

INTEGRATED VALUE CHAIN GOVERNANCE OF SPECIALTY AGRICULTURAL PRODUCTS IN THE DIGITAL ECONOMY CONTEXT: A CASE STUDY IN THE RAW MATERIAL REGION OF CAO BANG PROVINCE

Nguyen Thuy Linh

Ministry of Industry and Trade

Email: linhnth@moit.gov.vn

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ABSTRACT

In the context of the global agricultural economy's strong shift towards a data-driven and risk-resilient growth model, developing sustainable raw material areas is an urgent requirement for mountainous localities. This study analyzes the structural and governance factors affecting the effectiveness of developing endemic agricultural raw material areas in Cao Bang province during the period 2021–2025, as a basis for proposing a framework of solutions for the period 2026–2030. Applying Global Value Chain (GVC) theory combined with a mixed research methodology, the authors identify core bottlenecks hindering access to high-end value chains, including: (i) the lack of first-mile logistics infrastructure causing significant post-harvest losses; (ii) the fragmented capacity of farmers to absorb digital technology; (iii) information asymmetry; and (iv) vulnerability to extreme climate change. Based on the identification of empirical barriers, the study proposes an integrated management solution system focusing on: (1) Investing in mini cold storage infrastructure and pre-processing systems in growing areas to reduce physical losses; (2) Digitizing growing area codes and traceability using Blockchain technology; (3) Piloting an agricultural insurance mechanism based on weather indices to increase financial safety margins; and (4) Developing brands based on Geographical Indications (GI) combined with heritage ecotourism. The research results contribute a system governance framework to transform traditional mountainous agriculture into a transparent, adaptable, and multi-valued model, thereby enhancing the competitiveness of endemic agricultural products in the modern value chain.

Keywords: Sustainable raw material area, Global Value Chain (GVC), first-stage logistics, Weather Index Insurance, Cao Bang.

1. INTRODUCTION

In the context of a global economy facing complex fluctuations from supply chain disruptions and the negative impacts of climate change, reshaping sustainable agricultural development strategies has become a top priority for many countries. Agriculture is no longer simply a resource-intensive industry but is strongly shifting towards an agricultural economic model based on knowledge, technology, and connectivity. In Vietnam, Resolution No. 19-NQ/TW of the 13th Central Committee of the Communist Party of Vietnam, issued on June 16, 2022, emphasized the importance of forming concentrated raw material areas linked to processing and product consumption to enhance the added value and competitiveness of Vietnamese agricultural products.

However, the practice in the northern mountainous provinces, particularly Cao Bang, shows that this process is facing serious structural bottlenecks. With its fragmented terrain, underdeveloped transportation infrastructure, and small-scale production, establishing sustainable raw material areas here is not only a technical challenge in cultivation but also a challenge in integrated management. According to the latest OECD report [1], mountainous areas are vulnerable to extreme weather events, with predicted losses potentially reaching 5.6-6.2% of total agricultural output by 2030 if proactive response scenarios are not in place. In Cao Bang, key products such as tobacco, black jelly, and endemic plants, although initially forming specialized cultivation areas, remain largely spontaneous and lack organic linkages between stakeholders in the value chain.

Theory of Global Value Chain Management (GVC) [2] indicates that the success of a raw material region depends closely on three variables: transaction complexity, information encoding capabilities, and the capacity of the local supplier system. For a border province like Cao Bang, the lack of encoding capabilities (digitizing data on growing areas) and the ability to store and process information locally has put farmers in a "captive" position in the value chain, leading to value-added losses at intermediate stages. Furthermore, research by Tai Li et al. [3] in the mountainous region of Yunnan (China) has shown that the lack of "first-mile" logistics infrastructure is the main cause of post-harvest losses of up to 25-30% in remote areas.

Faced with these challenges, there is a need to develop a new integrated governance framework for the period 2026-2030. This framework should not only focus on providing technical support for agriculture but also integrate digital technology solutions (Smart Farming), financial risk management tools (weather index insurance), and branding strategies (geographical indications linked to tourism). Learning from similar geopolitical and ecological models such as Yunnan (China) in investing in on-site cold storage, or Chiang Mai (Thailand) in combining agriculture with heritage tourism, is extremely urgent.

