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DEVELOPING LOGISTICS INFRASTRUCTURE ASSOCIATED WITH AGRICULTURAL PRODUCTION IN THE CENTRAL HIGHLANDS REGION

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Abstract

Logistics infrastructure plays an important role in the agricultural supply chain in the Central Highlands. The study uses the abbreviated SCOR model to study logistics development associated with agricultural development in the Central Highlands with 3 factors: (i) Plan factor, (ii) Source factor; (iii) Deliver factor. The research results show that all variables have a positive impact on logistics infrastructure development, of which: Deliver (DE) has the largest impact (0.354), followed by Source (SO) = 0.297 and Plan (PL) = 0.232. To develop agricultural production in the Central Highlands, it is necessary to have a synchronous logistics infrastructure development strategy (Plan), complete highways, prepare multimodal connections, mobilize financial resources, digitize transportation processes and invest in professional warehouses (Source). Only when infrastructure, technology and support services are comprehensively upgraded (Delivery), can this key raw material area improve its competitiveness, reduce losses and expand the agricultural export market.

Keywords: Development, Logistics Infrastructure, Agricultural Production, Central Highlands.

1. PROBLEM STATEMENT

Logistics infrastructure plays an important role in the agricultural supply chain, especially for key export products such as coffee and pepper. According to Abdul AZ et al. (2012), logistics infrastructure includes the basic elements in the operation of logistics networks through the integration of transport modes such as maritime, air and road. Logistics infrastructure is not only limited to routes and vehicles but also includes management and operation systems, aiming to optimize the transportation process and ensure the efficient operation of the supply chain (Christopher, 2016).

The Central Highlands has great potential and advantages for large-scale agricultural development, making an important contribution to the economy. With a total natural area of about 5.45 million hectares, of which agricultural and forestry land accounts for up to 91.4% (GSO, 2021). This region has favorable conditions for developing high-quality agricultural products such as coffee, pepper, avocado, durian, rubber and Ngoc Linh ginseng. However, logistics infrastructure in the Central Highlands has not yet met

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development needs. Logistics infrastructure: lacks cold storage (only 10% of demand met), road transport accounts for 80%, high logistics costs (25-30% of agricultural product cost) affecting the efficiency of agricultural production and export.

Currently, Vietnam has more than 30,000 enterprises operating in the logistics sector, of which about 89% are domestic enterprises, mainly small-scale (VLA, 2023). Despite the rapid development of the logistics market, logistics costs in Vietnam remain high, accounting for about 16.8 - 17% of GDP, much higher than the global average of 10.6% of GDP (VIRAC, 2023). One of the main reasons is the lack of synchronization in transport infrastructure and poor connectivity between modes of transport (Vi NT, 2023).

With geographical characteristics of no sea or waterway traffic, no railway, limited air transport; the Central Highlands depends mainly on road traffic, while the current road system has not yet met the demand for freight transport. In addition, the role of air transport in the region has not really been effective. The strategic route of the East-West economic corridor plays an important role in connecting the region with ASEAN economies, but there are still many limitations in infrastructure quality (Ministry of Agriculture and Rural Development, (2023).

The study focuses on assessing the current status of logistics infrastructure development in the Central Highlands, analyzing limitations, challenges and proposing solutions to improve logistics efficiency, closely linked to the development of the agricultural sector in the region. The study uses the abbreviated SCOR model with 3 factors: (i) Plan factor, (ii) Source factor; (iii) Deliver factor; data collected by surveying enterprises and agricultural production cooperatives in the Central Highlands.

2. THEORETICAL BASIS

2.1. Concept and Components of logistic Infrastructure

Logistics is the part of supply chain, focused on planning, implementing, and controlling the efficient flow of goods, information, and services from the point of origin to the point of consumption, in order to meet customers' requirements.

"Logistics is component of supply chain practices that manage the efficient and effective forward and reverse flow and storage of goods, services and related information between supplier and manufacturer in order to meet customers' requirements"(Council of logistics management, 2003).

Infrastructure can be defined as the physical, institutional and organizational structures, that is, the economic and social basis for the functioning of a society.(Snieska & Simkunaite, 2009). From this concept, logistic infrastructure includes transportation and communication infrastructure.

According to the Vietnam Logistics Services Association (VLA), logistics infrastructure is "a collection of transport works (roads, railways, waterways, airways), logistics centers, warehouses, ports, and means of transport, along with information technology systems to support management and coordination." (VLA, 2020).

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According to World Bank (2018), logistics infrastructure is defined as “the physical and organizational infrastructure needed to ensure the efficiency of global supply chains”

Thus, logistics infrastructure is understood as a system of technical facilities and related services, designed and operated to support the circulation, storage, and distribution of goods effectively in the supply chain. This is the physical foundation that ensures smooth logistics activities, from production to consumption, including transportation, storage, and management of goods. In addition to the traditional factor of transportation infrastructure, information and communication technology (ICT) is an important component of the modern logistics system. Computerized systems for handling the flow of goods provide more options for intermodal transport networks worldwide within the reach of customers.(UNCTAD, 2008). They also create incentives for competition, which helps reduce shipping costs.(UNCTAD, 2008). The logistics system is made up of four elements: (1) Human resources and capabilities; (2) Public and private sector logistics and transport service providers; (3) Provincial and national institutions, policies and regulations; and (4) Transport and communications infrastructure (Banomyong, 2008). These factors are linked together to determine the overall capacity of the logistics system. In the scope of this study, the author focuses on the (4) dimension of transport and communication infrastructure.

Components of logistics Infrastructure

Logistics infrastructure includes not only the transportation network but also the warehouse system, technology and supporting services. The synchronous development of these components will help reduce logistics costs, improve supply chain efficiency and promote economic development.

(I) Transport System

Includes all types of transportation serving the movement of goods and people. This is the lifeline connecting production, consumption and export areas.

