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Supply chain management practices and performance in the banana industry of Nueva Ecija, Philippines

Romeo B. Campos *

College of Management and Business Technology, Nueva Ecija University of Science and Technology, Cabanatuan City, Philippines

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ABSTRACT

Given the critical role of effective supply chain management (SCM) in reducing post-harvest losses and ensuring the marketability of agricultural products such as bananas, this study investigated the SCM practices and performance of the banana industry in Nueva Ecija, Philippines. Using a descriptive survey design, data were collected from 53 banana farmers operating as small-scale sole proprietorships across four municipalities. The research instrument, a validated and reliable questionnaire, assessed business and owner profiles, nine SCM practice components, and three SCM performance dimensions. The findings revealed a notable gap between operational strengths and strategic weaknesses. Farmers demonstrated strong capabilities in operational areas, with well-developed logistics and transportation practices, high overall output performance and flexibility performance, and developing resource performance. However, significant deficiencies were identified in strategic SCM functions, particularly in integrated operations planning, inventory management, and supply chain information technology. Other SCM components, including procurement and manufacturing, warehousing, material handling and packaging, customer accommodation, and relationship management, showed foundational or developing practices. The study concludes that although the banana industry in Nueva Ecija demonstrates strong operational performance, a critical gap remains in strategic and information-driven SCM. This limitation affects profitability and resilience, highlighting the need for interventions that can bridge the gap between operational expertise and strategic planning to improve the industry's competitiveness and sustainability.

1. Introduction

The Philippine banana industry plays a big role in the country's economy. Over the last ten years, the number of bananas grown has increased significantly, from 7.23 million metric tons in 2012 to 9.02 million metric tons in 2023, with a peak of 9.36 million metric tons in 2018 (Pittman et al., 2026). Most of this production happens in regions like Davao and Northern Mindanao. Because of this high output, the Philippines is consistently one of the top banana producers in Southeast Asia. The Philippine government recognizes how important this is and has set a clear goal to keep the country a major player in the world's banana market. To achieve this goal, the industry must overcome many challenges. A critical step for long-term success is putting in place a well-managed Supply Chain Management (SCM) system.

SCM refers to the strategic coordination of activities required to plan, organize, and move a product from producer to customer. It involves managing the flow of goods, information, and resources to ensure products are produced, stored, and delivered efficiently and on time (Hugos, 2024). In the agricultural sector, this process is particularly critical, as agricultural products such as fruits and vegetables are perishable and susceptible to damage if not handled with care (Barrion et al., 2023). These vulnerabilities are particularly apparent in the case of the banana. After harvest, the fruit undergoes biological changes leading to eventual senescence, rot, and decay. Its high-water content makes it prone to shriveling, while its soft texture results in a high susceptibility to mechanical injury during handling and transport. These injuries accelerate

* Corresponding Author.
Email Address: camposromeo01@ineust.ph.education
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Corresponding author's ORCID profile:
https://orcid.org/0009-0005-8828-8911

deterioration and create entry points for pathogens, degrading the fruit's physical quality and reducing its marketability. Therefore, a properly managed supply chain is necessary to control these post-harvest processes, preserve quality, and deliver an acceptable product to the market.

To understand how supply chain management applies to the banana industry, it is necessary to examine its core components. An effective SCM system is not a single activity but a comprehensive framework of interconnected processes (Asgari et al., 2016). For clarity, these processes can be grouped into three key stages: the upstream activities of planning and sourcing; the physical journey of the product through logistics and storage; and the downstream, customer-facing activities that ensure market success.

A strong supply chain begins with smart planning and sourcing. It uses Supply chain information technology, which includes tools like computers, software, and the internet. This technology helps gather and analyze information, allowing everyone in the chain to see what's happening and make better decisions (Kumar et al., 2020). This data-driven approach also helps with Procurement and manufacturing, which is about getting the right supplies and preparing the product. The goal isn't just to find the cheapest supplier. It's also to build strong relationships with reliable partners who can ensure a steady supply of high-quality materials. All of these early activities are brought together through Integrated Operations Planning. This simply means making sure everyone is working from the same game plan, so that what is grown on the farm matches what the market actually wants.

After the bananas are harvested, their physical journey becomes the main focus. The overall plan for this journey is called Logistics. A key part of this is Transportation, which is the actual movement of the bananas using the most efficient routes and reliable delivery services. For perishable crops like bananas, these functions are critical to maximizing revenue and minimizing losses (Bhatia and Bhat, 2020). Proper Warehousing, Material Handling, and Packaging are also vital. This means storing bananas in the right facilities, moving them carefully to prevent damage, and using good packaging to protect them. At the same time, managing Inventory, or the amount of stock on hand, is a major challenge. Farmers have to find the right balance. Having too much stock leads to spoilage, while having too little means missing out on sales.

In the end, the customer decides if the supply chain is successful. This is where Customer Accommodation comes in. This is about reliably meeting customer orders and having products available when they are needed. This is strengthened by good Relationship Management, which focuses on building long-term trust and loyalty with buyers through clear communication and great service (Reklitis et al., 2021). All of these components must work together seamlessly, from technology and planning to transport and customer service.

The effectiveness of these practices is measured by supply chain performance. This study assesses performance across three key dimensions. Flexibility Performance measures the ability to respond to disruptions and demand variations (Yadav et al., 2021; Ramos et al., 2023). Resource Performance evaluates the efficiency of cost management. Finally, Output Performance assesses the results in terms of sales, order fulfillment, and customer service.