This paper aims to systematically analyze the factors affecting the sustainability of agricultural raw material areas in Cao Bang through the following methods

2. THEORETICAL FOUNDATION AND FRAMEWORK OF SUSTAINABLE AGRICULTURAL VALUE CHAINS

2.1. Global Value Chain (GVC) Governance Model and Power Coordination

The overarching theoretical foundation of this study is established based on the Global Value Chain (GVC) analytical framework by Gereffi, Humphrey, and Sturgeon [2]. Unlike the traditional supply chain approach, which focuses only on the physical movement of goods, GVC theory delves into the analysis of power relationships, coordination mechanisms, and the distribution of surplus value among participating actors. The operation of the chain is shaped by the dynamic interaction between three core variables: transaction complexity, information encoding capabilities, and the capacity of the supplier system.

In the agricultural sector, the complexity of transactions is often linked to stringent technical standards and requirements for food safety and hygiene. As these standards become more sophisticated, the need for coordination between leading businesses and producers increases accordingly. However, the ability to encode information – that is, to convert complex requirements into digital or standardized technical instructions – plays a crucial role in minimizing transaction costs. In particular, the capacity of the supplier system, reflected in the technical skills and technological adoption capacity of farmers, is a key variable determining their position in the chain.

From the interaction of these variables, GVC theory establishes five typical governance models, ranging from "Market" to "Hierarchical System". For the context of mountainous regions like Cao Bang province, the prevailing situation is the Captive governance model. In this model, small-scale producers are often tightly controlled by large purchasing units but receive the lowest rate of added value due to a lack of coding capacity and bargaining power. This study hypothesizes that improving digital capacity and on-site technical infrastructure will promote a shift from a dependent model to a Relational or Modular model, where value is shared more fairly and sustainably.

2.2. The Intersection of First-Mile Logistics and Economic Sustainability

The sustainability of raw material areas must first be built on the foundation of economic efficiency, which is directly influenced by the logistics structure. The research of Tai Li et al. [3] clarified a paradox in highland agriculture: production productivity may increase, but farmers' real income remains precarious due to post-harvest losses. The concept of First-Mile Logistics becomes a vital element in this theoretical framework. The lack of cold storage and processing facilities at the point of production not only causes a decline in the physical quality of agricultural products but also diminishes the "time value" of products when they reach the market.

The integration of storage infrastructure at the source, following the model of Yunnan (China), demonstrates that good management of logistics bottlenecks from the outset is a key solution to maintaining the value content of raw material areas. This aligns with the OECD's perspective [1] on optimizing the link between trade and the environment, where minimizing food waste through smart storage infrastructure is considered a dual strategy: ensuring income security for farmers while reducing the carbon footprint of the agricultural supply chain.

2.3. Climate Risk Management Through Modern Financial Tools

An inseparable pillar in the theoretical framework of sustainability is the adaptability of raw material areas to climate change. This research applies the theory of Climate-Smart Agriculture (CSA), but expands it to the aspect of financial risk management. In the context of increasingly complex extreme weather events such as flash floods or droughts in Cao Bang, traditional compensation mechanisms often reveal delays and inefficiencies.

The Weather Index Insurance (WII) theory by Miquelluti et al. [4] provides a new data-driven management method. Instead of assessing actual damage after a natural disaster, index insurance makes payments based on objective meteorological thresholds determined through observation stations or satellites. This mechanism not only helps farmers quickly access capital for reproduction but also creates confidence for credit institutions in investing in raw material areas. Integrating index insurance into value chain management is a solution to shift from passive to active risk management, ensuring that capital flows are not disrupted by environmental shocks.

2.4. Digital Transformation and Restructuring of Raw Material Area Absorption Capacity

Digital transformation in agriculture, as defined by Pham and Chan [5], is not simply about equipping with technological devices but a comprehensive restructuring of how data interacts and is managed within the agricultural ecosystem. The theoretical framework of this paper emphasizes the concept of Absorptive Capacity - the ability of producers to identify, absorb, and apply new information to production practices.

Digital technology plays the role of "encoding" complex transactions in Gereffi's GVC theory [2]. When data on soil, farming processes, and production logs are digitized through Blockchain or IoT, transparency is established, thereby reducing reliance on intermediaries with asymmetric information. Digital transformation helps to build "digital capital" for raw material

areas, allowing endemic growing regions like Cao Bang to objectively demonstrate origin and quality, opening up opportunities for direct access to high-end and sustainable markets.