- *Road:* Roads are the most basic transport infrastructure for both domestic and import-export freight transport, especially for countries that rely heavily on trade agreements (Cynthia Sénquiz-Díaz, 2021) (as is the case in Vietnam). Goods are transported to seaports and airports via inland transport modes (Rodrigue, JP., & Notteboom, T., 2017). Road infrastructure is essential for timely delivery, especially for time-sensitive goods such as agricultural products. Poor road quality can result in increased transportation costs due to increased fuel consumption and transit time (Celbis, M., Nijkamp, P., & Poot, J., 2014). Increased investment in roads has the effect of promoting export growth and reducing transportation costs, especially for transporting goods from the point of origin to ports and airports on time (Cosar, K., & Demir, B., 2016). Research conducted by Han et al. (2019) shows that, holding other factors constant, an increase in infrastructure investment by 1% in the previous year will increase GDP growth by 0.30% on average in the following year. The research results also demonstrate that this impact is 0.59% higher in developing countries in the ASEAN region than in advanced economies. This finding indicates that, for developing

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countries like Vietnam, promoting investment in infrastructure to continue economic development will be more effective in the current period.

- *Air route:* The contribution of air transport infrastructure to cargo trade is increasing (Button, Doh, & Yuan, 2010), specifically expressed in on-time delivery indicators and changes in production networks, affecting the development of industries and economic regions thanks to the promotion of the movement of people and goods (Florida, R., Mellander, C., & Holgersson, T., 2015). However, high costs and low flexibility are problems encountered when developing air routes in developing countries.
- *Sea route:* Maritime transport is considered an important component in international trade (Suárez-Alemán, A., et al., 2015), which has a particularly positive impact on developing economies (Munim, Z. & Schramm, H., 2018). Sea transport is often chosen for goods with large volume, difficult to transport by air or can be transported but the cost is high (Suárez-Alemán, A., et al., 2015).According to the United Nations Conference on Trade and Development (UNCTAD, 2018), about 80% of global trade is transported through seaports; therefore, the quality and efficiency of ports is essential to the development of a country.Munim and Schramm (2018) have demonstrated the positive impacts of port infrastructure on developing economies. However, the lack of "port-hinterland" connectivity is slowing down the flow of domestic logistics.
- *Railway:* Railways are considered an efficient inland transport mode providing easier access to inputs, raw materials (Rodrigue, J.P., & Notteboom, T., 2017). For countries without natural advantages in terms of sea routes, railways are a suitable choice (in addition to roads) to meet the demand for transporting goods, while reducing environmental problems in (Aritua, B., 2019).

(ii) Warehouses and logistics Centers

Warehouse systems and logistics centers play a key role in the supply chain, supporting the storage, classification, preservation and coordination of goods. According to Rodrigue, J.P., & Notteboom, T., 2017, warehouses are not only storage places but also an "important link" in ensuring the continuity and efficiency of logistics activities. Modern warehouses that meet the needs of preserving agricultural products require cold storage.

The development of large-scale logistics centers, especially in areas near seaports and airports, will help shorten transit times, reduce transportation costs and increase competitiveness for export goods (Nguyen, L.C., & Tongzon, J., 2010). A study by World Bank (2023) also shows that countries with well-developed logistics center networks have higher logistics performance index (LPI), thereby significantly improving national competitiveness in the global market.

(iii) Technology and Support Services

Technology and supporting services are indispensable "catalysts" to modernize the logistics system. The application of digital technology such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, and warehouse management systems (WMS) helps

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to enhance the ability to control, monitor, and optimize operations (Wang, Y., et al., 2019). According to research by Hofmann, E., & Rüsch, M. (2017), blockchain technology can increase transparency and traceability in the supply chain, which is especially useful in the agricultural, food and pharmaceutical sectors.

In addition, supporting services such as cargo insurance, electronic customs procedures, logistics financial services, and supply chain consulting also play an important role. Effective coordination between stakeholders - logistic enterprises, state management agencies, and service providers – will create a complete logistics ecosystem (Christopher, 2016).

2.2. Impact of Logistics Infrastructure Development on Agricultural Production

(I) Reduce The Cost of Production And Distribution of Agricultural Products

Developed logistics infrastructure significantly reduces production and distribution costs in the agricultural value chain thanks to a smooth, uninterrupted flow of goods (Button, K., Doh, S., & Yuan, J., 2010; Hoekman, B., & Nicita, A., 2010). This is especially important when the network of seaports, terminals, railways, roads and airlines is effectively connected. Delays not only increase supply times but also increase transportation costs, opportunity costs and reduce product quality, reducing market competition. Improved logistics infrastructure reduces the time to supply raw materials and distribute goods, thereby ensuring timely and stable supply for production. Manufacturers can have easier access to raw material markets and consumer markets in more distant areas, helping to allocate investment capital more effectively, promoting local production and contributing to equitable economic development between regions.

Improving the quality of port and airport infrastructure is one of the factors that helps reduce transportation costs, waiting times, and handling costs associated with moving goods from the place of production to the place of consumption. A well-developed infrastructure will reduce adverse impacts between regions, allowing businesses to choose better locations for economic activities (Schwab, K., 2018); reduce shipping costs (Cho, H., 2014) and complement the factors of production of labor and capital (Bruinsma, F., et al., 1989). In other words, countries and regions with adequate infrastructure become more attractive to multinational companies, which are looking for suitable locations to locate their production chains to reduce transportation costs and risks of supply chain disruptions (FICCI, 2010).

(Ii) Reduce Agricultural Product Transportation Time

Logistics infrastructure contributes to supporting agricultural production activities by shortening transportation time and improving access to production inputs (seeds, materials, equipment, etc.). Upgrading logistics infrastructure helps the process of transporting goods between regions become faster and more timely, contributing to effectively balancing supply and demand, and opening up trade flows (Limao, N. & Venables, A.J., 2002; Micco, A. & Serebrisky, T., 2006). Improved logistics infrastructure reduces the time it takes to deliver raw materials and distribute goods, ensuring a timely

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and stable supply for production. Manufacturers can access raw material markets and consumer markets in more remote areas more easily, allowing for more efficient allocation of investment capital and promoting local production. In addition, an efficient logistics system also helps businesses deliver products on time and ensure quality, especially for distant international markets. This is especially important for perishable and high-value products such as fresh fruits and seafood, where quality and delivery time play a decisive role.

(Iii) Reduce Post-Harvest Loss Rate

Agricultural products often have high post-harvest losses if proper transportation conditions are not ensured. Lessons from India show that transportation is a serious obstacle to the agricultural supply chain, notably: lack of transportation, inefficient and high-cost transportation, lack of refrigerated trucks for transporting fresh goods (FICCI, 2010). This is especially true in the context of agricultural exports playing an increasingly important role in the economic structure of regions such as the Central Highlands. With the high export proportion of agricultural products here, the role of quality transport infrastructure is increasingly emphasized. According to research by Portugal-Pérez, A. & Wilson, J. (2010), transport infrastructure quality has a positive impact on export growth in 101 countries, including developing economies. Rehman, F., Noman, A., & Ding, Y. (2020) also pointed out that infrastructure systems such as roads, railways and airports help reduce losses during transportation, thereby improving the efficiency of agricultural supply chains in South Asian economies.