However, significant problems arise when these components are ineffectively managed, leading to widespread inefficiencies and losses. While many studies have reviewed SCM challenges (Gera et al., 2022), they often focus on different industries or are not specific to the local Philippine context. For example, issues like slowed digital transformation and management of conventional inventory strategies are known as prime challenges in agri-food supply chains (Khandelwal et al., 2021). Yet, how these challenges manifest in a specific local context like Nueva Ecija, Philippines, and how they interact with local practices and performance, remains an area that is not yet fully understood.

Given the critical importance of each component and the severe consequences of its failure, a thorough analysis of an existing supply chain was imperative for the Philippine banana industry's continued success. The lack of a detailed, localized understanding represented a significant research gap. Therefore, this study aimed to analyze the supply chain management of the banana industry in Nueva Ecija. It described the profile of the industry, assessed the current state of its supply chain components, and evaluated its performance to identify key challenges and opportunities for improvement. This provides useful knowledge for local farmers and policymakers, and adds to the broader understanding of agricultural SCM in developing countries.

2. Materials and methods

This study employed a descriptive survey design, a quantitative method that involves administering a questionnaire to a sample to describe the attitudes, opinions, behaviors, or characteristics of a population (Creswell and Creswell, 2018). This approach was selected to describe the prevailing conditions of the Supply Chain Management (SCM) within the banana industry in Nueva Ecija, Philippines. The research was conducted across selected municipalities in Nueva Ecija (Fig. 1). Based on Department of Agriculture records, a total of 53 banana farm agribusinesses were identified as respondents, yielding a 100% response rate for the study. The primary instrument was a researcher-made questionnaire that underwent expert validation for content and reliability testing. Reliability was established via a pre-test with 10 respondents, yielding Cronbach's alpha coefficients that indicated excellent internal consistency for the supply chain management section ($\alpha = 0.964$) and good consistency for the supply chain performance

section (α = .873). The validated instrument was composed of three parts: the first profiled the respondents and their business operations; the second assessed supply chain management practices on a four-point scale ('Strongly Agree' to 'Disagree'); and the third measured supply chain performance, also on a four-point scale ('Extremely Better' to 'Disagree').

Prior to data gathering, formal permissions were secured, and informed consent was obtained from all participants. The questionnaires were personally administered by the researcher from January to August 2023, who provided clarification when necessary, and were collected upon completion. The collected data were subsequently analyzed using descriptive statistics. Frequency and percentage were used to summarize respondent profiles, while weighted mean and standard deviation were used to determine the assessed levels of supply chain management practices and performance. Interpretation of the mean scores was guided by the verbal descriptions accompanying the scales.