2.5. Geographical Indications (GI) and Multi-Value Agricultural Strategies

Finally, the study integrates the theory of Geographical Indication as a tool for managing identification and increasing value. According to Li et al. [6], GI is not just a legally protected trademark but a mechanism for creating competitive advantage based on the uniqueness of the ecological region and indigenous knowledge. Effective management of geographical indications (GIs) will create a ripple effect, allowing agricultural products to not only have consumer value but also become cultural values.

The combination of specialized agriculture and heritage tourism (Agritourism) – as successfully demonstrated in Chiang Mai (Thailand) – represents a trend towards multi-value agriculture. The theoretical framework suggests that when a raw material area is managed in an integrated manner, from GI protection and digitalization of the growing area to tourism connectivity, it will create a sustainable, self-reinforcing system. In this system, farmers not only sell agricultural products but also the heritage story of the land, diversifying income sources and reducing dependence on price fluctuations in the raw agricultural market.

3. INTERNATIONAL EXPERIENCE AND LESSONS FOR VIETNAM

3.1. The "First Stage" Infrastructure Management Strategy in Yunnan (China)

The experience from Yunnan Province provides a practical model for restructuring the agricultural value chain in mountainous areas through technical infrastructure intervention. The fragmented terrain and large distance between raw material areas and consumption centers in Yunnan closely resemble the situation in Cao Bang Province. Research by Tai Li et al. [3] indicates that, instead of focusing resources on giant logistics centers in urban areas, the Chinese government has shifted its focus to establishing small-scale cold storage systems right at the production site (production-site cold storage).

The presence of storage infrastructure at the source has directly addressed the "bottleneck" of post-harvest losses - which is the main cause of a 25-30% decrease in the economic value of fresh agricultural products. Under the theoretical framework of Gereffi et al. [2], possessing on-site storage capacity helps farmers and local cooperatives improve their ability to coordinate transactions. When time pressure (perishability) is relieved, the bargaining position of producers changes significantly, allowing them to move away from a "Captive" management model dependent on intermediaries towards a "Modular" or "Relational" management model, where more added value is retained locally.

3.2. Multi-value agriculture model and heritage identification in Chiang Mai (Thailand)

In Chiang Mai, the sustainability of the raw material area is built through an integrated strategy between specialized agriculture and the tourism service industry. According to statistics and analysis by David Mickelson [7], Thailand has successfully transformed purely agricultural production areas into agritourism ecosystems. The core of this model lies in the thorough application of the Geographical Indication (GI) system as a tool to encode indigenous knowledge into transparent economic value.

GI management in Chiang Mai goes beyond simply protecting the name; it also involves linking small-scale producers into a single entity with a strong brand in the international market. Empirical studies by Li et al. [6] show that GI-labeled products achieve a price premium 20-35% higher than mass-produced products. More importantly, this model diversifies revenue sources: farmers benefit not only from selling agricultural products but also from cultural experiences and eco-tourism services. This creates a natural economic

"safety net," helping the raw material area better withstand the erratic fluctuations of raw agricultural product prices in the global market.

3.3. Lessons Learned and Application Directions in Vietnam (Case Study of Cao Bang Province)

By comparing international models with the practical situation in Cao Bang, the study draws lessons that provide strategic direction for the period 2026-2030:

First, redefining logistics investment priorities: Vietnam needs to shift from a mindset of building large-scale transportation infrastructure to investing in "first-stage logistics." For Cao Bang's unique products such as black jelly or tobacco, the formation of small-scale cold storage clusters and preliminary processing centers in sub-regions of raw materials is more crucial in protecting added value and reducing operating costs of the supply chain.

Second, digitizing and "coding" geographical indications: GI protection needs to be linked to digital transformation [5]. Cao Bang has a significant advantage from its UNESCO Global Geopark, therefore it needs to utilize Blockchain technology and electronic logs to transparentize the production process, transforming indigenous ecological characteristics into traceable data. This is a prerequisite for developing a multi-value agricultural model based on Thailand's experience, connecting agricultural products with sustainable tourism.

