to obtain high-quality planting materials for establishing new Shan tea plantations, NOMAFSI collaborated with local authorities to implement individual selection for identifying elite ancient highland Shan tea trees exhibiting desirable morphological characteristics associated with high yield potential, superior quality, vigorous growth, and stable performance within local tea populations. Since 2001, a total of 604 elite Shan tea mother trees have been identified in seven northern mountainous provinces, including 245 trees in Ha Giang, 191 in Bac Kan, and 92 in Lao Cai (Do, V. N., *et al.*, 1998; Do, V. N., & Nguyen, H. L., 2006; Nguyen, T. H. L., 2017). All selected mother trees have been georeferenced using GPS and labeled with identification plates to facilitate annual monitoring and evaluation by local authorities.

Table 2. Elite high mountain Shan tea trees recognized in some provinces in the Northern Mountainous Region

No	Location	Number of Elite high mountain Shan tea trees recognized					Total
		Year 2001 – 2005	Year 2006 – 2010	Year 2011 – 2015	Year 2016 - 2020	Year 2021 - 2025	
1	Ha Giang	25	40	50	30	100	`245
2	Lao Cai	-		-	-	80	80
3	Yen Bai	15	-	10	30	15	70
4	Son La	5	-	7	-	-	12
5	Dien Bien	6	8	-	12	-	26
6	Bac Kan	49	-	-	-	142	191
7	Lai Chau	-	-	10	-	-	10
	Total						**604**

To recognize heritage Shan tea trees, NOMAFSI collaborated with local authorities to conduct field surveys, identify ancient Shan tea trees (over 100 years old), and prepare nomination documents for their recognition as Vietnam Heritage Trees. Following expert evaluation and review, the Vietnam Heritage Tree Council of the Vietnam Association for Nature and Environment Protection (VACNE) officially recognized eligible trees as Vietnam Heritage Trees. After recognition, local authorities organized official designation ceremonies, while local communities implemented conservation and management plans for the protected trees. To date, 2,591 ancient Shan tea trees in five northern mountainous provinces have been recognized as Vietnam Heritage Trees. Ha Giang has the largest number, with 1,629 trees aged between 100 and 500 years, followed by Yen Bai with 500 trees aged between 100 and 300 years (Nguyen, N. B., Tran, X. H., *et al*., 2022). Recognizing these heritage trees has contributed to conserving valuable tea genetic resources while promoting community-based cultural tourism, ecotourism, and experiential tourism in ethnic minority areas.

Table 3. The area of ancient Shan tea trees recognized as heritage trees

No	Location	No. of ancient Shan tea trees recognized until 2024	Age of the tree (year)	Note
1	Ha Giang	1.629	100 - 500	In Bac Quang, Hoang Su Phi, Vi Xuyen and Xin Man
2	Lao Cai	105	100 - 240	Cho Chai village, Hoang Thu Pho commune, Bac Ha district
3	Yen Bai	500	100 - 300	Suoi Giang village (400 trees), Sung Do commune (100 trees), Van Chan district
4	Son La	257	100 - 280	- Ban On sub-area, Moc Chau Farm town, Moc Chau district (57 trees) - Ta Xua commune, Bac Yen district (200 trees)
5	Dien Bien	100	100 - 300	At 2 villages Sin Chai, Hau Chua (Sin Chai commune, Tua Chua district)
	Total	**2.591**		

Some technical solutions for cultivation to enhance growth, yield, and quality of Shan tea in high mountain areas

Vegetative propagation of highland Shan tea: Studies on stem cutting propagation identified June as the optimal propagation period, with a nursery density of 250 pots m^{-2}. The optimal fertilization regime for nursery plants was 150 g m^{-2} of NPK fertilizer, applied in six split applications (60 g urea, 40 g superphosphate, and 50 g potassium sulfate). This protocol significantly improved seedling growth and quality, with measured growth parameters increasing by 11.53–58.73% relative to the control treatment (Nguyen, T. H. L., 2017).