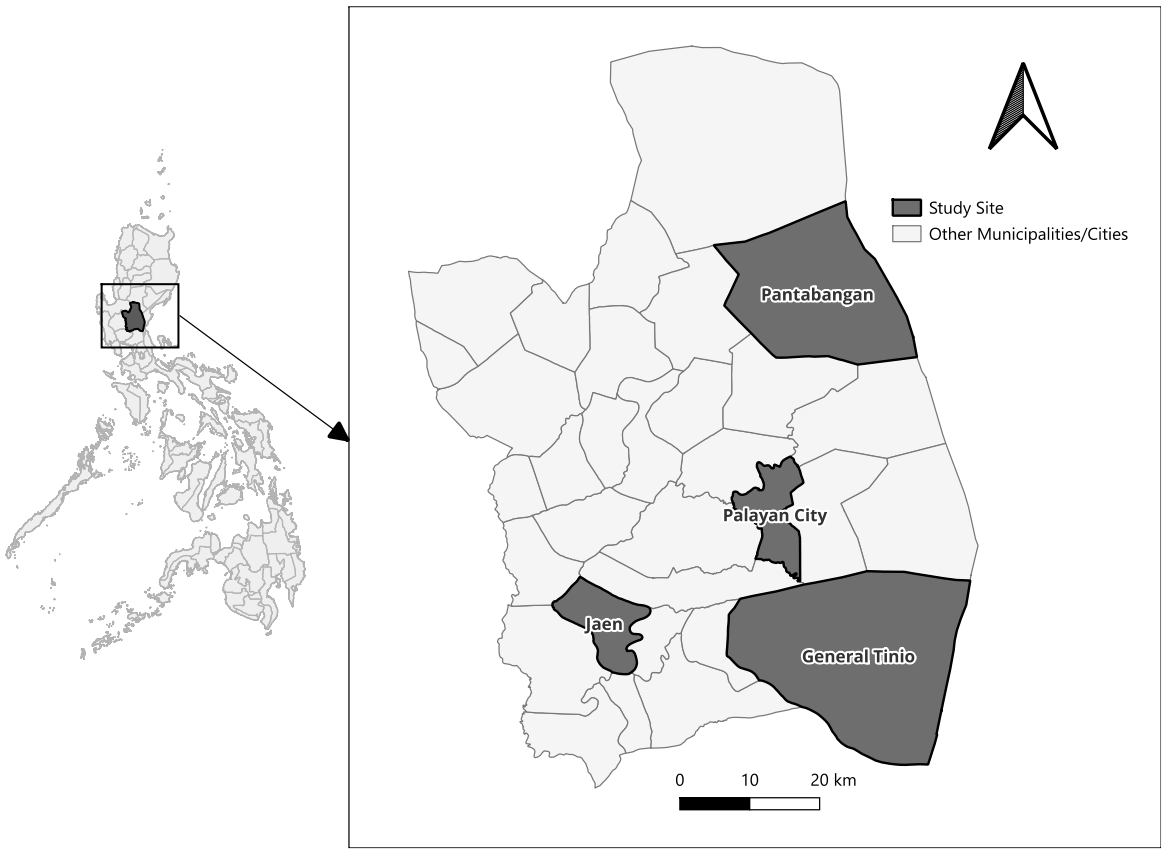

Fig. 1: Map of the study area

3. Results

3.1. Profile of the banana industry in Nueva Ecija

Table 1 presents the business profile of the banana enterprises in Nueva Ecija. As shown, all of the respondents (100%) operate as sole proprietorships, indicating that the industry is dominated by individually owned businesses. The majority of the enterprises (90.57%) are classified as micro enterprises, while only a small proportion (9.43%) fall under the small enterprise category. In terms of capital sources, nearly half of the respondents (49.06%) rely on personal savings, whereas slightly more than half (50.94%) obtain their capital through bank loans. Most of the enterprises (90.57%) have been operating for less than ten years, suggesting that the industry is relatively young. Furthermore, the majority of the businesses (92.45%) employ fewer than ten workers, reflecting their small-scale nature. With regard to annual revenue, most enterprises reported earnings below ₱800,000, with the largest proportion (43.40%) generating between ₱250,000 and ₱400,000 annually.

Table 2 presents the profile of the farmers/owners of banana enterprises. The majority of the respondents belong to the 41–50 age group (54.72%), followed by those aged 31–40 (33.96%). In terms of sex, the industry is predominantly male-dominated (92.45%). With respect to civil status, most of the respondents are single (94.34%), while only a small proportion are married (5.66%). In terms of educational attainment, a large majority (88.68%) reached secondary level, while only a few attained elementary education (7.55%) or short-term diploma courses (3.77%). None of the respondents reported having a bachelor's degree or higher educational qualifications. Regarding work experience, more than half of the respondents (54.72%) have been engaged in banana farming for 10 to 20 years, while 43.40 percent have less than 10 years of experience. In terms of monthly income, the largest proportion of respondents (37.74%) earn

less than PHP 9,100, while only 7.55 percent earn between PHP 36,401 and PHP 63,700. No respondents reported income beyond PHP 63,700.

Table 1: Profile of the business (N = 53)

Variables	Sub–variables	Frequency	Percentage
Type of ownership	Sole proprietorship	53	100.00
	Partnership	0	0.00
	Corporation	0	0.00
	Cooperative	0	0.00
Capitalization	Micro: Not more than P3,000,000	48	90.57
	Small: P3,000,001 – P15,000,000	5	9.43
	Medium: P15,000,001 – P100,000,000	0	0.00
Source of capitalization	Personal savings	26	49.06
	Bank loan	27	50.94
	Other non-banking financial institutions (lending)	0	0.00
	Microfinance	0	0.00
	Cooperatives	0	0.00
Years in operation	Less than 10	48	90.57
	10 – 20	5	9.43
	21 – 30	0	0.00
	31 years and above	0	0.00
Number of employees	less than 10	49	92.45
	10-99	4	7.55
	100-199	0	0.00
	200 or more	0	0.00
Annual revenue in Philippine Peso	250,000.00 and below	18	33.96
	More than 250,000.00 to 400,000.00	23	43.40
	More than 400,000.00 to 800,000.00	12	22.64
	More than 800,000.00 to 2,000,000.00	0	0.00
	More than 2,000,000 to 8,000,000.00	0	0.00
	More than 8,000,000.00	0	0.00

Table 3 presents the findings on Supply Chain Information Technology, where farmers moderately agreed with the statements overall, as shown by a grand mean of 1.84. As can be seen, respondents disagreed that their farm has enough hardware and software through a supply chain to gather, analyze, and execute information (M = 1.62, SD = 0.66).

However, they moderately agreed that their farm utilizes information technology to capture and analyze information necessary to make a decision (M = 1.94, SD = 0.89). Moderate agreement was also observed for their farm using information technology to analyze information that serves as a basis for action and recommendation (M = 1.75, SD = 0.83). In contrast, they disagreed that their farm uses information technology to set production schedules and to identify inventory levels (M = 1.74, SD = 0.71). They moderately agreed that their farm has accurate, accessible information in a timely manner (M = 1.81, SD = 0.59).

3.2. Supply chain management of the banana industry in Nueva Ecija

Moderate agreement continued for their farm setting information on harvesting schedules to determine product distribution (M = 1.83, SD = 0.75). They also moderately agreed that their farm collects detailed historical demand, cost, margin, and retailers' information (M = 1.85, SD = 0.74). Moderate agreement was found for their farm using information to tightly integrate its operations with marketing intermediaries (M = 1.75, SD = 0.81). Furthermore, respondents moderately agreed that their farm collects information regarding changes of production, prices, quality, and delivery lead time for sourcing decisions (M = 2.09, SD = 0.86). Finally, they moderately agreed that their farm has detailed information on costing and revenue management according to demand fluctuation (M = 2.04, SD = 0.81).