Thirdly, proactively manage risks through digital finance: Instead of relying on passive disaster relief mechanisms, Vietnam needs to learn from the implementation of Weather Index Insurance. By coding climate risks based on meteorological data [4], the raw material area will become more "reliable" in the eyes of investors and credit institutions, thereby attracting the necessary capital to upgrade the value chain towards modernity and sustainability.

In summary, international lessons emphasize that sustainability does not come from isolated solutions but is the result of an integration of infrastructure at the source, heritage-based brand management, and smart financial tools. This is the inevitable path for Cao Bang agricultural products to enhance their position in the global value chain.

4. ANALYSIS OF THE CURRENT SITUATION OF AGRICULTURAL RAW MATERIAL AREAS IN CAO BANG PROVINCE

According to the Cao Bang Provincial Statistics Office [8], the agriculture, forestry, and fisheries sector of Cao Bang province continues to play an important supporting role for the local economy, reaching a scale of VND 5,249 billion and accounting for 20.83% of GRDP. This sector attracts 146,228 workers, accounting for 62% of the total workforce in the province. However, the development of raw material areas still reveals multifaceted results between opportunities for linkages and structural bottlenecks.

4.1. Structural Characteristics and Effectiveness of the Value Chain Linkage Model

The total area of annual crop cultivation in the province in 2024 reached 97,985 hectares, an increase of 2% (equivalent to 1,919 hectares) compared to 2023. From the perspective of global value chain management (GVC), the structure of raw material areas in Cao Bang is clearly differentiating, with models involving the intervention of leading enterprises (Lead firms) through a "captive" management model showing outstanding scale expansion effectiveness:

- Tobacco raw material area: Affirming its position as a key crop with an area of 5,184 hectares, a sharp increase of 37.40% (equivalent to 1,411 hectares) compared to 2023. The strong expansion in Ha Quang, Hoa An, and Trung Khanh districts stems from commitments to purchase products as well as improved investment and support for farmers in the raw

material areas. Thanks to the application of science and technology and new varieties, production reached 13,910 tons, an increase of 39.48%.

- Cassava raw material area: The area planted with cassava reached 3,973 hectares (an increase of 18.42%), and production reached 59,405 tons (an increase of 30.06%). The main driving force comes from linkage models where farmers are supported by companies, supplied with seeds, and have a stable market outlet, with traders purchasing and transporting the produce to cassava starch factories.

Conversely, crops lacking chain linkages and with low economic efficiency are tending to shrink in scale and production, such as:

- Soybean cultivation reached 1,902 hectares, a decrease of 2.61% or 51 hectares. The decrease in area is mainly in Ha Quang and Trung Khanh districts due to low economic efficiency compared to other crops, leading many households to switch to growing tobacco and ginger.
- Yield is estimated at 9.98 quintals/hectare, an increase of 0.10% compared to the previous year; production is estimated at 1,898 tons, a decrease of 2.52% or 49 tons compared to 2023.

- Peanuts were planted on 1,590 hectares, a decrease of 7.13% or 122 hectares compared to the previous year; yield is estimated at 14.46 quintals/hectare, an increase of 1.62%; production is estimated at 2,299 tons, a decrease of 5.66% or 138 tons compared to 2023.

- Maize was planted on 40,633 hectares, a decrease of 2.40% or 1,001 hectares compared to the previous year. The decrease in area is due to areas completely lost in the winter-spring crop that could not be harvested and areas buried or damaged in the summer crop due to the impact of typhoon No. 3. Yield is estimated at 37.24 quintals/hectare, an increase of 3.44%. Production is estimated at 151,321 tons, an increase of 0.96% or 1,436 tons compared to the previous year.

