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Causes and Solutions for Agricultural Product Loss: A Study of the Shallot Supply Chain in Tra Vinh Province

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KEYWORDS

Shallot supply chain,
Stakeholders,
Shallot losses,
Distribution channels,
Post harvest losses.

ABSTRACT

This study investigates the shallot supply chain in Tra Vinh Province, Vietnam, focusing on distribution channels, stakeholder roles, and key factors contributing to post-harvest losses. A mixed-method approach was adopted, integrating qualitative interviews and field surveys conducted with 51 farmers, five collectors, and five retailers to analyze the flow and losses along the supply chain. Additionally, a SWOT analysis was employed to evaluate the strengths, weaknesses, opportunities, and threats faced by stakeholders within the supply chain. Results reveal that the average yield per crop per 1,000 m² is approximately 1,468 kg. Total shallot losses along the supply chain reach an estimated 31.7%, with 21.7% occurring during the production stage and an additional 10% lost post-harvest. The majority of shallots are distributed through traditional markets, with limited access to modern trade channels. Key challenges, including price fluctuations, inadequate storage facilities, and transportation issues, hinder the supply chain's efficiency. Based on these findings, this research recommends targeted interventions, such as infrastructure investment, improved stakeholder coordination, and the exploration of alternative distribution channels, to reduce losses and enhance profitability for local farmers.

1. Introduction

According to statistics from the Food and Agriculture Organization (FAO, 2019), approximately 800 million people are currently hungry worldwide, with over 60% of them residing in the Asia-Pacific region. FAO (2019) estimates that one-third of food produced for human consumption - equivalent to 1.3 billion tons or 750 billion USD - is lost or wasted each year. This food loss and waste (FLW) presents considerable economic, social, and environmental challenges, such as financial losses for producers and environmental degradation from waste disposal (Julien, 2023). In developing countries, food loss primarily occurs during production and processing, while in developed countries it is more common at the distribution stage, as retailers discard food that fails to meet appearance standards. Addressing the food products and supply chain stages that contribute most to FLW, as well

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as associated greenhouse gas emissions (GHGE) and nutrient loss, could enhance resource efficiency, mitigate climate change, and improve nutritional security (Axmann et al., 2022). Reducing food loss could potentially feed an additional 2 billion people and reduce negative impacts on stakeholders (VGP, 2017).

Vietnam, a developing country, ranks second in food waste in Asia (Vu Hong Anh, 2019), underscoring an urgent need for intervention. Research by CEL Consulting (2018) on three product groups - vegetables, seafood, and meat-revealed that the post-harvest loss rate in Vietnam is approximately 20-25%, amounting to an annual loss of 3.9 billion USD. Vegetables have the highest loss rate at around 32% of output (7.3 million tons per year), followed by aquaculture at 12% (804,000 tons per year) and meat at 7%. Additionally, up to 3 million tons of rice are lost annually (14-15% of production). According to data from Vietnam's FLW model (Ngoc Anh, 2020), FLW is assessed through three main indicators: FLW output, GHGE related to FLW, and protein loss. Five food products-rice, vegetables, freshwater fish, pork, and beef-are identified as having the highest combined FLW, GHGE, and nutritional losses.

Tra Vinh, a province in the Mekong Delta, has strong agricultural potential with key crops such as peanuts, chili peppers, watermelons, and shallots (NguyenVan Muoi, 2022). The strategic plan for sustainable agricultural and rural development in Tra Vinh for the period 2022-2030, with a vision to 2050, emphasizes cooperation, value chain development, and advanced, low-emission agricultural models (Plan No. 47/KH-UBND). In alignment with Tra Vinh's agricultural restructuring project aimed at enhancing added value and sustainability (Decision No. 2368/QD-UBND), shallots have been identified by Duyen Hai town and by Duyen Hai district as a key crop, with nearly 750 hectares under cultivation in Truong Long Hoa, Dan Thanh, and Dong Hai communes (Minh Dong, 2019; Nguyen Van Muoi, 2022). Due to their high economic value, shallots have the potential to become a pilot model for "high-tech shallot" production, supporting the province's sustainable agricultural goals through 2050.

Previous studies (Magalhães et al.; Spang, 2019; Irsyadillah et al.; Mesterházy et al., 2020; Tang et al., 2022; Thi et al., 2022; FAO, 2023; Falola et al., 2023) have identified multiple factors that hinder food production efficiency, including outdated technology, limited technical knowledge, and external environmental influences. These challenges reduce production efficiency within households and along the supply chain. Therefore, this study aims to explore the causes of agricultural product loss along the shallot value chain in Tra Vinh province. To achieve this, the study addresses the following research questions: What are the components of the shallot value chain in Tra Vinh province? How is shallot loss perceived by stakeholders, and what is the estimated level of loss? What factors affect agricultural product loss along the shallot value chain in Tra Vinh province? Based on these questions, the study will propose solutions to reduce agricultural product loss along the shallot value chain in Tra Vinh province.

2. Literature review

2.1. Theoretical foundation

2.1.1. Definitions

Food loss refers to the reduction in the quantity or quality of food due to decisions and actions of food chain actors, starting from the production stage in the chain, excluding retailers, suppliers, food services, and consumers (FAO, 2019). The issue of food loss is often considered unintended and is caused by the ineffective functioning of food production and supply systems or by poor institutional and legal frameworks. For example, food spoilage can occur due to poor preservation technology or inappropriate refrigeration, or food may not reach the market because of inadequate infrastructure, resulting in it not being consumed.

Food loss is often used to refer to what happens between the farm and the retail store, while waste occurs from the retail stage to the consumption stage. It's important to note that waste is not included in the Food Loss Index (FLI) (FAO, 2019).

The food supply chain (FSC) is the flow of goods and services along the food pricing chain with the goal of maximizing value for consumers while minimizing costs (Folkerts & Koehorst, 1988). The food supply chain addresses complex concerns, including product perishability, interactions with multiple partners, and cross-industry impacts.