2.3. Supply Chain Operations Reference model and its application in researching the development of logistic infrastructure associated with agricultural production in the Central Highlands region

2.3.1. Supply Chain Operations Reference

The SCOR (Supply Chain Operations Reference) model is an international standard reference framework, developed by the Supply Chain Council (now part of APICS), to analyze and improve the supply chain (APICS, 2017). SCOR includes the following elements:

- S (Supply): Refers to the entire supply system, including activities from sourcing raw materials to delivering to customers.
- C(Chain): Represents the chain of participants, from suppliers (farmers, cooperatives), manufacturers, logistics, to customers (domestic market, export).
- O (Operations): Refers to operational activities in the supply chain, including planning, production, transportation, and inventory management.
- R (Reference): Is a standard reference framework, providing processes, performance indicators (KPIs), and best practices for supply chain improvement.

According to Supply Chain Council (2012), the SCOR model consists of five main phases: Plan, Source, Make, Deliver, and Return.

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- Plan: Manage and plan supply chain activities, including demand forecasting, resource allocation, and logistics planning
- Source: Manage the search, purchase, and receipt of needed raw materials or resources. These resources include mobilizing financial capital, technology such as trucks, cold storage
- Make (Production): Manage the production process, including processing, storage, and preparation of goods for shipping
- Deliver: Manage deliveries, including shipping, distribution, and delivery to customers
- Return: Manage the process of returning or disposing of defective, damaged, or unused inventory.

This model provides key performance indicators (KPIs) and best practices for supply chain improvement, with logistics (Deliver phase) as the focus.

2.3.2. Research Overview

The SCOR (Supply Chain Operations Reference) model is an international reference framework used to analyze and improve supply chains. The original SCOR model is highly regarded for its ability to simplify the complexity of supply chains and support strategic decision making (Huan, S.H., etal., 2004). This study analyzed the strengths and weaknesses of the model, emphasizing its role in strategic planning. However, the study also pointed out that the model needs to be adapted to specific contexts, especially in developing countries, specifically the agricultural sector, due to infrastructure challenges, limited resources, and unique operating environments. The study by Hạnh., N.T.T., et al., (2021) conducted a performance measurement of the coffee supply chain in Vietnam using the SCOR model. The performance achieved for the entire coffee SC was 68.28 (average). Most of the processes, including Source, Production, Delivery, and Return, had smaller performance values. The study proposed a standardized coffee supply chain model with a detailed level of process elements. This proposed model facilitates the identification of external and internal issues that reduce the performance of the coffee supply chain in Kontum province, Vietnam.

From the original SCOR model, there are two approaches of previous researchers.

(1) Extended SCOR: Integrating environmental and social factors to increase sustainability, especially in agriculture.

The GreenSCOR model, an extended version of SCOR that integrates environmental and social factors into supply chain management, has been studied for application in the agricultural sector to increase sustainability. A study by Arjuna., et al, (2022) uses GreenSCOR to measure and improve green supply chain performance in the agricultural industry, emphasizing the role of reducing environmental impacts in production and distribution. A research by Ntabe EN, et al., (2015) applied SCOR with a focus on environmental issues. The study used several SCOR criteria and evaluation factors to review studies published between 2000 and 2012 that applied the SCOR model; paying

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special attention to environmental criteria. The results showed that GreenSCOR is suitable for assessing environmental performance in agricultural supply chains and found that the SCOR model is suitable for assessing financial performance of supply chains and is a practical decision support tool for assessing environmental and competitive decision alternatives along the supply chain.

The GreenSCOR model was also selected to measure supply chain performance in the furniture industry in Indonesia, an industry that uses wood as an input (A. Susanty, et al., 2016). The data used in this study were collected through personal interviews and closed-ended questionnaires. The sample of this study was 20 furniture enterprises, classified according to two criteria: product type (interior, exterior) and enterprise size (large and small, medium). The measurement results showed that enterprises in the large-scale and exterior manufacturing group had better overall performance index values for implementing GSCM practices than medium-scale and furniture manufacturing. As an industry that affects agricultural output, GreenSCOR can be applied to evaluate green supply chain performance in agriculture.

(2) SCOR Abbreviation: Simplify the model to suit the constraints in developing countries, where common constraints exist such as poor infrastructure, lack of financial resources, and lack of skilled professionals

Research by Georgise., F.B., et al., (2016) is an in-depth study on the application of the SCOR model in the context of developing countries. Based on fundamental studies on the global supply chain and the role of developing countries, the SCOR model is emphasized as a global standard reference model, including the processes: Plan - Source - Make - Deliver - Return. In addition, the authors also mention: GSCF, CCOR, DCOR, HP framework - which are other theoretical frameworks or reference models applied depending on the industry or target. However, the application of the SCOR model and other related models is difficult due to the common situation of developing countries: poor infrastructure, high transaction costs, political risks, corruption, lack of technical capacity, lack of resources (Todaro, M.P., and S.C. Smith., 2009). For export-related industries, a research by Magder, D. (2005) in the textile industry in Egypt shows that logistics infrastructure constraints including poor road and port infrastructure often lead to unresolved issues such as late deliveries and material shortages, affecting export expansion. Research overview shows that the general situation in developing countries with limitations such as:

- Poor technical and physical infrastructure: unstable power source, underdeveloped roads and seaports.
- High transportation and transaction costs, risky business and political environment
- Dependence on imported raw materials and machinery, leading to high costs and long production times.
- Lack of financial resources, and lack of skilled professionals.
- High inventory levels due to supply uncertainty.

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To overcome these limitations, previous studies have reduced the complexity of the SCOR model by using a shortened SCOR: adjusting the "Plan" stage to an annual plan due to the lack of shared information and unavailability for long-term supply chain planning; Focusing on inventory management efficiency rather than cost, due to dependence on imports and supply delays. These findings can be applied to the Central Highlands of Vietnam, which also faces mountainous terrain, limited infrastructure, and specific agricultural products such as coffee and pepper that require cold storage. The shortened SCOR model focuses on stages such as Plan, Source, Deliver to suit local conditions of mountainous terrain and high export demand, in order to optimize costs, transportation time, and logistics efficiency.