Table 1. Comparison of some key agricultural products in Cao Bang province in 2024 and 2023

Type of key agricultural product	Area (ha)	Production (tons)	Increase (+)/Decrease (-) in area	Increase (+), decrease (-) in production
Cassava	3.973	59.405	18,42% (618 ha)	30,06% (13.730 ton)
Tobacco	5.184	13910	37,40% (1.411 ha)	39,48% (3.937 ton)
Peanut	1.59	2.299	- 7,13% (122 ha)	-5,66% (138 ton)
Soybean	1.902	1.898	-2,61% (51 ha)	-2,52% (49 ton)
Corn	40.633	151.321	-2,40% (1.001 ha)	0,96% (1.436 ton)
Rice	30.292	139.417	1,97% (585 ha)	0,9% (1.250 ton)

Source: Cao Bang Province Statistical Yearbook 2025

4.2. Current Status of First-Mile Logistics Infrastructure by Key Agricultural Product Group

According to the GVC (Value Chain Value) theory, the capacity of the local supplier system is measured not only by output but also by the ability to preserve the value of agricultural products right after harvest. Instead of making a general assessment of the shortage of storage infrastructure for the entire raw material area, the structure of first-mile logistics in Cao Bang needs to be viewed specifically, because each group of agricultural products requires a completely different ecosystem of storage and processing infrastructure:

First, for the group of fresh and mechanically vulnerable agricultural products (fresh black jelly, tangerines, various vegetables): This group of products has a mandatory requirement for cold storage systems. The succulent nature and ease of fermentation cause these products to lose quality extremely quickly under the natural temperature and humidity conditions of the mountainous region. However, investment in mini cold storage facilities in clusters of communes growing black jelly (Thach An) or tangerine (Tra Linh) remains largely neglected due to high energy costs and initial investment. The lack of cold storage infrastructure or refrigerated trucks forces farmers to sell their products immediately after harvest to prevent spoilage, leading to localized price manipulation during peak harvest seasons.

Secondly, for dried industrial crops (tobacco), unlike fresh agricultural products, tobacco does not require cold storage but demands a completely different infrastructure system including: curing barns, drying equipment, and dry storage warehouses. Tobacco leaves are characterized by the need to be wilted, dried, and flavored immediately after harvesting to maintain their quality. The situation in major tobacco growing areas like Hoa An and Ha Quang shows that purchasing companies have invested in and provided certain technical support for drying systems at farms. However, drying technology is still largely manual, consuming a lot of biomass fuel and making it difficult to accurately control temperature and humidity. Household-level dry storage warehouses still do not meet standards for mold prevention, affecting the quality of tobacco leaves while waiting for businesses to purchase them.

Thirdly, for starch-producing root crops (cassava, arrowroot), the biological characteristics of cassava and arrowroot require the initial logistics chain to be closely linked to raw processing due to the very large, bulky harvest volume and the rapid starch loss. Essential infrastructure for this group includes primary processing stations, slicing and grinding equipment, and drying systems. In Cao Bang, particularly in areas associated with traditional vermicelli-making villages, farmers and cooperatives have begun to establish preliminary processing stations. However, most of the crushing and grinding equipment is small in capacity, uses outdated technology, and has a low starch recovery rate. The drying system still relies heavily on natural solar energy, causing supply chain disruptions or serious quality degradation (starch turning sour or moldy) during prolonged periods of rain and storms.

It can be asserted that the weakness of initial logistics in the Cao Bang raw material region is not simply a matter of "lack of mini-cold storage." The actual value breakdown stems from the localized shortage of specialized processing and preservation infrastructure (cold storage, curing barns, or slicing/grinding stations) corresponding to the biological characteristics of each product group. This lack of synchronization is the biggest obstacle preventing farmers from mastering the "time value" of agricultural products, causing them to continue to be in a "dependent" management position within the regional agricultural value chain.

4.3. Climate Risks and Financial Vulnerability of Agricultural Value Chains

The disruption of agricultural value chains in Cao Bang is heavily impacted by external risks. Assessing the financial vulnerability of farming households is a key basis for building sustainable raw material areas.

Main climate risks and actual damage: Local specialized farming areas are facing an increasing frequency of extreme weather events. For example, Typhoon No. 3 (Yagi) and flash floods inundated and buried more than 1,555 hectares of agricultural land, causing severe damage to corn and cassava growing areas in Nguyen Binh, Ha Quang, and Bao Lam districts, with total economic losses for the province estimated at over 880 billion VND. In addition, severe cold spells at the beginning of the year damaged nearly 2,000 hectares of corn, tobacco, and other crops, and more than 570 head of livestock; While local droughts during the dry

season reduce water flow and cause a 20-30% drop in fruit setting rates in mandarin and tea growing areas.