Table 4. Some technical solutions for propagation of High Mountain Shan tea

No	Technical Solutions	Monitoring indicators		
		Plant height (cm)	Number of leaves per plant (leaves/plant)	Harvesting rate (%)
1	Cutting season (cutting in June)	25,40	10,00	82,00
	Control (cutting in December)	18,90	6,30	62,30
	Compared to control (%)	*34,39*	*58,73*	*31,62*
2	Cutting density (250 pots/m²)	27,40	10,33	78,00
	Control (350 pots/m²)	20,50	8,33	66,00
	Compared to control (%)	*33,66*	*24,00*	*18,18*
3	Nutritional regime (Fertilization amount is 150 g/m² divided into 6 applications (60g urea + 40g superphosphate + 50g K_2SO_4	33,58	9,67	81,00
	Control (Fertilization amount is 110 g/m² divided into 4 applications (30g urea + 30g superphosphate + 50g K_2SO_4)	27,15	8,67	67,33
	Compared to control (%)	*23,68*	*11,53*	*20,30*

Note: After 10 months of cutting.

Pruning techniques for High Mountain Shan tea: Traditional pruning and harvesting practices for High Mountain Shan tea can adversely affect plant growth because excessive branch removal increases the risk of branch dieback and plant mortality under drought conditions. Therefore, researchers investigated optimized annual pruning practices to improve plant performance. Experimental studies conducted by NOMAFSI demonstrated that both canopy pruning and selective pruning significantly increased bud density and yield

compared with the traditional pruning method. Selective pruning produced 662.4 buds m^{-2}, a 27.78% increase over the control, with a yield of 2.76 kg $plant^{-1}$, a 16.95% increase. Canopy pruning resulted in 675.2 buds m^{-2} (30.25% higher than the control) and a yield of 3.08 kg $plant^{-1}$ (30.51% higher than the control). In addition, these pruning methods reduced pruning stress, minimized branch damage, promoted vigorous vegetative growth, and improved resistance to pests and diseases.

Table 5. Some technical measures for pruning and renovation of High Mountain Shan tea

No.	Technical measures for pruning	Monitoring indicators			
		Weight of bud with 1 stem and 2 leaves (g)	Weight of bud with 1 stem and 3 leaves (g)	Bud density (buds/m²)	Yield per harvest per plant (kg)
1	Topping pruning	1,15	2,0	662,4	2,76
	Compared to control (%)	-	-	*27,78*	*16,95*
2	Flat pruning	1,08	1,9	675,2	3,08
	Compared to control (%)	-	-	*30,25*	*30,51*
3	Traditional pruning (*control*)	1,08	1,65	518,4	2,36

* Note: Traditional pruning (painful pruning, simultaneous branch cutting)

Application of organic and microbial fertilizers to High Mountain Shan tea: High Mountain Shan tea is primarily cultivated on steep mountainous terrain, where substantial nutrient losses occur because of soil erosion and surface runoff. In many production areas, nutrient inputs are limited, resulting in reduced vegetative growth, lower bud yield, and inferior tea quality. To address these constraints, the application of organic and microbial fertilizers was investigated to improve soil fertility, plant growth, and tea productivity.

Table 6. Supplementing some nutrients affecting the yield and quality of High Mountain Shan tea

No.	Nutritional supplements	Yield (tons/ha)	Tanin (%)	Solute (%)	Axit amin (%)	Green tea tasting point
1	Fertilize with 20 tons of manure/ha (20 kg/tree)	3,98	30,38	43,76	3,45	17,27
	Compared to control (%)	*70,08*	-	-	-	-
2	Organic microbial fertilizer 2.000 kg/ha (2 kg/tree)	3,90	30,23	44,27	3,28	16,78
	Compared to control (%)	*67,95*	-	-	-	-
3	Organic microbial fertilizer 2.500 kg/ha (2,5 kg/tree)	4,23	30,18	44,05	3,48	16,72
	Compared to control (%)	*80,77*	-	-	-	-
4	Organic microbial fertilizer 3.000 kg/ha (3 kg/tree)	5,58	30,02	44,69	3,77	17,07
	Compared to control (%)	*138,46*	-	-	-	-
5	Traditional farming (control)	2,34	31,17	42,08	2,86	16,34

* Note: Traditional Cultivation: No fertilization, no care; Supplementary application of organic fertilizer increased yield compared with the control; Sensory evaluation score of green tea according to TCVN 3218:2012 in which Appearance (×1), Liquor color (×0.6), Aroma (×1.2), Taste (×1.2)

Nutrient supplementation for High Mountain Shan tea during the conservation and care process, compared to traditional cultivation (control), resulted in higher indicators for yield, soluble solids, amino acids, and sensory tasting scores of green tea products. In contrast, tannin content showed a decreasing trend and was lower than the control. With the application of 3,000 kg of organic and microbial fertilizer per hectare, yield reached 5.58 tons/ha, an increase of 138.46% compared to the control, while tannin content was 30.02%, 1.15% lower than the control. The sensory tasting score for green tea products ranged from 16.72 to 17.07, which is higher than the control by 0.38 to 0.73 points (Nguyen, T. H. L., 2017; Nguyen, H. L., 2009; Nguyen, N. B., Tran, X. H., *et al.*, 2022).