2.3.3. Proposed Research Model

The SCOR model is an international reference framework used to analyze and improve the supply chain, used in research on logistics development in the Central Highlands. Because the article focuses on the content of developing logistics infrastructure associated with agricultural production in the Central Highlands, the authors minimize the SCOR model, focusing on the Plan, Source, and Deliver stages to analyze the impact of financial resources, transport infrastructure, and logistics service quality on the development of logistics infrastructure in the Central Highlands.

(i) Plan Factor: plan, forecast, and manage logistics activities for agricultural products in the Central Highlands. From the perspective of enterprises (logistics enterprises or agricultural cooperatives), Plan focuses on:

- Planning logistics for agricultural products (forecasting coffee/pepper transportation demand, warehouse planning, resource allocation).
- Manage plans to optimize costs, time, and transportation/storage efficiency

(ii) Source Factor: related to the search, purchasing, and receipt of resources needed for agricultural product logistics in the Central Highlands. From the perspective of enterprises (logistics enterprises or agricultural cooperatives), Source focuses on:

- Mobilizing financial resources, technology, and raw materials to develop logistics. This capital is invested in trucks, cold storage, and supply chain management technology.
- Assess the accessibility and efficiency of these resources to support the transportation, storage, and distribution of agricultural products (coffee, pepper).

(iii) Deliver Factor: regarding the management of delivery, transportation, and distribution of agricultural products from the source (Central Highlands farm) to the point of consumption (Quy Nhon port, domestic markets, or international export). From the perspective of enterprises (logistics enterprises or agricultural cooperatives), Deliver focuses on:

- Efficient transportation of agricultural products (coffee, pepper, etc.) from farm to ports/consumption markets.
- Ensure on-time delivery, reduce costs, and reduce losses during transportation.

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- Optimize routes, vehicles (trucks, containers) and logistics services in the Central Highlands.

"Logistics infrastructure development" In this article, the level of improvement and efficiency of logistics infrastructure (roads, warehouses, transportation, technology) supporting the production and distribution of agricultural products in the Central Highlands is reflected. From the perspective of enterprises (logistics enterprises or agricultural cooperatives), this factor focuses on the level of improvement of logistics infrastructure factors, including:

- The level of cost reduction,
- The level of reduction in transportation time,
- Level of reduction of post-harvest losses.

The Central Highlands specific factors in this topic reflect the unique characteristics of the region, affecting logistics activities and agricultural production. These characteristics include:

- **The level of influence of mountainous terrain**: The mountainous terrain in the Central Highlands (such as Dak Lak, Gia Lai) makes it difficult to transport, store, and build logistics infrastructure.
- Characteristics of agricultural products: Key agricultural products such as coffee, pepper, rubber are perishable, need cold storage, and have high demand during the harvesting season.
- Export demand: High export demand (95% coffee, 80% pepper) requires fast, efficient logistics, and compliance with international standards, creating pressure for businesses.

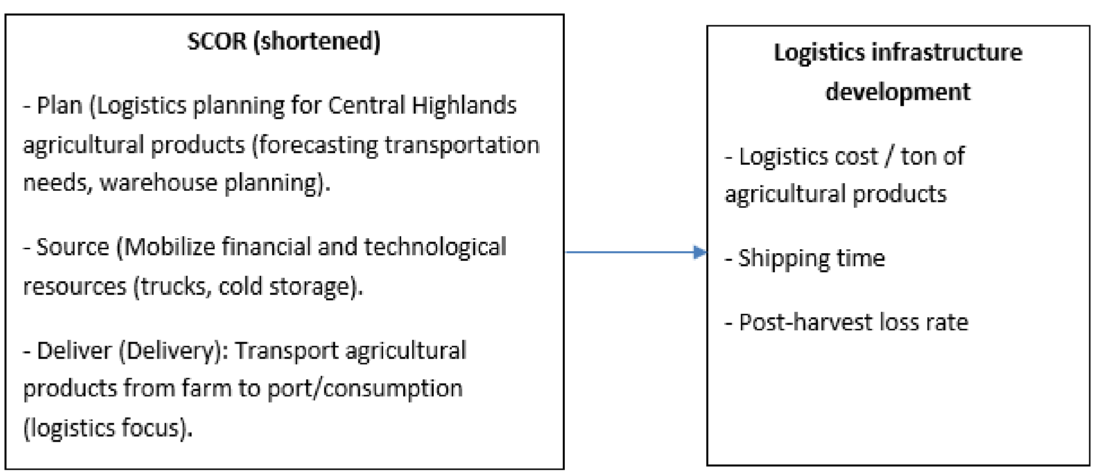

Figure 1: Proposed research model

Source: Author group

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Table 1: Scale content

Variable	Encryption	Scale content
Plan	PL1	- Does your enterprise/cooperative forecast agricultural product transportation demand to optimize logistics?
	PL2	- Does your enterprise/cooperative have a plan (warehouse, transportation route) to reduce costs and time for transporting agricultural products?
	PL3	- Does your enterprise/cooperative use technology (such as supply chain management software, GIS) to support logistics planning?
	PL4	- Does your enterprise/cooperative coordinate with relevant parties (farmers, government, logistics enterprises) in planning?
	PL5	- Your enterprise/cooperative's logistics plan meets the actual needs of transporting and storing agricultural products in the Central Highlands.
Source	SO1	- Your enterprise/cooperative can easily access financial resources to develop logistics for agricultural products in the Central Highlands.
	SO2	- Your enterprise/cooperative uses financial resources effectively to reduce logistics costs and increase the efficiency of transporting/storing agricultural products.
	SO3	- Your enterprise/cooperative can easily access logistics technologies (modern trucks, cold storage, management software) to support the transportation and storage of agricultural products in the Central Highlands.
	SO4	- Your enterprise/cooperative uses logistics technology (trucks, cold storage, software) effectively to optimize the transportation and storage of agricultural products.
Deliver	DE1	- Your enterprise/cooperative transports agricultural products (coffee, pepper) from farms to ports/consumption markets efficiently in the Central Highlands.
	DE2	- Your enterprise/cooperative ensures on-time delivery of agricultural products according to customer requirements in the Central Highlands.
	DE3	- Your enterprise/cooperative uses modern means of transport (trucks, containers, refrigerated vehicles) to optimize agricultural product delivery in the Central Highlands.
	DE4	- Your enterprise/cooperative reduces loss of agricultural products (coffee, pepper) during transportation in the Central Highlands.
	DE5	- Your customers are satisfied with the logistics delivery service in the Central Highlands.
Logistics infrastructure development	DL1	- Logistics costs per ton of agricultural products have decreased significantly compared to before.
	DL2	- Transportation time per ton of agricultural products is significantly reduced compared to before.
	DL3	- Post-harvest/delivery loss ratio is significantly reduced compared to before