Current prevention mechanisms and governance gaps: Currently, localities mainly use state budgets and the Disaster Prevention Fund to support production restoration costs. However, this mechanism reveals major gaps: (1) Passive nature (ex-post) with low support levels (usually only compensating 10-15% of the actual damage value) and delays in assessment procedures; (2) The absence of the traditional agricultural insurance market due to excessively high assessment costs in the fragmented mountainous terrain and information asymmetry barriers.

Basis for proposing Weather Index Insurance (WII): The above bottlenecks require a new financial instrument such as Weather Index Insurance (WII). Unlike traditional insurance, WII automatically triggers claims based on objective meteorological data (rainfall, temperature) without requiring on-site inspection. This advantage completely eliminates costly transaction fees and speeds up payouts. When risks are transparently "financed" through WII, farmers gain a financial safety margin to confidently invest in technology, adopt VietGAP standards, and upgrade their position in the global value chain.

4.4. Digital Transformation and Barriers to Technology Absorption Capacity

The digitalization process of agriculture in Cao Bang is currently facing a conflict between policy expectations and actual implementation capacity. Although the province has implemented planting area codes and a traceability system, the level of data interaction from producers remains very limited. Applying the theoretical framework of Pham and Tran [5], it can be seen that the "Absorbive Capacity" of the farming community - especially ethnic minorities - is a bottleneck variable.

The shortage of digital capital makes the deployment of platforms such as electronic logs or Blockchain fragmented. When planting area data is not accurately and continuously "coded," the transparency value of the product is lowered. This directly affects the ability to export officially to demanding markets such as China (through new protocols on agricultural products). The reality shows that information in the value chain in Cao Bang still mainly flows through traditional channels with a high degree of asymmetry, where producers are always at a disadvantage in terms of market forecasting.

4.5. Geographical Indications (GI) and the Fragmentation in Multi-Value Linkages

Although Cao Bang province has successfully protected Geographical Indications for products such as Thach An black jelly or Trung Khanh chestnuts, the exploitation of post-protection economic value remains unclear. According to the meta-analysis by Li et al. [6], GIs only truly generate profit when they are operated as a "heritage brand" combined with tourism.

Locally, the connection between endemic raw material areas and the UNESCO Non Nuoc Cao Bang Global Geopark remains very weak. Agricultural products have not been transformed into "experiential products" to serve the growing tourist flow. This situation leads to agricultural products being sold only as raw materials at low value, instead of being integrated into the tourism value chain — a model that has brought great success to Chiang Mai (Thailand) in diversifying income sources for highland farmers.

Based on the analysis of the current situation of agricultural raw material areas in Cao Bang, the author summarizes it in the following table:

Table 2. Analysis of the current situation of agricultural raw material areas in Cao Bang

Analytical aspects	Characteristics and Current Situation in Cao Bang	Consequences and Limitations
1. Raw material area structure	The province has developed specialized areas for tobacco cultivation (Hoa An, Ha Quang), black jelly (Thach An), and temperate fruit trees.	Production is fragmented, mainly on a small, scattered, and household scale.
	The relationship between farmers and purchasing units falls into the category of Captive management.	Lack of uniformity in technical procedures hinders the application of VietGAP/GlobalGAP standards.
	Farmers have little say in determining prices and standards.	Value added is "leaking" to intermediaries outside the province.
2. Logistics Infrastructure	Transportation costs are 20-30% higher compared to lowland areas due to the complex mountainous terrain.	This creates the paradox of "losses at source," where commercial value declines right at the temporary storage stage.
	There is a severe shortage of initial logistics infrastructure (mini-cold storage, preliminary processing stations) in the commune clusters.	Fresh produce deteriorates rapidly in nutritional and sensory quality if not properly refrigerated.
	The cold chain was broken right at the point of production.	It is difficult to directly access high-end markets or e-commerce platforms.
3. Digital Transformation & Technology	While planting area codes and traceability systems have been implemented, data interaction remains limited.	The implementation of electronic journals or Blockchain has become fragmented.
	The "capacity to absorb" technology among farming communities (especially ethnic minorities) is still low.	Information flow through traditional channels is highly asymmetrical, putting farmers at a disadvantage in terms of market forecasting.
	A lack of digital capital prevents accurate "encoding" of agricultural data.	The value of transparency has been diminished, directly impacting the ability to export officially to China.
4. Climate Risk Management	The raw material growing areas are frequently affected by frost, localized droughts, and flash floods.	Causes recurrent disruptions to the livelihoods of upland farmers.
	Risk management is based on a "post-incident response" mindset and relies on government funding.	The lengthy and untimely support procedures are hindering farmers from resuming production.
	There is a lack of proactive management tools such as Weather Index Insurance.	This reduces investment attractiveness because natural disaster risks are not quantified and cannot be transferred through digital financial mechanisms.
5. Brand Value	Geographical Indication (GI) protection has been granted for Thach An black jelly and Trung Khanh chestnuts.	The mechanisms through which protection generates economic value remain unclear.
	The connection between the raw material source areas and UNESCO Global Geoparks is still very weak.	Agricultural products are mainly sold in raw form with low value.
	Agricultural products have not yet been transformed into "experiential products" to serve tourism.	Missing the opportunity to integrate into the tourism value chain to diversify income sources for farmers.