On harvesting techniques linked to processed products: Normally, local farmers harvest tea with one bud and 3-4 leaves. While this method may increase yield in a single harvest, it negatively impacts processing

quality, leading to quicker aging of the tea and reduced yield in subsequent years. Harvesting tea buds with one bud and two leaves yields 4.80 kg/plant/year, an increase of 73.91% compared to the control, and increases the sensory tasting score for specialty green tea products by 0.50 to 1.05 points. Harvesting with one bud and three leaves yields 4.94 kg/plant/year, an increase of 78.99% compared to the control, with the sensory tasting score for specialty green tea products increasing by 0.40 to 0.82 points. This demonstrates that harvesting tea buds using proper techniques contributes to the development of a strong canopy structure, enhancing both yield and product quality compared to traditional harvesting methods (Nguyen, T. H. L., 2017; Nguyen, N. B., Tran, X. H., *et al.,* 2022). Additionally, proper harvesting techniques facilitate the processing of high-quality tea products such as white tea, black tea, and needle tea, which command higher prices and are more favored by consumers.

Table 7. Harvesting techniques related to yield and product quality

No.	Harvesting techniques	Yield (kg/tree/year)	Productivity increase compared to control (%)	Total score for sensory evaluation of special green tea products		
				Spring crop	Summer crop	Autumn crop
1	Traditional method by farmers (picking 1 bud and 3-4 leaves) (control)	2,76	-	16,35	15,95	16,25
2	Picking 1 bud and 2 leaves	4,80	73,9	17,30	16,45	17,00
3	Picking 1 bud and 3 leaves	4,94	79,0	16,45	16,05	16,48

Tea processing and preservation technology

1) Processing technologies for High Mountain Shan tea: Traditional processing of High Mountain Shan tea in northern mountainous areas primarily follows conventional green tea manufacturing practices. After harvesting, fresh tea leaves undergo enzyme inactivation (fixation) using a heated pan or rotary drum, followed by rolling and final drying by pan-firing or hot-air drying. Traditional processing generally relies on simple equipment with limited process control, which may reduce product quality and consistency. To increase the added value of High Mountain Shan tea, NOMAFSI has developed and transferred processing technologies for a range of value-added products, including Pu-erh tea, yellow tea, white tea, black tea, and specialty scented green tea.

2) Pu-erh tea: Pu-erh tea is produced through a controlled post-fermentation process in which microbial activity and enzymatic reactions induce substantial biochemical changes in tea constituents. These transformations contribute to the product's characteristic flavor, aroma, and sensory quality. Pu-erh tea is widely consumed and has strong market demand, particularly in China and Taiwan.

Table 8. The effect of fermentation time on quality indicators of Pu-erh tea

Tea variety	Analysis indicators	Pu-erh tea fermentation time (days)			Note
		30	40	50	
Shan Tham Ve (Ha Giang)	Tanin (%)	13,95	13,50	12,89	
	Solute (%)	45,00	44,37	44,15	
	Watercolour intensity	3,49	3,63	3,97	λ = 460 nm
	Total sensory evaluation score (points)	72	68	66	
Shan Nam Bung (Yen Bai)	Tanin (%)	14,50	14,45	14,25	
	Solute (%)	44,54	42,60	42,25	
	Watercolour intensity	3,09	3,20	3,36	λ = 460 nm
	Total sensory evaluation score (points)	63	60	57	

Data sources: Nguyen, H. L., 2011

Fermentation duration significantly affected the sensory quality of Pu-erh tea produced from different High Mountain Shan tea varieties. A fermentation period of 30 days resulted in the highest sensory scores for Shan Tham Ve (72) and Shan Nam Bung (63), whereas longer fermentation periods (40 and 50 days) reduced sensory quality. Increasing fermentation duration produced darker tea liquor and was associated with a decline in tannin content, while soluble solids remained relatively unchanged.