Source: Author group

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3. RESEARCH METHODOLOGY

3.1. Data Collection Method

- *Secondary data:*Secondary data provided by the Ministry of Agriculture and Rural Development, the project "Developing a logistics system to improve the quality and competitiveness of Vietnamese agricultural products by 2030 and vision to 2050", Vietnam Logistics Service Enterprises Association, General Statistics Office, websites of 5 provinces in the Central Highlands: Kon Tum, Gia Lai, Dak Lak, Dak Nong, Lam Dong.
- *Primary data:*Based on the theory and overview of research on the development of logistics infrastructure associated with agricultural production, the factors included in the research model include 3 independent variables of the minimalist SCOR model: ***(i) Logistics plan for Central Highlands agricultural products (PL); (ii) Financial and technological resources (SO); (iii) Delivery (DE); Influence on the dependent variable is "Logistic infrastructure development" (DL).***

The survey was constructed with a 5-point Likert scale, with:

1. *Totally disagree*
2. *Disagree*
3. *Normal*
4. *Agree*
5. *Totally agree*

After developing the survey form, the research team conducted a random pilot survey of 05 enterprises and 03 agricultural cooperatives in the Central Highlands.

The preliminary survey results showed that opinions agreed with the factors included in the model.

Due to time and resource constraints for the survey, the author used a convenient sampling method, the minimum sample size required was calculated according to the formula n=50 + 8*m (m: number of independent variables) (Tabachnick and Fidell, 1996), in the case of a study with 3 variables, the minimum number of ballots collected was 50 + 8*3 = 74 ballots.

The subjects surveyed were agricultural enterprises/cooperatives in the Central Highlands. From the viewpoint of collecting as many observation samples as possible to ensure the stability of the impact, the ballots were sent to the subjects by sending online via the google form link https://forms.gle/Zret9zNgxD7y3XbcA.

The number of collected survey ballots was 152 valid ballots that were included in the analysis.

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3.2. Data processing method

Quantitative research methods were used to process research data collected from surveys of enterprises/cooperatives producing and trading agricultural products in the Central Highlands. The structural regression equation has the general form:

$$DL = a*PL + b*SO+c*DE$$

SMARTPLS software is used to test hypotheses and evaluate the impact level of factors.

Step 1: Evaluating Measurement Model

Evaluating measurement model based on examining values of reliability, quality of observed variable, convergence, and discriminant

- Testing the quality of observed variables (Outer Loadings)

Outer Loadings of observed variables are indicators showing the degree of association between observed variables and latent variables (proxy variables). Basically, outer loadings in SMARTPLS are the square root of the absolute value of R2 linear regression from the latent variables to the sub-observed variables.

Hair et al. (2016) suggest that the outer loadings should be greater than or equal to 0.708 observed variables that are quality. To make it easier to remember, the researchers rounded off the threshold to 0.7 instead of the number 0.708.

- Evaluating Reliability

Evaluating the reliability through SMARTPLS by two main indicators, Cronbach's Alpha and Composite Reliability (CR). Composite Reliability (CR) is preferred by many researchers over Cronbach's Alpha because Cronbach's Alpha underestimates the reliability compared with CR. Chin (1998) claims that in exploratory research CR must be over 0.6.

For confirmed studies, the 0.7 threshold is the appropriate level of CR (Henseler & Sarstedt, 2013). Other researchers agree that 0.7 is the appropriate threshold for the vast majority of cases such as Hair et al. (2010), and Bagozzi & Yi (1988).

Thus, the reliability through SMARTPLS is shown by Cronbach's Alpha ≥ 0.7(DeVellis, 2012);Composite Reliability CR ≥ 0.7 (Bagozzi & Yi, 1988).

- Testing Convergence

Evaluating Convergence on SMARTPLS is based on Ave (Average Variance Extracted). Hock & Ringle (2010)claim that a scale reaches a convergence value if AVE reaches 0.5 or higher. This level of 0.5 (50%) means that the average latent variable will explain at least 50% of the variation of each sub-observed variable. Thus, convergence is evaluated by Average Variance Extracted AVE ≥ 0.5 (Hock & Ringle, 2010).

- Testing Discriminant Validity

Discriminant value is used to consider whether a research variable is really different from other research variables in the model.

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To evaluate the discriminant validity, Sarstedt & et al (2014) said that considering two criteria including cross-loadings and the measurement of Fornell and Larcker (1981).

Cross-loading coefficients are often the first approach to evaluate the discriminant validity of indicators (observed variables) (Hair, Hult, et al., 2017).

The load factor of the observed variable (indicator) linked in the factor (latent variable) should be greater than any of its cross-load factors (its correlation) in the other factors.

Fornell and Larcker (1981) recommend that discriminant is guaranteed when the square root of AVE for each latent variable is higher than all correlations between latent variables. In addition, Henseler & et al (2015) used simulation studies to demonstrate that discriminant validity is better evaluated by the HTMT index that they developed.

With the HTMT index, Garson (2016) says that the discriminant validity between two latent variables is guaranteed when the HTMT index is less than 1. Henseler & et al (2015) propose that if this value is below 0.9, the discriminant validity will be guaranteed. Meanwhile, Clark, L.A., & Watson, D. (1995) used a stricter standard threshold of 0.85. SMARTPLS preferred a threshold of 0.85 in the evaluation.

- Testing Multicollinearity

In this study, the author uses a scale related to multicollinearity as a variance magnification factor (VIF). Very high levels of multicollinearity are indicated by VIF values >= 5; the model does not have multicollinearity when VIF indicators < 5 (Hair et al., 2016).

Step 2: Evaluating Structural Model

After evaluating the satisfactory measurement model, evaluate the structural model through the impact relationship, path coefficient, R squared, and f squared.