According to Vittuari et al. (2016), the food

Figure 1. Stages of the food supply chain (Vittuari et al., 2016)

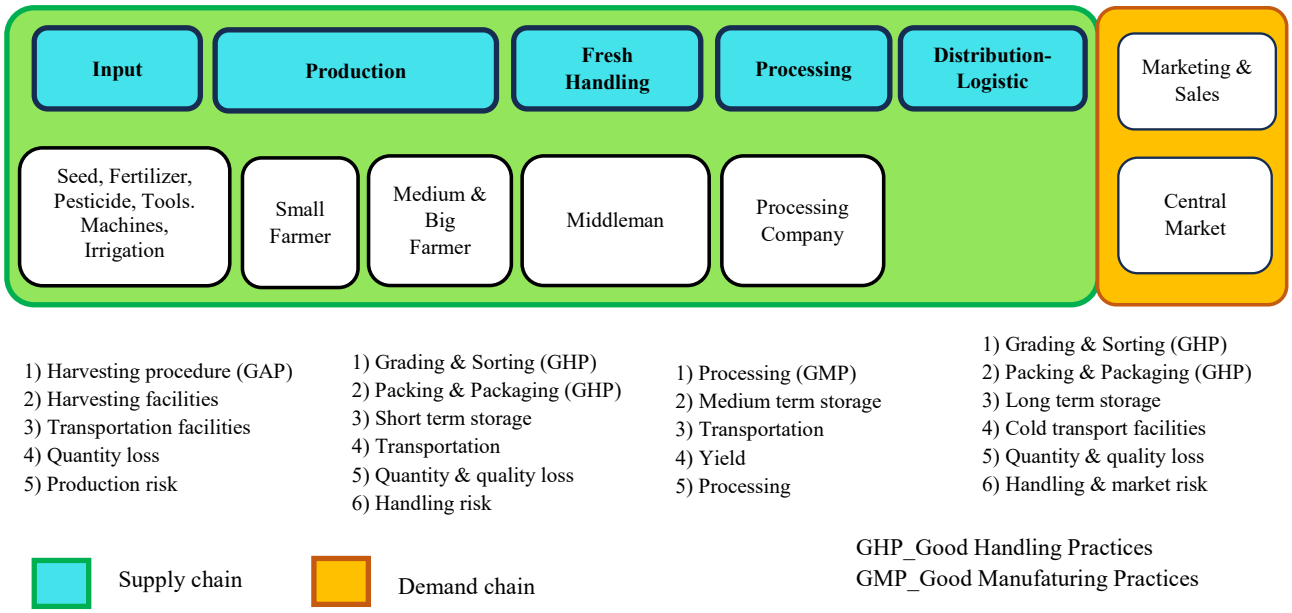

Figure 2. Value chain critical point

supply chain is a series of connected activities used to produce, process, distribute, and consume food. Food loss and waste can occur at all stages of the food supply chain. Before products reach supermarket shelves, they must go through various processes such as transportation, processing, and packaging, leading to changes in the original shape and resulting in waste in the process (Martínez et al., 2014).

2.1.2. Stages of the food value chain

Ineffective supply chain management can lead to food loss and waste at each level within the chain (Hartikainen et al., 2018). It is also conceivable that the causes of FLW at one stage will be masked or transferred to a later stage (Raak et al., 2017). According to Urutyan (2013) and Vittuari et al. (2016), there are 5 stages in the food supply chain, including (1) Agricultural Production, (2) Post-harvest Handling and Preservation, (3) Processing and Packaging, (4) Wholesale and Retail, and (5) Consumption (Figure 1).

2.1.3. Measuring food loss along the supply chain

Food loss is commonly quantified in terms of food mass, although some studies convert it into calorie units, emission units, or economic units (Moraes et al., 2021; Axmann et al., 2023). Therefore, this study measures agricultural losses in terms of Shallot mass by calculating the percentage of Shallot lost at each stage of supply chain activities carried out by each actor (Figure 2).

According to UNECE (Moraes et al., 2021), food loss is calculated by comparing the quantity of product obtained from a supply chain activity (output) with the quantity of product processed during the supply chain activity (input). Subsequently, food loss is expressed as a percentage using the following formula:

$$\text{Food loss (\%)} = \frac{\text{x (kg) real output}}{\text{x (kg) output estimation or input}} 100\%$$

2.1.4. System approach for value chain strategy

The value chain system furnishes diverse management principles essential for formulating and orchestrating the meticulously designed planning and oversight of the supply network. This is undertaken with the aim of harmonizing the dynamic oscillations in consumer and market demand with the inherent uncertainties pertaining to the capacities of suppliers. Technically, the systemic approach seamlessly amalgamates supply chain management, warehousing, transportation, and enterprise resource planning, wherein the value proposition is intricately embedded within each discrete segment (Basher, 2018).

The viable system model for horticultural agribusiness is formulated to include operations such as coordination, integration, and a policy-making framework across key points within the value chain.

2.2. Previous study

Magalhães et al. (2019) identified early-stage causes of food loss and waste in the food supply chain, attributing them to management issues, technical inefficiencies, and intrinsic product characteristics. Key causes include: (1) short shelf life and expired products, (2) inadequate demand forecasting, (3) poor handling and operations, (4) incorrect storage temperatures, (5) non-compliance with retail specifications, (6) product quality issues, (7) overproduction and excess inventory, and (8) inadequate or defective packaging. Similarly, Spang et al. (2019) conducted a comprehensive survey of stakeholders across the food supply chain, covering primary production, processing, transportation, storage, and wholesale to retail, restaurants, and household

Irsyadillah et al. (2020) examined fruit losses during distribution, focusing on bananas. Their survey results indicated that farmers generated no waste, as all fruits were sold to wholesalers. Mesterházy et al. (2020) highlighted technical limitations-such as plant breeding, protection, and agronomy-as well as social factors, as causes of grain losses. They noted that pest management practices, both direct and indirect, had a significant impact on grain production losses.