Table 2: Profile of the farmers/owners (N = 53)

Variables	Sub–variables	Frequency	Percentage
Age	less than 30	6	11.32
	31 – 40	18	33.96
	41 – 50	29	54.72
	51 and above	0	0.00
Sex	Male	49	92.45
	Female	4	7.55
Civil status	Single	50	94.34
	Married	3	5.66
	Widow/er	0	0.00
	Separated	0	0.00
	Preferred not to disclose	0	0.00
Education	Elementary	4	7.55
	Secondary	47	88.68
	Short-term diploma courses	2	3.77
	Bachelor's degree	0	0.00
	with MA units	0	0.00
	Master's degree	0	0.00
	with Doctorate units	0	0.00
	Doctorate degree	0	0.00
Experience	less than 10 years	23	43.40
	10 – 20 years	29	54.72
	21 – 30 years	1	1.89
	31 – 40 years	0	0.00
	41 – above years	0	0.00
Monthly income in Philippine Peso	Less than PHP 9,100	20	37.74
	9,100 to 18,200	12	22.64
	18,201 to 36,400	17	32.08
	36,401 to 63,700	4	7.55
	63,701 to 109,200	0	0.00
	109,201 to 182,000	0	0.00
	At least 182,001	0	0.00

Table 4 details the respondents' assessment of their logistics management practices, which were generally agreed upon, as reflected in an overall grand mean of 2.58. The analysis of individual statements began with strategic procurement of raw materials and capital equipment, where agreement was observed (M = 2.57, SD = 0.57). Farmers similarly indicated agreement regarding integrating supply chain activities for competitive advantage (M = 2.55, SD = 0.64) and ensuring timely and efficient delivery of goods (M = 2.58, SD = 0.57). The perception of logistics as an integral part of the supply chain process also received agreement (M = 2.60, SD = 0.57), as did the notion that logistics contribute to improving production standards (M = 2.45, SD = 0.57). Moving to the subsequent statements, the highest level of agreement was reported for focusing on core logistics activities, such as customer service, transportation, and inventory management (M = 2.72, SD = 0.53). Agreement continued with the execution of a customer-focused strategy (M = 2.60, SD = 0.57) and the employment of structured decision-making processes (M = 2.68,

SD = 0.55). The final items showed consistent agreement for the use of integrated tracking systems for coordination (M = 2.51, SD = 0.58) and following strategic planning for on-time delivery (M = 2.58, SD = 0.57). Table 5 presents the findings on customer accommodation, where farmers moderately agreed with the statements overall, as shown by a grand mean of 2.47. As can be seen, respondents agreed that their farm has a customer-focused marketing approach (M = 2.68, SD = 1.01). However, they moderately agreed that their farm understands customer satisfaction and success (M = 2.28, SD = 1.08) and demonstrates a customer accommodation strategy (M = 2.40, SD = 1.17). They also agreed that their farm facilitates customer service concerning stock availability, fill rate, and order shipment (M = 2.66, SD = 1.09). Similarly, they agreed that their farm performs service reliability according to customer orders and related activities (M = 2.58, SD = 1.22) and that their farm is committed to all customer levels in terms of availability, operational performance, and reliability (M = 2.60, SD = 1.15). In contrast, respondents moderately agreed that their farm assures customer satisfaction based on logistic expectations (M = 2.45, SD = 1.05). They also moderately agreed that their farm meets the expectations of their customers (M = 2.47, SD = 1.07), meets customer requirements (M = 2.25, SD = 1.00), and meets internal standards for customer service (M = 2.34, SD = 1.11).

Table 3: Supply chain management of the banana industry in Nueva Ecija in terms of supply chain information technology

Supply chain information technology	Mean	SD	Verbal description
Our farm has enough hardware and software through a supply chain that gathers, analyzes, and executes information.	1.62	0.66	Disagree
Our farm utilizes information technology to capture and analyze information necessary to make a decision.	1.94	0.89	Moderately agree
Our farm uses information technology to analyze information that serves as the basis for action and recommendations.	1.75	0.83	Moderately agree
Our farm uses information technology to set production schedules and to identify inventory levels.	1.74	0.71	Disagree
Our farm has accurate, accessible information in a timely manner.	1.81	0.59	Moderately agree
Our farm sets information on the harvesting schedule to determine where to distribute the product in different docking facilities.	1.83	0.75	Moderately agree
Our farm collects detailed historical demand, cost, margin, and retailers' information to determine the carrying cost, cost of stocking out, and cost of ordering.	1.85	0.74	Moderately agree
Our farm uses information to tightly integrate its operations with different marketing intermediaries to implement a smooth network that can save both inventory and transportation costs.	1.75	0.81	Moderately agree
Our farm collects information regarding changes in production, prices, quality, and delivery lead time, which is important in making sourcing decisions.	2.09	0.86	Moderately agree
Our farm has detailed information on costing and revenue management according to the fluctuation of demand based on different customer segments.	2.04	0.81	Moderately agree
Total	1.84	0.29	Moderately agree

Table 4: Supply chain management of the banana industry in Nueva Ecija in terms of logistics

Logistics	Mean	SD	Verbal description
Our farm is strategically procuring the right raw materials and capital equipment for farming efficiently and to dispatch quality products.	2.57	0.57	Agree
Our farm integrates activities associated with the flow and transformation of goods from raw materials through end users' information flows, through improved supply chain relationships to achieve sustainable competitive advantage.	2.55	0.64	Agree
Our farm gets the right goods or services to the right supplier, at the right time, and in the desired condition, at the lowest cost and highest return on investment.	2.58	0.57	Agree
Our farm considers logistics as an integral part of the entire supply chain process.	2.60	0.57	Agree
The logistic factor of our farm is a key to increasing and improving the standard of production.	2.45	0.57	Agree
The primary key activities/processes of our farm are meeting customer service goals, transportation, inventory management, and determining strategic location.	2.72	0.53	Agree
The logistic strategy of our farm is well executed to achieve customer goals.	2.60	0.57	Agree
Our Farm uses a strategic, tactical, and operational decision-making process.	2.68	0.55	Agree
Our Farm uses integrated logistics systems for tracking and coordinating to function effectively.	2.51	0.58	Agree
Our Farm follows marketing logistics objectives for strategic logistics planning and on-time delivery of the products.	2.58	0.57	Agree
Total	2.58	0.32	Agree