- Evaluating impactful relationships

To evaluate impact relationships, use the results of Bootstrap analysis. Based mainly on two columns (1) Original Sample (normalized impact factor) and (2) P Values (sig value compared to 0.05 significance level).

- Original Sample: Standardized impact factor of the original data. SMARTPLS has no unstandardized impact factor.
- Sample Mean: The average standardized impact factor of all samples from Bootstrap.
- Standard Deviation: Standard deviation of the standardized impact factor (according to the original sample).
- T Statistics: Test value t (test student the meaning of the impact).
- P Values: The significance level of the T Statistics. This significance level is considered with comparative thresholds such as 0.05, 0.1, or 0.01 (usually used as 0.05).

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Evaluating the level of interpretation of the independent variable for the dependent variable by R2 coefficient (R square). To evaluate the R2 coefficient, we will use the results of the PLS Algorithm analysis. The R2 value evaluates the predictive accuracy of the model and shows the level of interpretation of the independent variable for the dependent variable. R square is between 0 and 1, the closer to 1 indicates the more independent variables that account for the dependent variable (Hair, Hult, et al, 2017).

4. RESEARCH RESULTS

4.1. Descriptive Statistics of Survey Sample

The research team received 152 valid questionnaires for analysis. The survey participants were representatives of agricultural production enterprises/cooperatives in the Central Highlands. The survey subjects were grouped according to criteria of enterprise size, agricultural product type, and main output market as follows:

Table 2: Grouping of survey participants

Criteria	Classify	Quantity	%
Scale	Small	85	55.9%
	Fit	45	29.6%
	Big	22	14.5%
Agricultural products	Coffee	60	39.5%
	Rubber	30	19.7%
	Pepper	25	16.4%
	Fruits	20	13.2%
	Other	17	11.2%
Main market	Domestic	55	36.2%
	Export	97	63.8%

Source: Survey results

The majority of enterprises/cooperatives participating in the survey are small and medium-sized (85.5%). Small enterprises/cooperatives mostly serve the domestic market or export markets through intermediaries.

Coffee is the main agricultural product in the region (60 enterprises/cooperatives, accounting for 39.5% of coffee production), followed by rubber and pepper.

4.2. Test Results

4.2.1. Results of assessing the quality of observed variables in the measurement model

The quality of the observed variable is evaluated through the outer loadings. In the first run, the outer loadings result of SO4 is less than 0.7, indicating that the observed variable SO4 does not satisfy (Hair & et al, 2016).

The research team conducted a second run to test the quality of the observed variables after removing the observed variable SO4, the results are shown in Table 3.

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Table 3: Outer loadings of factors affecting "Logistic Infrastructure Development" (DL)

	DE	DL	PL	SO
DE1	0.862			
DE2	0.828			
DE3	0.839			
DE4	0.741			
DE5	0.773			
DL1		0.822		
DL2		0.874		
DL3		0.898		
PL2			0.753	
PL3			0.768	
PL4			0.790	
PL5			0.724	
SO1				0.820
SO2				0.874
SO3				0.847
PL1			0.806	

Source: Test results of the research team

The results from Table 3 show that the outer loadings of all the total variable correlation coefficients of the variables affecting "Logistic Infrastructure Development" (DL) (all > 0.7) (Hair & et al, 2016) shows that the remaining observed variables are significant.

Testing the reliability of the scale

Assessing the reliability of the scale of factors affecting the "Logistic Infrastructure Development" (DL) on PLS-SEM through two main indexes: Cronbach's Alpha and Composite Reliability (CR).

Table 4: Reliability coefficient (Cronbach's Alpha) and composite reliability (Composite Reliability) of factors affecting the development of logistics infrastructure" (DL)

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
DE	0.868	0.872	0.905	0.656
DL	0.832	0.832	0.900	0.749
PL	0.831	0.841	0.878	0.591
SO	0.803	0.807	0.884	0.718

Source: Test results of the research team

According to Table 4, after analyzing the reliability test using Cronbach's Alpha coefficient of the factor, the results are: Planning (PL) reached 0.831; Resources (SO) reached 0.803; Delivery (DE) reached 0.868; Logistics Development (DL) reached 0.832.

Thus, all scales satisfy the condition > 0.7 (DeVellis, 2012) and does not violate any rules for eliminating variables so no variables are eliminated and are acceptable in terms of

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reliability. Composite Reliability (CR) of all observed variables is also > 0.7 (Bagozzi & Yi, 1988) (Table 4).

Therefore, the scale is reliable, has analytical significance and is used in the next factor analysis.

Convergence

According to the data analysis results in Table 4, the average variance extracted (AVE) of the factors: Planning (PL) reached 0.591; Resources (SO) reached 0.718; Delivery (DE) reached 0.656; Logistics Development (DL) reached 0.749.

Thus, the average variance extracted (AVE) of all variables is > 0.5 (Hock & Ringle, 2010) which shows that the model satisfies the convergence conditions.

Discriminant Validity

The results in Table 5 on the Fornell-Larcker index of the research model of factors affecting "Logistic Infrastructure Development" (DL): Planning (PL); Resources (SO); Delivery (DE) all ensure discrimination because all the square root values of AVE on the diagonals are higher than their off-diagonal values.

Therefore, in terms of discrimination value, the two criteria including cross-loading factor and Fornell and Larcker criteria have satisfied the conditions (Fornell, DF Larcker., 1981).

Table 5: Fornell-Larcker index of the research model of factors affecting "Logistic infrastructure development" (DL)

	DE	DL	PL	SO
DE	0.810			
DL	0.707	0.866		
PL	0.541	0.591	0.769	
SO	0.765	0.699	0.566	0.847

Source: Test results of the research team

Function value f^2

The f^2 function value represents the influence level of the structure (factor) when removed from the model. The f^2 values correspond to 0.02, 0.15, and 0.35, corresponding to small, medium, and large influence values (Cohen, 1988) of the exogenous variable.

If the effect size < 0.02, it is considered to have no influence.

Table 6: Summary table of f2 values

	DE	DL	PL	SO
DE		0.123		
DL				
PL		0.086		
SO		0.083		

Source: Test results of the research team

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In this model, in Table 6 we see the factors: “Planning” (PL) reaches 0.086; “Resources” (SO) reaches 0.083; “Delivery” (DE) reaches 0.123 with average impact on “Logistic Infrastructure Development” (DL).