According to FAO (2023), key points of food loss in the Indonesian onion supply chain involve farmers, intermediaries, rural collection centers, post-harvest processing centers, and wholesale markets. However, improper harvesting techniques, poor infrastructure, and the distance between growing areas and markets contribute to losses and reduce farmers' profits. In Nigeria, Falola et al. (2023) identified rot, pests, wilting, bruising, lack of credit, inadequate storage facilities, and limited extension services as primary causes of onion losses. Factors such as farmer age, farm size, yield, distance to market, and storage time are associated with higher losses, while education level, household size, extension services, and credit access correlate with lower post-harvest losses.

The SNV project (2022) assessed vegetable, aquaculture, and gender-integrated value chains, including the purple onion value chain in Duyen Hai town. Key actors studied include input suppliers, seed providers, producers, and distributors. Losses were attributed to poor storage conditions, lack of linkages, and inadequate processing facilities, which lead to low added value. Across Vietnam's agricultural value chain-from input and production to post-harvest, processing, and export-there remain limitations at each stage, such as high input costs, low production quality and efficiency, high post-harvest losses, low processing technology, and suboptimal export quality.

Tang et al. (2022) identified technology as a critical factor in food loss, emphasizing the need for synchronized technology use to optimize performance. The study advocates for low-cost solutions like remote monitoring of temperature, time, and location to minimize losses due to refraction. Thi et al. (2022) examined the cold chain's role in Vietnam's food supply, concluding that 25% of agricultural losses occur during cultivation and processing, while 14% result from storage, handling, and transportation. An additional 20% of losses stem from quality degradation and quantity reduction in production and processing stages.

Although many studies have examined food loss and waste in supply chains, particularly in developing countries, in-depth analyses of losses for specific products, such as purple onions in Vietnam, remain limited. The unique factors contributing to losses in the shallot supply chain in Tra Vinh-a region with significant agricultural potential and a focus on sustainable value chain development-have not been

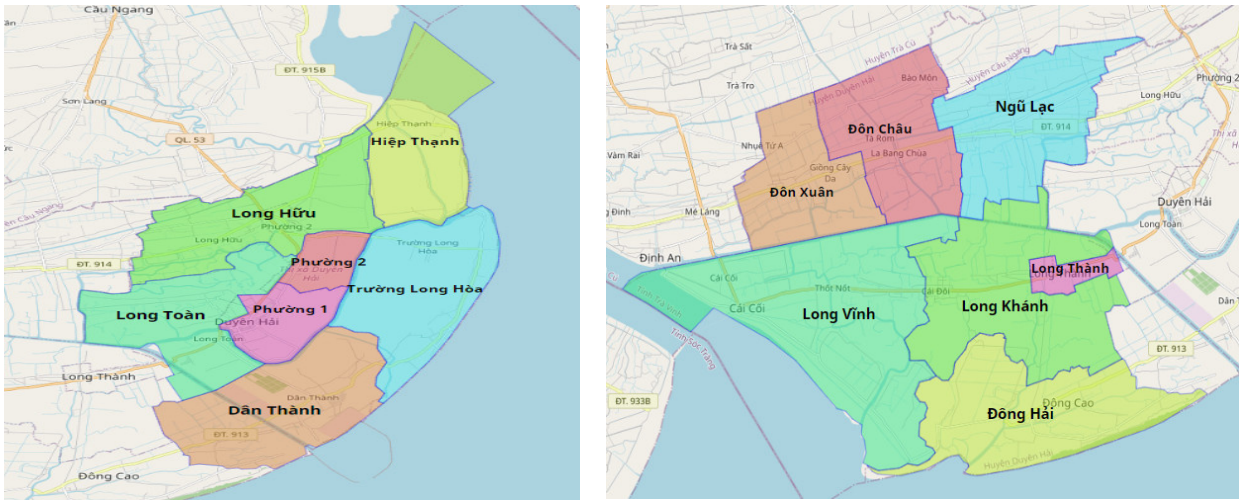

Figure 3. Map of Duyen Hai Town and Duyen Hai District, Tra Vinh Province, Vietnam

fully explored. This study seeks to address this gap by providing targeted solutions to reduce losses, thereby enhancing the efficiency and sustainability of agricultural production in Tra Vinh.

3. Methodology

3.1. Overview of the study area

According to the Vietnam Industry and Trade Information Center (VITIC, 2019), Tra Vinh province has over 180,000 hectares of agricultural land, including 74,000 hectares allocated for triple-crop rice farming, more than 35,000 hectares for aquaculture, 142 hectares for safe vegetable production, and over 26,000 hectares for industrial crops. Additionally, 100 hectares of rice and 100 hectares of orchards are VietGAP-certified. Industrial crops provide high income for farmers in coastal districts such as Cau Ngang District, Duyen Hai District, and Duyen Hai Town, with purple onions being the primary crop. On average, each hectare of coastal sandy land generates an income of approximately 135 million VND per hectare per crop. The total area dedicated to shallot cultivation is nearly 750 hectares, with over 550 hectares located in Duyen Hai Town (Nguyen Van Muoi, 2022) and 191.5 hectares in Duyen Hai District (Minh Dong, 2019). The study titled "Causes and solutions for agricultural product loss: A case study of the onion supply chain in Tra Vinh province' was conducted in Duyen Hai Town and Duyen Hai District, Tra Vinh province".

3.2. A mixed methods study

This study employs a mixed-methods approach, integrating both qualitative and quantitative research techniques to comprehensively address the study's objectives. Initially, a qualitative phase was undertaken, using expert interviews to refine the survey questionnaire and to gain deeper insights into the vegetable value chain and food loss issues. The author began by reviewing relevant literature from reputable sources, including the Binh Duong University Journal of Science and Technology, Vietnam, Transportation Research Procedia, Industrial Engineering and Operations Management I: XXIV IJCIEOM, Annual Review of Environment and Resources, AIP Conference Proceedings, and Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi. Drawing from these studies, the author adapted methods and survey questions to develop a semi-structured interview guide. This qualitative stage aimed to identify key actors in the onion supply chain and explore underlying causes of agricultural product loss.