Table 6 presents the findings on Integrated Operations Planning, where farmers disagreed with the statements overall, as shown by a grand mean of 1.62. As can be seen, respondents disagreed that their farm has supply chain visibility to track inventory and resources (M = 1.43, SD = 0.50). They also disagreed that their farm requires exception management for potential problems (M = 1.49, SD = 0.50) or has simultaneous resource consideration for demand, capacity, and material requirements (M = 1.42, SD = 0.50). Furthermore, respondents disagreed that their farm utilizes a management system in information technology for S&OP (M = 1.38, SD = 0.49) or develops forecasts used in supply chain processes to anticipate sales levels (M = 1.57, SD = 0.50). In contrast, they moderately agreed that their farm enables the identification of trade-offs that can increase functional costs but lower total system costs (M = 2.15, SD = 0.69).

However, they disagreed that their farm's production planning uses demand management to develop a realistic manufacturing plan (M = 1.47, SD = 0.50). Disagreement was also noted for their farm's logistics planning, integrating movement demand, vehicle availability, and transportation cost to minimize overall freight expense (M = 1.58, SD = 0.50). Finally, respondents moderately agreed that their farm uses forecasting to determine production and inventory levels (M = 1.89, SD = 0.85) and that the sales and operations planning integrates

information systems and organizational processes (M = 1.87, SD = 0.76). Table 7 presents the findings on Procurement and Manufacturing, where farmers moderately agreed with the statements overall, as shown by a grand mean of 2.06. As can be seen, respondents moderately agreed that their farm obtains desired resources at the lowest possible purchase price from suppliers (M = 1.98, SD = 0.82). They also moderately agreed that the goals of their farm in procurement are to maintain supply continuity with minimum inventory (M = 2.36, SD = 0.79). Moderate agreement was noted for the statement that the quality of finished goods and services is dependent upon the quality of the banana tree (M = 2.00, SD = 0.85). Furthermore, they moderately agreed on identifying suppliers as sources of innovation and technology (M = 2.11, SD = 0.67) and that the simplest procurement approach is to allow users to determine their own purchase needs (M = 2.15, SD = 0.86).

Table 5: Supply chain management of the banana industry in Nueva Ecija in terms of customer accommodation

Customer accommodation	Mean	SD	Verbal description
Our farm has a customer-focused marketing.	2.68	1.01	Agree
Our farm understands customer satisfaction and success.	2.28	1.08	Moderately agree
Our farm demonstrates a customer accommodation strategy.	2.40	1.17	Moderately agree
Our farm facilitates customer service in terms of availability of stock, fill rate, and order shipping.	2.66	1.09	Agree
Our farm performs service reliability according to customer orders and related activities.	2.58	1.22	Agree
Our farm is committed to all customer levels in terms of availability, operational performance, and reliability.	2.60	1.15	Agree
Our farm assures customer satisfaction based on logistic expectation are reliability, responsiveness, access, communication, credibility, security, courtesy, and competency.	2.45	1.05	Moderately agree
Our farm meets the expectations of our customers.	2.47	1.07	Moderately agree
Our farm meets customer requirements.	2.25	1.00	Moderately agree
Our farm meets internal standards for customer service.	2.34	1.11	Moderately agree
Total	2.47	0.40	Moderately agree

Table 6: Supply chain management of the banana industry in Nueva Ecija in terms of integrated operations planning

Integrated operations planning	Mean	SD	Verbal description
The supply chain visibility of our farm has the ability to track inventory and resources.	1.43	0.50	Disagree
Our farm requires exception management of potential problems as they are identified.	1.49	0.50	Disagree
Our farm has simultaneous resource consideration to include demand capacity, material requirements, and constraint-defining alternatives.	1.42	0.50	Disagree
Our farm enables the identification of trade-offs that can increase functional costs but lower total system costs.	2.15	0.69	Moderately agree
Our farm utilizes a management system in information technology for identifying the sales and operations planning (S&OP) process.	1.38	0.49	Disagree
Our farm develops the forecasts used in the supply chain processes to anticipate sales levels.	1.57	0.50	Disagree
Our farm uses forecasting to determine production and the amount of inventory to hold.	1.89	0.85	Moderately agree
The production planning of our farm uses requirements from demand management to develop a realistic manufacturing plan.	1.47	0.50	Disagree
The logistics planning of our farm integrates an overall movement demand, vehicle availability, and relevant transportation cost as a vital consideration to minimize overall freight expense.	1.58	0.50	Disagree
The sales and operations planning of our farm integrates the combination of information systems and organizational processes.	1.87	0.76	Moderately agree
Total	1.62	0.19	Disagree

Table 7: Supply chain management of the banana industry in Nueva Ecija in terms of procurement and manufacturing