3) Special green tea*:* The main feature of this processing protocol, compared with conventional green tea processing, is a light withering step (2.0–2.5 h) prior to fixation to enhance the natural aroma while reducing the bitterness and astringency characteristic of High Mountain Shan tea. The leaves are subsequently subjected to fixation, followed by a two-stage drying process consisting of preliminary drying at 100–110°C, a 2-h tempering period for moisture equilibration, and final pan-firing at 90–100°C. The resulting specialty green tea has been well accepted in the domestic market, increasing the selling price by 28–30% and profitability by approximately 1.7-fold compared with conventionally processed green tea. Local tea producers can readily adopt the processing protocol (Nguyen, M. H., *et al.*, 2021).

Supporting localities to promote high-quality Shan tea production

Based on the research results, NOMAFSI has developed technical processes for cultivating and processing several high-quality Shan tea products. NOMAFSI has transferred these processes to households, enterprises, and cooperatives producing tea in various provinces within the region. Additionally, NOMAFSI has collaborated with localities to research and propose several socio-economic solutions to promote the development of indigenous Shan tea production, such as:

Policy consultation: NOMAFSI has advised authorities on developing specific support policies for High Mountain Shan tea in Ha Giang, Yen Bai, and other regions. These policies include support for conserving and developing raw material areas, such as creating a mapping plan for highland Shan tea cultivation, providing subsidies for protection and care, supporting organic fertilizer, assisting with processing equipment, and building brand identity, among others. In addition to national policies, several northern mountainous provinces have introduced local support mechanisms to promote the sustainable and organic development of Shan tea. These measures include providing organic fertilizers (approximately 2–3 kg $tree^{-1}$ $year^{-1}$ for conserved Shan tea trees), financial support for organic certification, and investments in branding, geographical indication, and market promotion. Several provinces have also allocated dedicated funding for developing and promoting Shan tea brands and OCOP products, enhancing product value, expanding market access, and providing economic incentives for farmers to conserve indigenous ancient Shan tea resources.

Supporting localities in brand and product label development: Since 2008, NOMAFSI has collaborated with localities to provide technical support and guide legal procedures for certifying organic Shan tea production areas, as well as for OCOP (One Commune One Product) High Mountain Shan tea products and geographical indications for specialty High Mountain Shan tea regions. The area of certified organic Shan tea has reached 331 hectares, including 200 hectares in Ha Giang and 100 hectares in Yen Bai. The geographical indication for High Mountain Shan tea products covers 8,564 hectares, with Ha Giang's snow Shan tea reaching 7,000 hectares in 2018 (Ha Giang DARD, 2022) and Na Hang snow Shan tea in Tuyen Quang reaching 64 hectares in 2021 (Tuyen Quang Agricultural Extension Center, 2022).

Three collective trademarks for Shan tea have been established, including Tua Chua Snow Shan Tea (2008) (Do, V. N., Nguyen, H. L., *et al.*, 2009), Bang Phuc Snow Shan Tea (Luu, N. Q., 2019), and Lung Phin Green Tea (2024) (Nguyen, T. H. L., 2024). Six products have been certified as OCOP (One Commune One Product), and seven enterprises have received support. Additionally, there is a need to diversify and enhance product quality by standardizing production processes according to VietGAP, organic, or international standards (such as Organic EU, USDA, etc.), and developing various product lines, including green tea, black tea, white tea, cold-brewed tea, and gift tea. The establishment of collective brands, geographical indications, and organic certification has substantially enhanced the market competitiveness and value addition of Shan tea products. Certified Shan tea generally achieved price premiums of 15–50% over non-certified products, while OCOP-certified products expanded into high-value domestic and international markets, including the European Union, the United States, Japan, and Taiwan. These improvements contributed to revenue increases of approximately 15–40% for participating cooperatives and enterprises and income gains of 10–25% for tea growers in certified production areas. Collectively, these findings demonstrate that quality certification, branding, and market integration are key drivers of value-chain upgrading and the sustainable conservation and utilization of indigenous Shan tea resources.

Table 9: Statistics on brand and product label development for High Mountain Shan tea in some localities

Province	Number of organic certified areas (ha)	Number of geographical indications (GI) (ha)	Number of collective trademarks	Number of OCOP products	Number of enterprises and cooperatives supported
Ha Giang	200	7.000	01	03	03
Tuyen Quang	21	64	-	01	01
Dien Bien	-	-	01	01	01
Yen Bai	100	1.500		01	01
Bac Kan	10	-	01	01	01
Total	**331**	**8.564**	**03**	**06**	**07**

Training and dissemination of techniques: From 2020 to 2025, NOMAFSI has organized training sessions for 1,070 individuals, including 450 from Ha Giang, 150 from Yen Bai, 100 from Bac Kan, 120 from Lao Cai, 50 from Dien Bien, 50 from Lai Chau, and 150 from Tuyen Quang. The training content focuses on raising awareness of Shan tea conservation, as well as techniques for caring for, harvesting, and processing High Mountain Shan tea for local farmers (Nguyen, N. B., 2025).