Building on these findings, the quantitative phase involved field surveys conducted with 51 farming households, five collectors, and five retailers to investigate specific factors contributing to onion loss. Data analysis combined descriptive statistics, SWOT analysis, interpretation, and induction, enabling a nuanced understanding that informed the development of solution strategies. Combined, these methods yielded actionable insights aimed at minimizing losses and enhancing economic

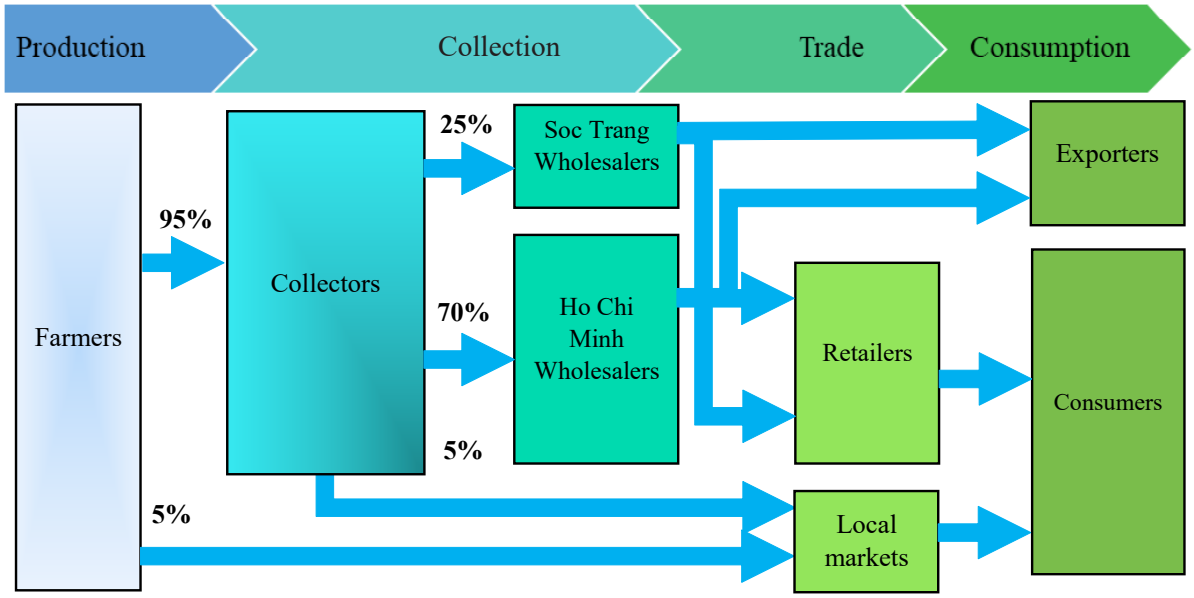

Figure 4. Diagram of the shallot supply chain in Tra Vinh Province

efficiency for all stakeholders.

4. Results and Discussion

4.1. Mapping the shallot supply chain in Tra Vinh province

The results of focus group discussions conducted from April 1 to April 27, 2024, with farmers, local authorities, and intermediaries on the shallot value chain in Dong Hai Hamlet, Duyen Hai District, Truong Long Hoa Commune, Duyen Hai Town, Tra Vinh Province, revealed key actors and their participation levels. The shallot supply chain in Duyen Hai Town is relatively short, with limited involvement of local actors, including farmers, intermediaries (traders, warehouse owners, retailers, local markets, exporters), and consumers.

In the initial stage of the supply chain, farmers purchase shallot seeds and agricultural inputs (pesticides, agricultural chemicals) from suppliers. Preferred seed characteristics include large bulbs, a glossy skin, and freedom from pests or diseases. Agricultural chemicals are often bought on credit, and fertilizer prices have nearly tripled compared to the previous year, adding to production costs. Due to the high price of seeds, many farmers propagate their own or purchase from peers within or outside the province, with seed prices ranging from 30,000 to 50,000 VND/kg-2 to 3 times higher than commercial shallots. Poor storage conditions also contribute to a significant seed loss rate.

Shallots are primarily cultivated in Duyen Hai Town and Duyen Hai District, particularly in Truong Long Hoa, Dan Thanh and Dong Hai Communes, with an estimated 750 hectares dedicated to shallot production in 2023 (Minh Dong, 2019; Nguyen Van Muoi, 2022). According to focus group discussions with farmers, the selling price of shallots averages 15,000–23,000 VND/kg.

The main intermediaries in the shallot supply chain include collectors and wholesalers operating within the province and in local markets. Findings from discussions with 51 farmers in Truong Long Hoa Commune indicate that approximately 95% of post-harvest shallots are collected by provincial collectors (Tra Vinh), while the remaining 5% is sold in local markets. Farmers pack shallots in 50kg and 100kg bags for transportation to wholesalers. About 25% of the output is transported to wholesalers in Soc Trang Province, 70% to Ho Chi Minh City, and 5% remains in local markets.

Channel 1: Farmer → Collectors → Wholesalers → Exporters

In this channel, farmers harvest shallots and package them in 50kg or 100kg bags. Provincial collectors, primarily from Tra Vinh, purchase approximately 95% of the post-harvest shallots from farmers. These collectors then transport the shallots to *Wholesalers* in other provinces: 25% are sent to

Soc Trang, and 70% are directed to Ho Chi Minh City. In these locations, wholesalers or exporters take charge of further distribution, primarily targeting international markets.

Channel 2: Farmer → Collectors → Wholesalers → Retailers → Consumers

In the second channel, farmers package and sell their harvested shallots to collectors. These collectors then purchase and transport the shallots to wholesale markets. At the wholesale level, shallots are either sold directly to consumers or distributed through retail outlets. This channel primarily targets domestic consumption, with a focus on large urban markets, including Ho Chi Minh City and other metropolitan areas.

Channel 3: Farmer → Collectors → Local Market → Consumers

This channel begins with farmers retaining approximately 5% of their shallot harvest for local sales. Farmers bring these shallots directly to markets in Tra Vinh and nearby areas, where local collectors and vendors purchase them and sell to consumers. Primarily supporting the local community, this channel focuses on direct, small-scale sales within Tra Vinh.