Source: Compiled by the author

5. SYSTEM OF SOLUTIONS FOR BUILDING SUSTAINABLE AGRICULTURAL RAW MATERIAL AREAS IN CAO BANG PROVINCE, 2026-2031

To realize the goal of sustainable development, Cao Bang province needs to shift from a mindset of simply supporting production to an integrated, multi-objective governance framework. The solutions below are designed to simultaneously address bottlenecks in governance structure, logistics infrastructure, climate risks, and brand value.

5.1. Restructuring the value chain governance model through upgrading "first-stage logistics" infrastructure

The key solution to enhance the position of producers in the value chain (GVC) is mastering the infrastructure for storage at the source. Applying the research of Tai Li et al. [3], Cao Bang needs to implement a strategy of investing in small-scale cold storage systems and direct processing centers in endemic raw material areas (such as black jelly in Thach An or tobacco in Hoa An).

Establishing "first-mile logistics" is not simply a technical solution to reduce post-harvest losses from 25% to below 5%, but also a power management tool in the chain. According to Gereffi's theory [2], storage capacity helps eliminate the pressure of "selling off" fresh products, thereby shifting the management form from Captive to Relational. When agricultural products are processed and preserved according to standards right at the source, the "modularity" of the product increases, allowing the raw material area to directly access modern distribution channels and official export markets without going through too many intermediaries with asymmetrical information.

5.2. Promoting Digital Transformation Based on Data Encryption Capabilities and "Digital Capital" of Farmers

Digital transformation cannot stop at equipping with hardware but must focus on creating "digital capital" for the raw material area. According to Pham and Tran [5], the technological absorption capacity of producers is the variable that determines the success of smart agriculture. The central solution is to build an electronic production log system integrated with Blockchain technology for all registered growing areas.

This process helps to "encrypt" indigenous farming knowledge and technical standards (VietGAP, GlobalGAP) into digital data with global traceability. When all transactions and farming processes are transparent, transaction costs will decrease and the trust of leading firms in the raw material area will increase. The province needs to play a role in creating a shared data ecosystem, connecting data from field monitoring stations with e-commerce platforms, helping Cao Bang's agricultural products not only "have a presence" but also "gain prestige" in the digital space.

5.3. Policy Orientation: Coordinating the Pilot Program for Weather Index Insurance (WII)

Due to its technical complexity and resource requirements, Weather Index Insurance (WII) is not a tool that local governments can operate independently but should be considered a long-term policy orientation. This paper recommends that Cao Bang province play a facilitating role, coordinating with insurance companies and financial institutions to implement the pilot program according to the following roadmap:

- Cooperation and data sharing: The Meteorological and Hydrological Station and the Department of Agriculture and Rural Development will cooperate in providing historical data series on climate and productivity. This will serve as the basis for insurance companies to develop scientific "trigger points" suitable for the specific characteristics of key crops such as cassava, tobacco, and black jelly.

- Insurance premium support mechanism: In the initial phase, the government can integrate funding from National Target Programs to partially support insurance premiums (subsidies) for farmers. This subsidy helps reduce financial barriers and encourages farmers to become familiar with modern risk management tools.