Organize production for farmers: NOMAFSI has collaborated with localities to establish models of supply chain linkage between enterprises/cooperatives and households to produce High Mountain Shan tea. This includes two models in Ha Giang (Phin Ho Cooperative and Lung Phin Agricultural Processing Cooperative), one model in Yen Bai (Suoi Giang Cooperative), one model in Tuyen Quang (Hong Thai Snow Shan Tea Cooperative), and one model in Bac Kan (Hong Ha Cooperative) (Nguyen, N. B., 2025).

Additionally, NOMAFSI has supported several enterprises in various provinces, including Phin Ho Tea Processing Cooperative and Lung Phin Agricultural Processing Cooperative (Ha Giang), Suoi Giang Cooperative (Yen Bai), Kia Tang Mountain Tea Joint Stock Company (Tuyen Quang), and Hong Ha Cooperative (Bac Kan), by providing techniques for harvesting that are linked to the processed products of these enterprises/cooperatives. This support has contributed to an increase in economic efficiency of 15% to 20% compared to conventional products. The products have been recognized as OCOP products with ratings of 3, 4, and 5 stars.

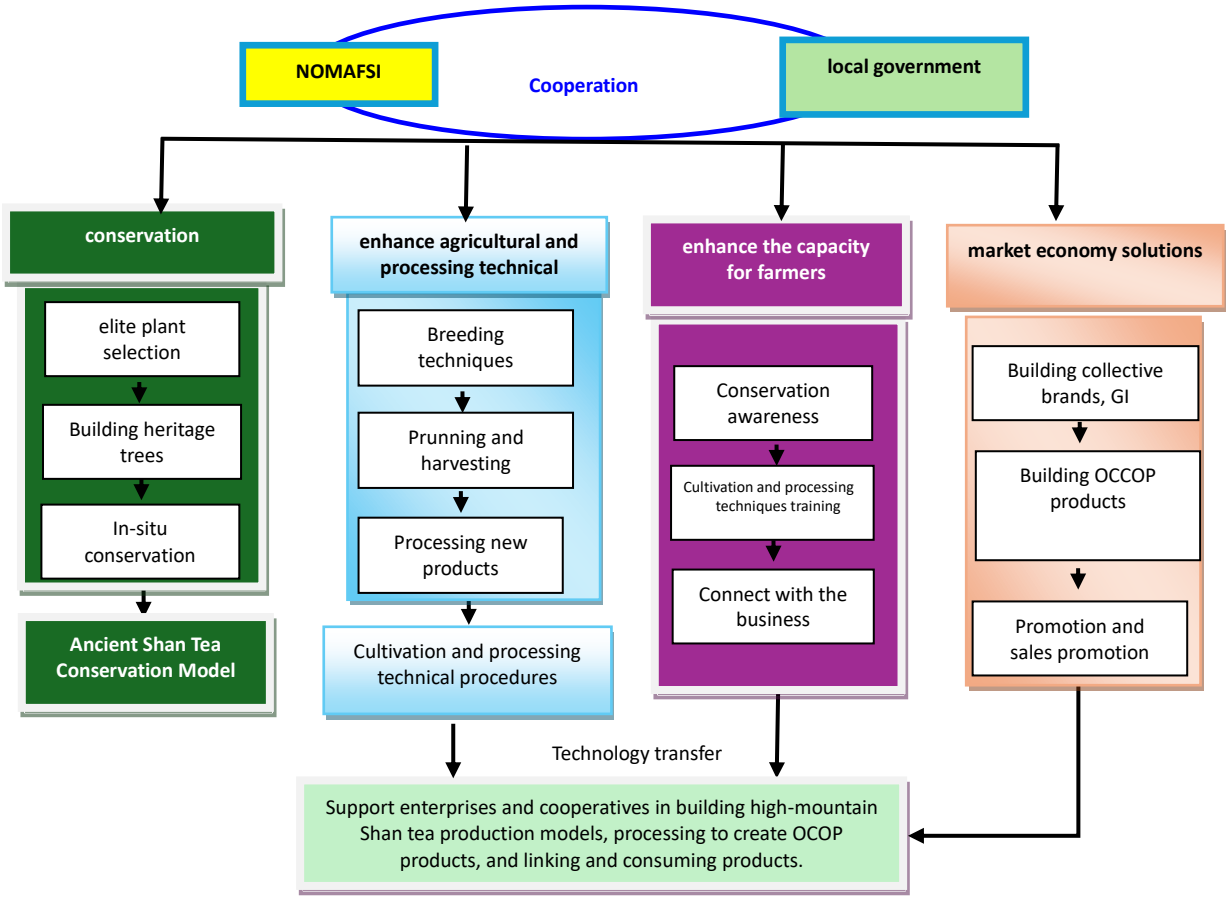


Figure 2. The impact model for conserving and developing indigenous Shan tea production in several northern mountainous provinces.

Figure 2 shows that the sustainable conservation of indigenous Shan tea can only be achieved through the integration of genetic resource conservation, technology transfer, and value chain development. The linkage among scientific research, technical training, demonstration models, OCOP product development, and market integration not only enhance tea productivity, quality, and value addition but also creates economic incentives for local communities to actively conserve ancient Shan tea populations. These findings are consistent with previous studies, which have shown that sustainable tea production depends on the integration of technological innovation, stakeholder participation, and value chain development to improve farmers' livelihoods while ensuring the conservation of Camellia sinensis genetic resources (Nguyen *et al*., 2019; Sarkar *et al*., 2022; Manetti *et al*., 2026).

CONCLUSION AND RECOMMENDATIONS

The Shan tea plant is a valuable botanical and cultural resource Vietnam's northern mountainous region. The conservation and development of Shan tea not only brings economic benefits but also helps preserve cultural identity and protect the environment. Through our research efforts, NOMAFSI has played a significant role in conserving and developing indigenous Shan tea in the northern mountainous provinces over the years. NOMAFSI's research results have helped preserve Shan tea, particularly the area of ancient Shan tea trees, enabling local people and some enterprises and cooperatives to create new high-value products, thereby increasing the income of tea producers and promoting the value of indigenous Shan