Channel 4: Farmer → Local Market → Consumers

Farmers retain a small portion (approximately 5%) of their shallot harvest for local sales. They bring these shallots directly to local markets in Tra Vinh and surrounding areas, where consumers purchase them from either market vendors or the farmers themselves. This channel primarily serves the local community, focusing on direct, small-scale consumer sales within Tra Vinh.

4.2. Stakeholders' awareness of shallot losses along the value chain

4.2.1. Assessing farmers' awareness of shallot loss

Farmers' general information

Of the 51 surveyed households, 37 were headed by men and 14 by women. The average age of household heads was 43.6 years, with the majority (47.1%) aged between 35 and 45 years. Ten households (19.6%) were headed by individuals aged 45 to 55, while the groups under 35 and over 55 accounted for 15.7% and 17.6%, respectively. In terms of education, 45% of household heads had a junior high school education, 31.4% had a high school education, 15.7% had primary school education, and 7.8% had not attended school. The average household size was 4-5 people, with the largest household having 8 members and the smallest 2. Notably, 36 households (70.6%) had two main laborers.

Market Distance: Most households were located a considerable distance from the market, with an average distance of 11.5 km. Specifically, 5 households (9.8%) were less than 5 km from the market; 16 households (31.4%) were 5–10 km away; 13 households (25.5%) were 10–15 km away; 7 households (13.7%) were 15–20 km away; and 10 households (19.6%) were located over 20 km from the market.

Income from Shallots: Regarding income from shallots, 20 households (39.2%) derived less than 50% of their household income from this source. Seventeen households (33.3%) earned exactly 50% of their income from shallots, 8 households (15.7%) earned between 50% and 90%, and 6 households (11.8%) relied entirely on shallots for income.

Participation in Cooperatives: Among the 51 households, 5 were members of cooperatives, specifically the Farmers' Professional Association, Truong Long Hoa Agricultural and Rural Development Cooperative, Phuong Dong Cooperative, and Khoan Tieu Cooperative.

Farming situation of households

Capital source: The average capital for shallot farming among surveyed households is 1.2 million VND. The average agricultural land area per household is 8 hectares, with a maximum of 21 hectares and a minimum of 2 hectares. Specifically, the average area allocated to shallot cultivation is 5.5 hectares, with the largest and smallest cultivation areas being 20 hectares and 2 hectares, respectively.

Shallot crop cycle: Households typically cultivate two shallot crops per year, with planting occurring in September and December. The average growing period for each crop is 3 to 4 months, and the average yield per hectare is approximately 76 kg. Some households engage in supplementary planting, particularly those cultivating more than 5 hectares, adding an average of 10 kg. This additional planting incurs an average cost of 200,000 VND per hectare.

The average production cost per shallot crop

Table 1. Information on shallot yield, prices, and total revenue for households

Type	Yield (kg)	Unit Price (Thousand VND/kg)	Total Revenue (Thousand VND)
Type 1	1,170	23	26,785
Type 2	297.9	16	4,766
Total	1,468	-	31,551

Table 2. Average cost of purchasing a ton of shallots

Indicator	Cost per 1,000 m²	
	Average cost per crop (Thousand VND)	Average cost per crop (Thousand VND)
Transportation cost from purchase to warehouse	0.5	30.3
Packaging cost	0.2	0.6
Labor cost (loading, unloading)	0.3	18.2
Labor cost for sorting, packaging	0.15	9.1
Warehousing and preservation cost	-	-
Transportation cost to consumption place	0.3	18.2
Sales cost (communication, sales, etc.)	0.2	12.1
Export logistics service cost (if any)	-	-
Total	1.65	100

is 12,372,000 VND, with expenses allocated as follows: 42.1% for seed purchase and land preparation, 26.2% for fertilizers and pesticides, 11.9% for labor hiring (planting and care), and 19.8% for other costs, including electricity, water, machine depreciation, harvesting, transportation, sales contact, and packaging.

Yield and revenue per crop per household: The data on yield and revenue per crop per household are summarized as follows. For Type 1, the average yield is 1,170 kg per crop per worker, with a selling price of 23,000 VND per kg, resulting in an approximate revenue of 26,785,000 VND per crop per worker. In contrast, Type 2 yields an average of 297.9 kg per crop per hectare, sold at 16,000 VND per kg, leading to a revenue of approximately 4,566,000 VND per crop per hectare. Consequently, the total revenue per crop is 31,551,000 VND, as illustrated in Table 1.

For the 2022-2023 crop cycle, the average selling price of shallots is 23,000 VND per kg, with an average yield of 1.8 tons per hectare. Traders purchase shallots from farmers at prices ranging from 23,000 to 25,000 VND per kg, generating an estimated profit of 20 million VND per 1,000 square meters for many shallot farmers.

4.2.2. Assessing collectors' awareness of shallot losses

Collectors' general information

A survey was conducted with five collectors in Duyen Hai District. Most collectors have over 10 years of experience in purchasing shallots, with the majority of their income, approximately 60%, derived from these activities. The purchasing of shallots does not occur throughout the year; it is limited to two periods: January (mid-December of the lunar calendar) and April, corresponding to two crops per year. Traders primarily source shallots from farmers within the province, particularly from Truong Long Hoa Commune (55%) and Dong Hai Commune (45%).

Purchase method: Transactions are carried out through oral agreements, with no formal contracts established.

Criteria for selecting shallots: Colletors prioritize large, dark bulbs when selecting shallots for purchase.

Preservation and storage: Shallots are stored in cool houses, but no advanced preservation technologies are employed. The storage duration is generally 6 to 7 days before the shallots are transferred to large warehouse owners.

Table 3. Shallot loss rate per 1,000 m^2 per crop

Indicator	Unit	Input quantity	Additional input quantity	Total
Input	kg	76	21	97
Output	kg	1,468	406	1874
Food loss	%			21.7

Table 4. Collectors' awareness of shallot loss

Awareness of shallot loss	Rate (%)
Decrease in quantity of shallots after harvest (waterlogging, disease, low weight, ...)	40
Decrease in quantity and quality of shallots before planting, during planting, after harvesting, and during storage (waterlogging, disease, death, low weight)	60

Packaging design: Collectors typically do not have custom-designed packaging. They use standard mesh bags, specifically designed for shallots, with an average weight of 50 kg per bag.