- Pilot implementation in key areas: Priority will be given to piloting in districts that suffered heavy damage from Typhoon No. 3 (such as Ha Quang and Nguyen Binh). Practical results from this model will help assess feasibility and refine the compensation payment process before scaling up.

Transferring climate risks to the financial market through public-private partnerships will reduce pressure on the relief budget and create a safety margin for the sustainable development of the raw material area.

5.4. Strategy for identifying heritage and integrating agricultural-tourism value chains

Social and cultural sustainability requires that raw material production areas be managed as multifunctional heritage landscapes, where economic, ecological, and cultural values are jointly preserved and enhanced. Drawing on the experience of Chiang Mai, Thailand, and the studies of David Mickelson [7], Cao Bang should consider adopting a tourism-oriented agricultural development strategy. Specifically, GI-protected production areas could be integrated into the visitor experience and tourism routes of the UNESCO Non Nuoc Cao Bang Global Geopark, thereby linking agricultural production, local heritage, and tourism-based value creation.

GI governance needs to be upgraded from a designation protection model to a rigorous community-based quality governance model [6]. When agricultural products are linked to the cultural, historical, and ecological stories of the region, the added value received will no longer be limited to use value but will encompass emotional and heritage value. The province should encourage "agritourism" models, where tourists directly participate in the harvesting and processing process. This model helps diversify income streams, minimize dependence on fluctuations in raw material prices, and create incentives for biodiversity conservation within the raw material areas.

5.5. Completing the Integrated Multi-Stakeholder Governance Institution (4P)

Finally, the sustainability of the raw material area cannot be separated from a tightly coordinated multi-stakeholder mechanism: Government - Businesses - Scientists - Farmers (4P). In this mechanism, the role of the provincial government is to create the legal framework, digital infrastructure, and support market connectivity. Businesses act as the "tractors" for technology and product distribution. Scientists help decipher technical barriers, and farmers are the direct operators.

Cao Bang needs to establish inter-commune and inter-district raw material area governance councils to coordinate production according to market signals, avoiding the situation of "bumper harvest, low prices." Forming production alliances based on shared economic interests will help the Cao Bang raw material area become a highly competitive entity, capable of participating deeply and sustainably in the global agricultural value chain in the next decade.

6. CONCLUSIONS AND LIMITATIONS OF THE STUDY

The study confirmed that building a sustainable agricultural raw material area in Cao Bang province during the 2026–2030 period is not merely a process of expanding the area or increasing biological productivity, but the core lies in the ability to restructure the integrated management system. Through the lens of Global Value Chain (GVC) theory, the study

identified that the structural "bottleneck" of local agriculture lies in the disadvantaged position of producers due to the lack of logistics infrastructure at the source and the capacity to encode data in the growing areas.

The results of the analysis of the current situation and comparison with international experience from Yunnan and Chiang Mai show that the sustainability of the raw material area must be established based on the intersection of three pillars: Technology - Finance - Heritage. Investing in "first-stage logistics" with a mini-cold storage system is a necessary condition to protect the physical value of agricultural products; Meanwhile, digital transformation and weather-indexed agricultural insurance are necessary conditions to create a proactive "defense system" against market shocks and climate change.

Finally, the study emphasizes that Cao Bang's potential lies in the unique combination of endemic products and the heritage value of its Global Geopark. Identifying raw material areas through geographical indications linked to ecotourism will create a multi-value development roadmap, helping local agricultural products escape the low-value trap and penetrate deeper into high-end market segments. The integrated governance solutions proposed in this study are expected to provide a practical action framework for the government and economic actors to realize the goal of making Cao Bang agriculture an adaptive, transparent, and highly competitive ecosystem in the digital economy era.

The biggest limitation of the study is that the analyses are primarily based on qualitative methods and secondary data. The paper has not established econometric models to accurately measure the impact of logistical disruptions or climate risks on the profit margins of farming households.

Therefore, further studies need to focus particularly on using quantitative methods and empirical analysis. Specifically, micro-surveys should be conducted to collect primary data from farmers, thereby building empirically test models on: (1) Willingness to Pay for Weather Index Insurance (WII) products; and (2) Quantifying the increase in income when switching to VietGAP standards. These quantitative proofs will strengthen the scientific foundation for local policy planning.

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