Procurement and manufacturing	Mean	SD	Verbal description
Our farm obtains the desired resource at the lowest possible purchase price from suppliers.	1.98	0.82	Moderately agree
The goals of our farm in terms of procurement are to maintain supply continuity with the minimum investment in inventory possible.	2.36	0.79	Moderately agree
The quality of finished goods and services of our farm is dependent upon the quality of the banana tree.	2.00	0.85	Moderately agree
Our farm identifies suppliers as sources of innovation and technology to perpetuate high quality of output.	2.11	0.67	Moderately agree
The simplest approach of our farm in terms of procurement is to allow users in the organization to determine their own purchase needs, evaluate sources of supply, and execute the purchasing process.	2.15	0.86	Moderately agree
Our farm considers important steps in developing an effective procurement strategy by reducing the number of suppliers.	1.87	0.86	Moderately agree
Our farm integrates processes and activities as an attempt to achieve substantial performance improvement.	1.91	0.88	Moderately agree
Our farm typically purchases items that involve a low percentage of marginal cost and involve a very small supply risk.	2.17	0.83	Moderately agree
Our farm identifies a unique procurement problem, items that involve a small percentage of the firm's spend, supply risk, and lack of availability, which can cause significant operational problems for the buyer.	2.09	0.77	Moderately agree
Our farm involves a little supply risk; the items are general commodities where many alternatives exist.	1.92	0.83	Moderately agree
Total	2.06	0.27	Moderately agree

Moving to the latter items, respondents moderately agreed that their farm considers reducing the number of suppliers in developing an effective procurement strategy (M = 1.87, SD = 0.86). They also moderately agreed on integrating processes and activities as an attempt to achieve substantial performance improvement (M = 1.91, SD = 0.88). Moderate agreement was expressed for their farm typically purchasing items that involve a low percentage of marginal cost and little supply risk (M = 2.17, SD = 0.83). Finally, respondents moderately agreed on identifying unique procurement problems involving small spend and lack of availability (M = 2.09, SD = 0.77), and that their farm's items are general commodities with little supply risk (M = 1.92, SD = 0.83).

Table 8 presents the findings on Inventory, where farmers disagreed with the statements overall, as shown by a grand mean of 1.74. As can be seen, respondents disagreed that their farm's inventory

management focuses on inventory risk (M = 1.70, SD = 0.67). They also disagreed that their farm identifies the geographical location among distributors (M = 1.62, SD = 0.69) or allows economies of scale within a single facility to operate at maximum efficiency (M = 1.74, SD = 0.68).

Table 8: Supply chain management of the banana industry in Nueva Ecija in terms of inventory

Inventory	Mean	SD	Verbal description
The inventory management our farm focuses on inventory risk, which varies depending on the situation in the distribution channel.	1.70	0.67	Disagree
Our farm identifies the geographical location among distributors and other enterprises.	1.62	0.69	Disagree
Our farm allows economies of scale within a single facility and permits each process to operate at maximum efficiency rather than having the speed of the entire process, which can increase the marginal cost.	1.74	0.68	Disagree
Our farm provides enough time for monitoring the inventory availability (manufacturing, growing, or extraction) and consumption.	1.94	0.69	Moderately agree
Our farm accommodates uncertainty related to demand in consideration of forecasted or expected delays in order receipts and order processing for delivery.	1.81	0.71	Moderately agree
Our farm maintains an average inventory for work-in-process and volume of output within the logistic system.	1.74	0.68	Disagree
Our farm monitors inventory carrying costs to avoid potential losses.	1.87	0.62	Moderately agree
Our farm considers the historical demand trend as a basis for anticipating the market demand.	1.68	0.67	Disagree
The inventory management of our farm serves as the basis of our inventory policy.	1.64	0.71	Disagree
Our farm considers the demand of the end-users to identify the derived demand of the entire supply chain.	1.70	0.67	Disagree
Total	1.74	0.39	Disagree

In contrast, farmers moderately agreed that their farm provides enough time for monitoring inventory availability and consumption (M = 1.94, SD = 0.69). They also moderately agreed that their farm accommodates uncertainty related to demand in consideration of forecasted delays (M = 1.81, SD = 0.71).

However, respondents disagreed that their farm maintains average inventory for work-in-process and volume of output within the logistic system (M = 1.74, SD = 0.68). Moderate agreement was expressed for their farm monitoring inventory carrying cost to avoid potential losses (M = 1.87, SD = 0.62). Finally, respondents disagreed that their farm considers the historical demand trend as a basis for anticipating market demand (M = 1.68, SD = 0.67), that inventory management serves as the basis of their inventory policy (M = 1.64, SD = 0.71), and that their farm considers the demand of end-users to identify derive-demand for the entire supply chain (M = 1.70, SD = 0.67).

Table 9 presents the findings on Transportation, where farmers agreed with the statements overall, as shown by a grand mean of 2.87. As can be seen, respondents agreed that their farm provides a transportation network (M = 2.87, SD = 0.83). They also agreed that their farm selects the most efficient shipping routes (M = 2.74, SD = 0.81) and tracks the performance of transportation providers (M = 2.91, SD = 0.79).

Table 9: Supply chain management of the banana industry in Nueva Ecija in terms of transportation

Transportation	Mean	SD	Verbal description
Our farm provides a transportation network.	2.87	0.83	Agree
Our farm selects the most efficient shipping routes.	2.74	0.81	Agree
Our farm tracks the performance of transportation providers.	2.91	0.79	Agree
Our farm works with reliable transportation providers.	2.83	0.75	Agree
Our farm uses transportation to enhance customer service.	3.09	0.77	Agree
Our farm utilizes the supply chain technology.	2.85	0.77	Agree
Our farm uses transportation to bypass geographical limitations.	2.75	0.81	Agree
Our farm divides shipments based on priority.	2.98	0.80	Agree
Our farm uses various modes of transportation to deliver products on time.	2.77	0.78	Agree
Our farm uses multimodal transportation to expand accessibility.	2.87	0.81	Agree
Total	2.87	0.31	Agree

Agreement was noted for their farm working with reliable transportation providers (M = 2.83, SD = 0.75). A high level of agreement was found for their farm using transportation to enhance customer service (M = 3.09, SD = 0.77), which was the highest mean in this section.