Cost of purchasing a ton of shallots

The average cost per ton of shallots is approximately 1.65 million VND. The cost breakdown is as follows (Table 2)

Collectors' sales situation

After purchasing shallots, collectors store them in cool houses for 6-7 days before transferring 95% of the product to other collectors or selling the remaining 5% at local markets. The purchase price from farmers is 23,000 VND per kg, with an additional transportation cost of 1,650 VND per kg. The selling price to other collectors is approximately 28,000 VND per kg, while the selling price at local markets is around 22,000 VND per kg. Consequently, the profit margin for collector ranges from 2,500 VND to 3,000 VND per kg. Therefore, the profit for collectors on a ton of shallots is approximately 2.05 million VND, representing roughly 12% of the total costs.

4.3. Causes of agricultural product losses along the shallot value chain

4.3.1. Input stage

Based on the survey results from 51 households growing shallots, 41 households (equivalent to 80.4%) perceived agricultural product loss as a decrease in both quantity and quality of purple onions before planting, during planting, after harvesting, and during storage (due to waterlogging, disease, death, and low weight). The damage rate is approximately 21 kg per 1,000 m^2 per crop.

Farmers primarily encounter pests and diseases, such as waterlogging, rot, fungi, etc., which account for 74.5% of losses. Additionally, 21.6% of losses are attributed to climate change and unfavorable weather conditions (e.g., rain, frost), while 3.9% result from poor-quality input seeds.

4.3.2. Handling of shallot losses

Production Stage: This involves selecting healthy, high-quality shallot seeds and implementing measures to prevent pests and diseases (74,5%), including the use of natural predators, methods to control harmful organisms, and the application of pesticides.

Processing during harvest: Of the 51 households surveyed, 39 (equivalent to 76.5%) chose to classify shallots before selling them to obtain higher prices. Specifically, more than 70% of households sorted the shallots during harvest, primarily based on size. Type 1 consisted of large, dark purple, shiny bulbs, while type 2 included smaller bulbs.

Use of technology during and post-harvest: A significant 98% of farmers still rely on manual harvesting, with no machinery or equipment used during the harvesting or preservation process.

Participation in training on shallot cultivation: 96% of farmers did not attend training courses on shallot cultivation techniques. The primary reasons for non-participation were lack of information about available courses (33.7%) and time constraints (11.7%), while the remainder cited other reasons.

Handling of shallot losses: To manage losses, farmers typically sell damaged shallots at lower prices to traders and consumers (45%), discard

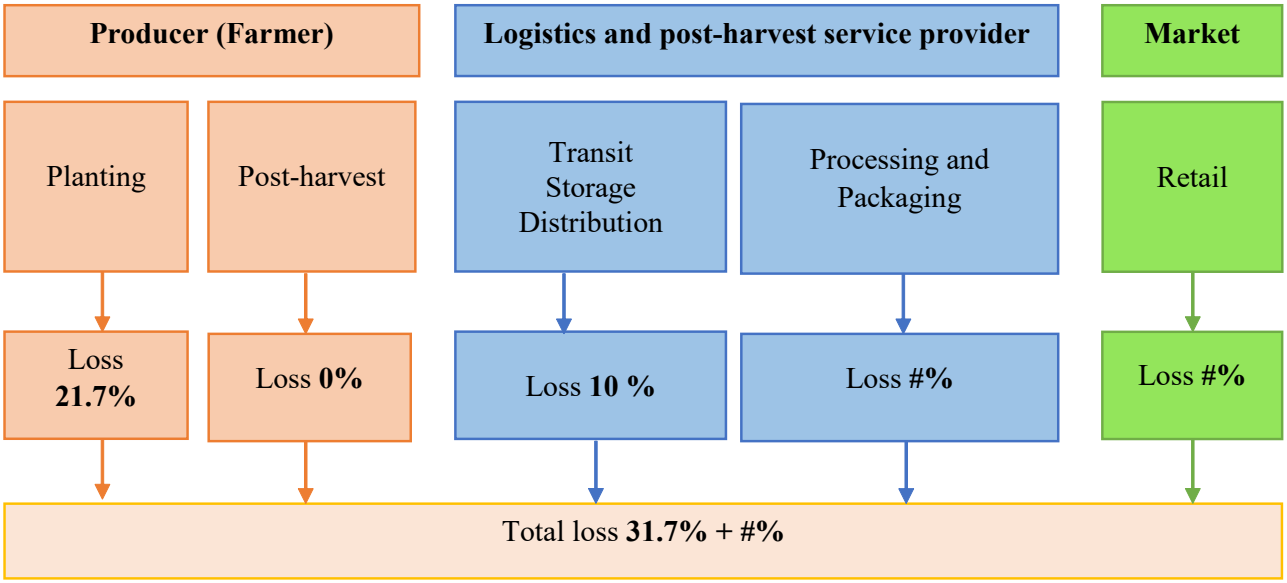

Figure 5. Measurement framework for shallot loss along the shallot supply value chain

them or use them as agricultural fertilizer (39.2%), or apply fertilizers and pesticides to prevent further pest and disease damage (15.7%).

This method of handling losses impacts the economic efficiency of farming households, as most households opt to sell at a lower price or discard the produce, which fails to recover capital and incurs additional costs in early-stage care. Although the loss rate of shallots is small, it remains noticeable, primarily due to pests, unfavorable weather conditions, and poor seed quality. Implementing classification measures, using technology, and participating in technical training courses can help reduce loss rates and improve the economic efficiency of farming households.

4.3.3. Intermediary stage

The survey results from five collectors in Duyen Hai district on traders' awareness of agricultural product loss (shallots) are in Table 4.

Thus, agricultural product loss is understood as a decrease in both quantity and quality of shallots before planting, during planting, after harvesting, and during storage (waterlogging, disease, death, low weight).