tea both domestically and internationally. However, the widespread adoption of these research outcomes requires coordinated efforts among government agencies, research institutions, enterprises, cooperatives, and local communities. Policy frameworks should support such collaboration by promoting organic agriculture, sustainable value chains, and biodiversity conservation (FAO, 2021). In Vietnam, the Organic Agriculture Development Scheme for 2020–2030 (Decision No. 885/QĐ-TTg) provides an important policy framework for expanding environmentally friendly agricultural production, conserving natural resources, and improving the value of agricultural products (Prime Minister of Vietnam, 2020). In addition, the National Target Program on New Rural Development (Decision No. 263/QĐ-TTg) and the One Commune One Product (OCOP) Program (Decision No. 919/QĐ-

TTg) have promoted value-chain development, product standardization, and market access for local specialty products, including Shan tea (Prime Minister of Vietnam, 2022a, 2022b). These policy instruments align with previous studies showing that sustainable tea production depends on integrating technological innovation, stakeholder participation, and market-oriented value chains to improve farmers' livelihoods while conserving Camellia sinensis genetic resources (Nguyen *et al*., 2019; Sarkar *et al*., 2022; Manetti *et al*., 2026). Therefore, integrating scientific research with supportive policies and market-based mechanisms is essential for the long-term conservation and sustainable development of indigenous Shan tea in Vietnam's northern mountainous regions.

In addition, the government needs to establish appropriate mechanisms to support, facilitate, and encourage qualified organizations and individuals to participate in the production, processing, and consumption of Shan tea products, especially those that are certified organic. Integrate and harmonize existing policies issued by the central government and the province to promote the development of organic agriculture.

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AUTHORS' CONTRIBUTIONS

The co-authors have collectively contributed to the completion of this article. Luu Ngoc Quyen served as the first author to make contributions to conceptualizing the research framework, developing the main conceptual ideas, and editing the manuscript. He is also the corresponding author during the review, editing, results confirmation, and submission process. Tran Xuan Hoang is listed as the second author and contributed to devising the project, outlining the research, conducting data analysis, and drafting the manuscript. Nguyen Ngoc Binh and Nguyen Thi Hong Lam is acknowledged as the third author and fourth author, providing their research results for the article.

COMPETING INTERESTS

Luu Ngoc Quyen, Tran Xuan Hoang, Nguyen Ngoc Binh and Nguyen Thi Hong Lam declare no conflict of interest.