4.2.2. Results of impact assessment using structural model

4.2.2.1. Assessment of influential relationships

The relationship and level of influence of factors affecting the investment intentions of young people living in Vietnam on SMARTPLS is shown in Figure 2.

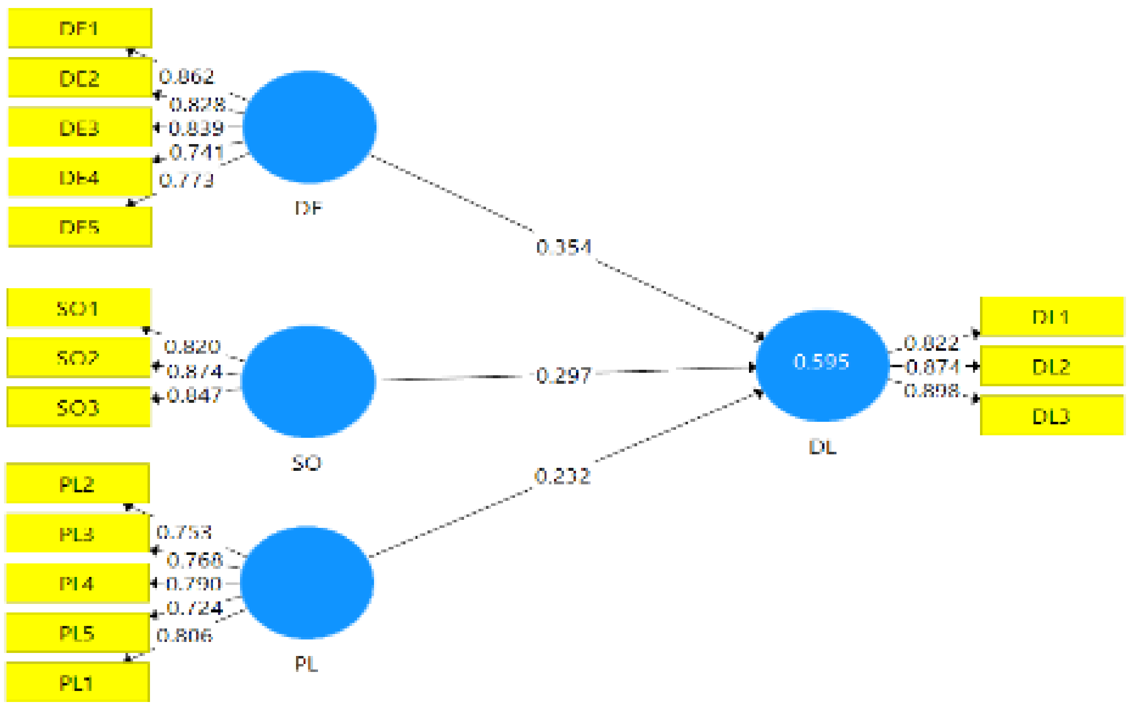

Figure 2: Factors affecting “Logistic Infrastructure Development” (DL)

Source: SMARTPLS test results of the research team

The results of Bootstrap analysis to evaluate the influencing relationships are shown in Table 7. Accordingly, the factors “Plan”, “Resources”, “Delivery” have P Values < 0.05, which reflects that these factors are statistically significant enough to show a positive influencing relationship with “Logistic Infrastructure Development” (Hypotheses H1, H2, H3 are accepted).

Table 7: Structural model path coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
DE -> DL	0.354	0.349	0.111	3,193	0.001
PL -> DL	0.232	0.239	0.084	2,772	0.006
SO -> DL	0.297	0.299	0.082	3,640	0.000

Source: SMARTPLS test results of the research team

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The test results in Table 7 show that with 95% confidence, “Delivery” (DE) has the strongest influence on “Logistic Infrastructure Development” with an influence level of 0.354; followed by the factor “Resources” (SO) with an influence level of 0.297, the factor “Planning” (PL) has an influence level of 0.232. Thus, we have the following regression equation:

DL = 0.232*PL +0.297*SO+0.354*DE

4.2.2.2. Evaluation of the overall coefficient of determination R^2 *(R square)*

The result of PLS Algorithm analysis gives R^2 value, reflecting the level of explanation of the independent variable for the dependent variable. R^2 index measures the overall coefficient of determination (R-square value), which is an index to measure the level of model fit of the data (explanatory ability of the model). According to Hair et al. (2010) Suggested R-square values are 0.75, 0.50, or 0.25.

Table 8: Explanation coefficient of independent variables for dependent variables (R Square)

	R Square	R Square Adjusted
DL	0.595	0.587

Source: Test results of the research team

The results from Table 8 show that R^2 of 0.595 and adjusted R^2 of 0.587 are suitable in this case study, thus the independent variables in the model explain 59.5% of “Logistics Infrastructure Development”.

5. DISCUSS THE RESULTS

The regression model results show that all three factors “Logistics planning (PL)”, “Financial and technological resources (SO)”, and “Delivery (DE)” have positive impacts on the development of logistics infrastructure in the Central Highlands region.

Regression model: **DL = 0.232 × PL + 0.297 × SO + 0.354 × DE**

The regression coefficient shows that all variables have a positive impact on logistics infrastructure development, of which: Deliver (DE) has the largest impact (0.354), followed by Source (SO) = 0.297 and Plan (PL) = 0.232.

(i) Deliver (DE)

Deliver (DE) has a coefficient of 0.354, thus having the strongest impact, showing that the delivery factor plays a key role in promoting the development of logistics infrastructure in the Central Highlands. This result is consistent with the current reality of transportation in the Central Highlands. The Central Highlands is a key agricultural production region of Vietnam, however, the road and traffic system connecting to major seaports in the Central and Southeast regions is still limited (VCCI, 2021). The Central Highlands is a region with complex mountainous terrain, including 5 provinces: Dak Lak, Dak Nong, Gia Lai, Kon Tum and Lam Dong. In terms of scale, by 2023, the total length of roads in the Central

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Highlands is estimated at more than 20,000 km, including national highways (such as National Highway 14 - the main route connecting the Central Highlands with the Central and Southeast regions) and provincial and district roads. National Highway 14 has been upgraded to Ho Chi Minh Road, with a length of about 700 km through the Central Highlands. The density of highways in the Central Highlands is currently very low compared to the Red River Delta or the Southeast. This greatly affects the time and cost of transporting goods. In terms of quality, although major national highways such as National Highways 14, 19, 20 have been renovated and expanded; many provincial and inter-commune roads are still dirt roads or narrow roads, unable to withstand heavy loads. Road surface quality is still uneven, many roads are degraded, especially in the rainy season.