4.3.4. Identifying the main causes

In the process of purchasing shallots from farmers to deliver to large warehouse owners, collectors often encounter problems with loss of purchased output and reduced quality of finished shallots, mostly due to lack of techniques, preservation technology, and imbalance, leading to output loss (60%). Additionally, pests and diseases (such as waterlogging and rot) hidden inside the product contribute to further loss (40%).

The loss rate for traders is about 10%, equivalent to approximately 100 kg lost for every 1,000 kg in storage. Timely intervention measures are needed to maintain productivity and quality within the shallot value chain.

4.3.5. Handling of shallot losses

Collectors currently lack effective measures to address the causes and consequences of loss. The common practice among traders is to discard affected output.

4.4. Determining the level of shallot losses along the supply chain

Due to time constraints, this shallot loss measurement framework is limited to investigating only two actors in the chain: farmers and collectors. The diagram below summarizes the stages in the shallot value chain in Tra Vinh and the percentage of of losses occurring at each stage.

Table 5. SWOT analysis for shallot farmers

Internal capacity	
Strengths (S) S1: Sandy soil conditions are highly suitable for shallot cultivation. S2: Farmers have extensive experience in shallot production. S3: Cooperatives are active within the shallot value chain, supporting collaboration and resource sharing. S4: Shallots produced locally exhibit attractive color and size, enhancing market appeal	Weaknesses (W) W1: Limited technical and market capacity among shallot growers. W2: Insufficient investment capital for advanced technology and equipment. W3: Production remains small-scale, fragmented, and lacks consolidation. W4: Limited knowledge of post-harvest handling and preservation techniques. W5: Constrained access to input and output markets for processing facilities. W6: High production costs, including expenses for harvesting, fertilizers, and seeds. W7: Lack of trademark registration for shallot products, with minimal focus on promotional activities.
External capacity	
Opportunities (O) O1: Growing market demand for shallots. O2: Implementation of agricultural restructuring projects to boost efficiency and sustainability. O3: Supportive government and local policies for cooperative economic development, industrial promotion, and public-private partnerships. O4: Advancements in technology for improved production and preservation of shallots.	Threats (T) T1: Price fluctuations and market instability. T2: High competition from imported shallots (notably from China, India, and Thailand). T3: Climate change and natural disasters impacting shallot yields. T4: Susceptibility to pests and diseases. T5: Increasing scarcity of groundwater resources.

At the famer stage: The most significant losses occur during production and are attributed to pests, adverse weather conditions, and poor-quality seeds. These factors substantially reduce yields, leading to a loss rate of up to 21.7%. The estimated average loss value is VND 2,685 thousand per 1,000 m² per crop. However, losses caused by untimely harvesting and mechanical damage are relatively minor.

At the collector stage: The primary causes of losses include inadequate storage conditions and internal pest infestations, which together account for an additional 10% loss, equivalent to VND 2,580 thousand per 1,000 m² per crop. Shallots stored for 5–7 days under suboptimal conditions are particularly susceptible to deterioration. Additionally, waterlogging and internal rotting, mainly due to pest infestations during transportation and storage, further contribute to losses.

Overall, the total loss across the shallot supply chain is estimated at 31.7%, with an average financial loss of VND 5,265 thousand per 1,000 m² per crop.

4.5. General assessment of farmer and collectors' competences

4.5.1. Farmer capacity

Farmers possess a long-standing tradition and extensive experience in agriculture, with many families having been involved in farming for multiple generations. They are also known for their hard work and dedication. However, moving shallot products from production to consumption involves multiple stages and presents various challenges within the shallot value chain. The capacities of farmers are summarized in Table 5.

4.5.2. Collector capacity

The capacities of collectors are summarized in Table 6.

5. Conclusion and recommendations

The study of the shallot supply chain in Duyen Hai, Tra Vinh, highlights the strengths and weaknesses of the actors involved across the production, post-harvest, and consumption stages. The loss rate in the production stage is 21.7%, while the post-harvest

Table 6. SWOT analysis for shallot collectors

Internal capacity	
Strengths (S) S1: Extensive experience in purchasing agricultural products. S2: Established, long-term cooperative relationships with shallot growers, built on trust. S3: Widespread and effective distribution network. S4: Ability to forecast and analyze the market, allowing for flexible adjustment of business strategies.	Weaknesses (W) W1: Limited capital, posing challenges to business expansion. W2: Minimal application of modern technology in management and operations. W3: Weak connections with farmers, leading to insufficient coordination in production and consumption activities. W4: Limited investment in promotional activities and brand building.
External capacity	
Opportunities (O) O1: Growing domestic and international demand for purple onions presents substantial opportunities for collectors to expand their markets. O2: Government-driven agricultural restructuring initiatives are fostering policies that support the development of purple onion crops and related products. O3: Supportive policies for cooperative economic development encourage the formation of cooperatives and strengthen production linkages between farmers and collectors, promoting a more robust agricultural sector.	Threats (T) T1: Purple onion prices are susceptible to significant fluctuations due to supply-demand imbalances, weather variability, and broader economic factors, potentially impacting collectors' revenue stability. T2: Increa'ed competition from other collectors and imported products poses challenges that may affect the profitability of domestic collectors. T3: The potential for disease and pest outbreaks could adversely impact both the supply and quality of purple onions, complicating the market landscape.

stage accounts for a 10% loss. These substantial losses in the production and post-harvest processes adversely affect the economic efficiency and productivity of the entire supply chain. However, data on the loss rate in the consumption stage is currently unavailable, indicating a need for further detailed research in this area.

To enhance understanding and optimize the shallot supply chain in Duyen Hai, Tra Vinh, future studies should address this gap by examining the consumption stage and incorporating a broader analysis of socio-economic and environmental factors. Additionally, recommended measures to reduce food loss, increase economic efficiency, and establish a sustainable supply chain include: improving cultivation and harvesting techniques, strengthening post-harvest management, researching and developing markets, securing government and organizational support, enhancing cooperation and linkages within the value chain, and issuing relevant guidance documents.