The findings further showed agreement that their farm utilizes supply chain technology (M = 2.85, SD = 0.77) and uses transportation to bypass geographical limitations (M = 2.75, SD = 0.81). Respondents agreed that their farm divides shipments based on priority (M = 2.98, SD = 0.80) and uses various modes of transportation to deliver products on time (M = 2.77, SD = 0.78). Finally, agreement was expressed for their farm using multi-modal transportation to expand accessibility (M = 2.87, SD = 0.81).

Table 10 presents the findings on Warehousing, Material Handling, and Packaging, where farmers moderately agreed with the statements overall, as shown by a grand mean of 2.04. As can be seen, respondents moderately agreed that their farm conducts site selection to identify both the general area and the specific warehouse location (M = 2.00, SD = 0.76). They also moderately agreed that their farm considers warehouse design to include facilities and product flow characteristics (M = 2.19, SD = 0.81).

Moderate agreement was noted for their farm conducting product mix analysis for products to be distributed (M = 2.02, SD = 0.80) and that the handling system is the basic foundation of warehouse design for efficient storage (M = 2.00, SD = 0.83). Furthermore, they moderately agreed that

their farm uses mechanized systems employing various handling equipment (M = 1.98, SD = 0.82).

Moderate agreement was found for their farm using automated systems for faster and more accurate operations (M = 2.11, SD = 0.87). However, they also moderately agreed that their farm has automated storage/retrieval for unit load handling (M = 1.92, SD = 0.83). Respondents moderately agreed that their farm uses packaging design for efficient handling (M = 2.17, SD = 0.83) and uses unitization for segmenting product types into one physical unit for proper handling (M = 2.04, SD = 0.85). Finally, moderate agreement was expressed for their farm having communication for content identification, tracking, and handling instructions (M = 1.98, SD = 0.87).

Table 10: Supply chain management of the banana industry in Nueva Ecija in terms of warehousing, material handling, and packaging

Warehousing, material handling, and packaging	Mean	SD	Verbal description
Our farm conducts site selection to identify both the general area and the specific warehouse location.	2.00	0.76	Moderately agree
Our farm considers the warehouse design to include facilities, a cube utilization plan for product flow, and movement characteristics.	2.19	0.81	Moderately agree
Our farm conducts product mix analysis that will be distributed in the warehouse for product annual demand and storage processes.	2.02	0.80	Moderately agree
The handling system of our farm is the basic foundation of warehouse design for an appropriate structure and design to facilitate efficient product storage.	2.00	0.83	Moderately agree
Our farm uses mechanized systems that employ a wide range of handling equipment such as lift trucks, towlines, tractor-trailer devices, conveyors, and carousels.	1.98	0.82	Moderately agree
Our farm uses automated systems to operate faster for more accurate, less product damage.	2.11	0.87	Moderately agree
Our farm has an automated storage/retrieval unit load handling system.	1.92	0.83	Moderately agree
Our farm uses packaging design for handling packaging efficiently.	2.17	0.83	Moderately agree
Our farm uses unitization for segmenting the type and variety into one physical unit for proper handling.	2.04	0.85	Moderately agree
Our farm has communication or information transfer for content identification, tracking information, handling instructions, and information essential for security.	1.98	0.87	Moderately agree
Total	2.04	0.24	Moderately agree

Table 11 presents the findings on Relationship Management, where farmers moderately agreed with the statements overall, as shown by a grand mean of 1.96. As can be seen, respondents moderately agreed that their farm includes processes between the enterprise and its customers downstream in the supply chain (M = 1.98, SD = 0.87). They also moderately agreed that their farm has an order management process to facilitate customer orders (M = 2.09, SD = 0.84) and a call/service center as the primary point of contact (M = 2.06, SD = 0.82).

Table 11: Supply chain management of the banana industry in Nueva Ecija in terms of relationship management

Relationship management	Mean	SD	Verbal description
Our farm includes processes that take place between the enterprise and its customers downstream in the supply chain.	1.98	0.87	Moderately agree
Our farm has an order management process to facilitate customer orders and execute order fulfillment.	2.09	0.84	Moderately agree
Our farm has a call/service center, which serves as the primary point of contact between the company and the customer.	2.06	0.82	Moderately agree
Our farm helps customers place orders, suggest products, solve problems, and provides information on order status.	1.92	0.81	Moderately agree
Our farm addresses customer needs when using online or web-based applications.	1.96	0.85	Moderately agree
Our farm enables businesses to make informed decisions using intelligence gleaned from customers.	1.83	0.78	Moderately agree
Our farm provides records of work in progress and reports on customer service functions.	2.00	0.85	Moderately agree
Our farm helps the management improve customer performance and take steps to improve performance.	1.74	0.84	Disagree
Our farm allows us to create closer and more intimate customer relationships.	2.08	0.83	Moderately agree
Our farm builds greater customer satisfaction and loyalty, which in turn boosts customer retention.	1.96	0.71	Moderately agree
Total	1.96	0.24	Moderately agree

Moderate agreement was found for their farm helping customers with orders, suggestions, problem-solving, and status information (M = 1.92, SD = 0.81) and addressing customer needs using online or web-based applications (M = 1.96, SD = 0.85). Furthermore, they moderately agreed that their farm enables informed decisions using customer intelligence (M = 1.83, SD = 0.78) and provides records of work in progress and customer service functions (M = 2.00, SD = 0.85).