Logistics infrastructure for agricultural products in the Central Highlands is still in its early stages of development, with the main bottlenecks stemming from the “monopoly” nature of the road transport network and the low level of digitalization in transportation. First of all, the entire region depends almost exclusively on roads as the main transportation channel, while the terrain conditions of the Central Highlands require more diverse and flexible modes of transportation. The lack of railways, inland waterways or inland ports increases costs, travel time and the risk of agricultural product loss, especially for products with short shelf life such as fresh fruits or semi-processed agricultural products.

In addition, the logistics infrastructure of the Central Highlands still lacks connectivity (nhandan.vn, 2025). There are not many large-scale integrated logistics centers (warehouses, yards, transportation services), most businesses build their own warehouses, yards or rent small-scale private warehouses. Improving delivery capacity not only helps reduce logistics costs but also enhances access to domestic and foreign markets for key products of the region such as coffee, pepper and rubber. Efficient delivery helps reduce post-harvest losses (according to survey DE4), increase customer satisfaction (DE5), and reduce logistics costs. This result is similar to the study of Rodrigue, J-P., & Notteboom, T., 2017 “logistics delivery performance has a direct impact on the competitiveness of agricultural supply chains”.

(ii) Source (SO)

The ability to mobilize and effectively use financial and technological resources plays a key role. According to the survey results, enterprises/cooperatives can easily access investment capital for trucks, cold storage, and logistics management software (SO1, SO3) to help increase transportation and storage capacity and reduce losses. This result is similar to the research of World Bank (2023) stated that “Access to financial and technological resources is a pivotal driver for logistics infrastructure development in emerging agricultural regions.” Investment in modern logistics technology and increased access to capital help improve operational efficiency across the supply chain. However, according to research by World Bank (2023), logistics enterprises in Vietnam, especially small and medium enterprises in the Central Highlands region, are facing difficulties in accessing investment capital for technological innovation and service expansion.

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The network is outdated, single-line, and lacks multimodal connectivity. The development of logistics railways needs to be synchronized with the chain of warehouses and logistics centers near the station - which has not been properly invested in. With the characteristics of agricultural products, modern means of transport such as refrigerated trucks help maintain the quality of agricultural products such as coffee and pepper in hot and humid climates. The lack of digital infrastructure and data synchronization between management agencies and logistics enterprises is currently a major barrier in Vietnam due to financial challenges, leading to the need for new funding models, such as public-private partnerships (PPPs), Private Finance Initiatives (PFIs), and reasonable risk allocation. The “Beneficiary Pays” and “Polluter Pays” principles are proposed for equitable cost allocation.

According to government policies: Sustainable agricultural and rural development strategy for the period 2021 - 2030, vision to 2050 (Government, 2022), and the Cooperative Development Support Program for the period 2015-2020 (Government, 2014), cooperatives/enterprises in the Central Highlands are supported with capital, land, and technology to develop logistics, especially in concentrated production areas such as Dak Lak and Gia Lai. Regarding investment in road infrastructure, although in recent years the Government and localities have launched a series of important expressway projects such as Khanh Hoa - Buon Ma Thuot, Gia Nghia - Chon Thanh, Ngoc Hoi - Pleiku, Pleiku - Buon Ma Thuot and Buon Ma Thuot - Gia Nghia, most of them are still under construction or about to start construction. Construction progress and site clearance are still slow, and the planning of assembly points, transit hubs and temporary wharves has not been invested synchronously. If completed, these expressways will create an important “arc” of connection through Dak Lak, helping to shorten travel time, increase transport frequency and reduce pressure on the current provincial road system and rural roads.

(iii) Plan (PL)

Although it had the lowest impact of the three factors studied, the logistics planning is still very necessary to ensure that logistics operations take place systematically. With the potential of the Central Highlands, the land has a lot of potential with more than 5 million hectares of agricultural land, favorable for growing industrial crops, forestry, fruit trees; of which, there are up to 668,000 hectares of coffee, 228,000 hectares of rubber, 77,000 hectares of pepper, 75,000 hectares of durian (nhandan.vn, 2025). Large scale combined with the characteristics of industrial crop products (coffee, pepper) having large volume and being easily damaged are two factors that require logistics infrastructure to develop in a modern direction.

Activities such as transportation demand forecasting (PL1), warehouse and route planning (PL2), and application of planning support technology (PL3) help optimize overall transportation costs and time. Effective logistics planning helps orient infrastructure development appropriately, create regional linkages, and minimize overlapping or unsynchronized investment. Research by Asian Development Bank (2022); Chopra, S., & Meindl, P. (2019) also affirmed that synchronous planning is a

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prerequisite for key economic regions, especially those with complex terrain such as the Central Highlands, to develop sustainable logistics. However, with the Central Highlands' characteristic of fragmented production, planning may not be fully effective if it is not accompanied by good resources (SO) and delivery capabilities (DE). Regarding the application of technology in logistics planning and management, according to the Vietnam Logistics Index Report 2023 by VLA (Vietnam Logistics Business Association), only about 30% of Vietnamese logistics enterprises have applied technology at an average level or higher. This shows the potential and urgent need to promote investment in technology to improve competitiveness in the region.

6. CONCLUSION

The current state of logistics infrastructure for agricultural products in the Central Highlands requires a synchronous development strategy, from completing highways and preparing for multimodal connections, to digitizing transportation processes and investing in professional warehouses. Only when infrastructure, technology and support services are comprehensively upgraded can this key raw material area improve its competitiveness, reduce losses and expand the agricultural export market. The study uses the abbreviated SCOR model to study logistics development associated with agricultural development in the Central Highlands with 3 factors: (i) Plan factor, (ii) Source factor; (iii) Deliver factor. The research results show that all variables have a positive impact on the development of logistics infrastructure, of which: Deliver (DE) has the largest impact 0.354, followed by Source (SO) = 0.297 and Plan (PL) = 0.232. This result is consistent with the characteristics of the Central Highlands terrain and agricultural products. The limitation of the study is that the development of logistics is measured through the assessment of enterprises/cooperatives trading agricultural products in the Central Highlands, there is no actual measurement of performance. The next research direction is to combine the use of secondary data to measure factors affecting the development of logistics associated with agricultural production in the Central Highlands.

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