This study primarily focuses on the production and post-harvest stages of the shallot supply chain in Duyen Hai, Tra Vinh, identifying significant losses of 21.7% and 10%, respectively. Nevertheless, it does not include an assessment of the consumption stage, resulting in incomplete data on total losses across the entire supply chain. Future research should address this gap by examining the consumption stage and incorporating a broader analysis of socio-economic and environmental factors that may influence the efficiency and sustainability of the shallot supply chain.

5.1. Solutions to reduce shallot losses for farmers

S14O12: Leveraging the advantageous sandy soil conditions, farmers can expand shallot cultivation areas to meet increasing market demand. This approach entails fostering cooperation among farmers to increase the cultivated land area and adopting advanced farming techniques to improve productivity and product quality. Developing and maintaining high-quality shallots is also essential to support the agricultural restructuring project. To achieve this, farmers should actively participate in technical training programs and adopt innovative practices that continuously enhance shallot quality. Additionally, forming strong partnerships with businesses and cooperatives can ensure a stable output market for shallot products, further securing their position in the value chain.

S34T1: To mitigate market fluctuations and enhance competitiveness against imported shallots, farmers can leverage cooperatives to secure timely access to market information, which helps reduce price volatility. Cooperatives also facilitate product diversification and access to new markets, lessening dependency on a single market. Additionally, the inherent quality of local shallots can be promoted by developing regional brands, which reinforces the competitive edge against imports. Expanding both online and offline sales channels will enable access to a broader customer base, further stabilizing the shallot market for local producers.

W12O13: Enhancing technical and market competencies, along with financial resources, will enable farmers to fully benefit from cooperative economic development support policies and meet increasing market demand. Participation in training programs offered by government and non-governmental organizations, coupled with establishing networks with larger enterprises and cooperatives, can enhance market access. Furthermore, farmers can strengthen financial capacity by seeking capital support from agricultural and industrial extension programs and microfinance institutions. Developing credit cooperative models also serves as a viable approach to provide the necessary financial assistance to farmers.

W67T12: Reducing high production costs and enhancing product promotion efforts are crucial strategies for farmers to adapt to harsh climate conditions and compete with imported shallots. Employing drought-resistant shallot varieties and sustainable farming practices can significantly reduce irrigation and pesticide expenses, thus lowering overall production costs. Concurrently, expanding promotional activities, such as active participation in agricultural fairs and exhibitions, increases product visibility. Leveraging digital platforms, including social media and websites, can further broaden outreach, attract potential customers, and strengthen market positioning.

5.2. Solutions to reduce shallot losses for collectors

S13O12: Leveraging strong relationships with farmers enables collectors to meet growing market demand by ensuring a stable and high-quality supply of shallots. Establishing close cooperation and long-term contracts with farmers further supports efforts to fulfill increasing demand. Additionally, developing an efficient distribution system is essential for capitalizing on the agricultural restructuring project. This strategy involves strengthening the distribution network to broaden market reach and forming partnerships with enterprises and cooperatives to actively participate in restructured agricultural value chains, ultimately enhancing market access and supply chain resilience.

S24T12: Employing advanced market forecasting techniques allows collectors to manage market fluctuations effectively by utilizing data analysis to predict price trends and adapt purchasing strategies accordingly. Furthermore, diversifying supply sources and products helps mitigate risks linked to market variability. To address challenges posed by harsh climate conditions, implementing robust warehousing and preservation systems is essential. Investment in modern preservation technologies, such as cold storage facilities, enables long-term shallot preservation, reduces climate-induced losses, and ensures consistent product quality.

W13O13: Strengthening financial capacity is essential for collectors to capitalize on support policies for cooperative economic development. By seeking capital assistance from industrial and agricultural promotion programs and partnering with financial institutions to access preferential loans, collectors can enhance financial stability. Additionally, upgrading management and technological systems is crucial to meet growing market demand. Investment in information management systems and technology not only improves operational efficiency but also optimizes warehouse and transportation workflows, contributing to a more responsive and effective distribution process.

W24T1: Reducing operating costs is essential for improving competitiveness against imported shallots. Implementing cost-saving measures and enhancing operational efficiency can significantly lower expenses, while taking advantage of government tax and fee incentives further alleviates cost pressures. Simultaneously, strengthening promotional efforts and brand-building initiatives plays a crucial role in positioning local shallots in the market. Active participation in agricultural fairs and exhibitions promotes product visibility, while leveraging social media and targeted marketing strategies enhances brand awareness, broadening the reach to new customer segments.

5.3. Recommendations for local authority and government

Policy development and implementation: Develop and promote policies supporting sustainable agricultural practices, with a focus on crop diversification and enhancing value chains. This includes providing subsidies for essential inputs like fertilizers, drought-resistant seeds, and irrigation systems, as well as grants for post-harvest infrastructure investments such as cold storage and drying facilities to reduce spoilage losses. Additionally, enforce import standards for shallots to limit competition from lower-quality imports, ensuring local products remain competitive in quality and market value.

Infrastructure development: Investing in or incentivizing centralized storage and warehousing facilities with temperature and humidity controls is essential for maintaining shallot quality throughout the supply chain. Additionally, improving rural road networks and transport facilities can significantly reduce delays and post-harvest losses caused by inadequate infrastructure. Enhanced logistics support is also crucial to enable the swift transportation of shallots to markets, especially in remote areas, ensuring that produce reaches consumers fresh and minimizes overall losses.

Training and capacity building: Conducting training sessions for farmers on sustainable farming practices, pest management, post-harvest handling, and preservation techniques is essential for minimizing losses caused by poor handling and storage. Additionally, establishing systems that provide real-time market information on prices, demand, and supply fluctuations will empower farmers and collectors to make informed decisions regarding selling and storage, thereby improving overall efficiency and profitability in the supply chain.

Financial support and credit access: Providing or facilitating access to low-interest loans and credit facilities enables farmers and collectors to secure affordable financing for essential investments in technology, equipment, and inputs needed to reduce post-harvest losses. Additionally, developing insurance schemes that cover crop losses due to climate-related events, such as droughts, floods, and storms, helps farmers and collectors manage the risks associated with unpredictable weather patterns, fostering greater resilience in the agricultural sector.

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