In contrast, respondents disagreed that their farm helps the management of customer performance and takes steps to improve it (M = 1.74, SD = 0.84). However, they moderately agreed that their farm allows for creating closer and more intimate customer relationships (M = 2.08, SD = 0.83) and builds greater customer satisfaction and loyalty (M = 1.96, SD = 0.71).

3.3. Supply chain performance of the banana industry in Nueva Ecija

Table 12 presents the findings on Supply Chain Performance, which is divided into three components: Flexibility, Resource, and Output Performance. The first component, Flexibility Performance, was rated as Better overall, with a grand mean of 2.56. As can be seen, respondents rated their farm's ability to accommodate demand variations as Better (M = 2.58, SD = 0.50). Their ability to accommodate poor manufacturing performance was also rated as Better (M = 2.55, SD = 0.50), as was their ability to accommodate poor supplier performance (M = 2.60, SD = 0.49). In contrast, their ability to accommodate poor delivery performance was rated as Moderately Better (M = 2.49, SD = 0.50). Finally, their ability to

accommodate new products, markets, or competitors was rated as Better (M = 2.58, SD = 0.50). The second component, Resource Performance, was rated as Moderately Better overall, with a grand mean of 2.48. As can be seen, the total cost of resources used was rated as Moderately Better (M = 2.45, SD = 0.50). The total cost of distribution (M = 2.42, SD = 0.50) and the cost associated with held inventory (M = 2.42, SD = 0.50) were also rated as Moderately Better. In contrast, the total cost of manufacturing (M = 2.57, SD = 0.50) and the return on investment (M = 2.57, SD = 0.50) were both rated as Better.

The final component, Output Performance, received a very positive assessment, rated as Better overall with a high grand mean of 3.12. As can be seen, all seven indicators in this section were rated as Better. This includes the capacity to maintain the level of sales (M = 3.08, SD = 0.78) and the capacity to maintain the order fill rate (M = 3.11, SD = 0.72). The capacity to deliver on time (M = 3.04, SD = 0.81) also received a better rating. Respondents rated their farm's capacity to answer customer queries on time highly (M = 3.19, SD = 0.68), as well as their capacity to handle shipping errors (M = 3.11, SD = 0.80).

Finally, the capacity to produce the target volume on time (M = 3.06, SD = 0.77) and the capacity for handling customer complaints (M = 3.23, SD = 0.75) were also rated as Better.

Table 12: Supply chain performance of the banana industry in Nueva Ecija

Performance dimension	Indicators	Mean	SD	Verbal description
Flexibility performance	Ability to respond to and accommodate demand variations, such as seasonality	2.58	0.50	Better
	Ability to respond to and accommodate the periods of poor manufacturing performance, such as machine breakdown	2.55	0.50	Better
	Ability to respond to and accommodate the periods of poor supplier performance	2.60	0.49	Better
	Ability to respond to and accommodate the periods of poor delivery performance	2.49	0.50	Moderately better
	Ability to respond to and accommodate new products, new markets, or new competitors	2.58	0.50	Better
	Total	2.56	0.24	Better
Resource performance	Total cost of resources used	2.45	0.50	Moderately better
	Total cost of distribution, including transportation and handling costs	2.42	0.50	Moderately better
	Total cost of manufacturing, including labor, maintenance, and rework costs	2.57	0.50	Better
	Cost associated with held inventory	2.42	0.50	Moderately better
	Return on investment	2.57	0.50	Better
	Total	2.48	0.21	Moderately better
Output performance	Capacity to maintain the level or volume of sales	3.08	0.78	Better
	Capacity to maintain the order fill rate	3.11	0.72	Better
	Capacity to deliver on time	3.04	0.81	Better
	The capacity to answer the queries of the customer on time	3.19	0.68	Better
	Capacity to handle shipping Errors	3.11	0.80	Better
	Capacity to produce the target volume on time	3.06	0.77	Better
	Capacity for handling customer complaints	3.23	0.75	Better
	Total	3.12	0.32	Better

4. Discussion

The study on the banana industry in Nueva Ecija shows a clear difference between the strengths in daily operations and weaknesses in overall planning. The farmers surveyed mostly run small, independent businesses. They demonstrated strong skills in the hands-on parts of their supply chain, especially in Logistics and Transportation. This led to a very good Output Performance, meaning they were effective at delivering products and providing service. They also reported good Flexibility Performance, showing they could adapt to issues like changing demand or problems with suppliers. These strengths likely come from the farmers' many years of practical experience and the small-scale nature of their businesses. With most farmers having worked for over a decade, their decisions are often based on their experience, not always on formal, data-driven analysis (Šūmane et al., 2018). Their success also reflects an adaptive approach, as small farms often create their own ways of handling logistics to succeed without getting bigger. This focus on getting things done efficiently also matches findings in other Philippine supply chains, where making money is a main reason for decisions (Tan et al., 2025). This suggests farmers focus on the most important, cost-sensitive parts of their work to get their product to market.

However, despite these strong operational skills, the study found shortcomings in how farmers approach strategic planning and use information in their supply chains. There was general disagreement with good practices in both Integrated Operations Planning and Inventory management. These problems seem to come from not using enough information technology. Farmers reported not having enough 'hardware and software' and not using IT to plan production or track stock levels. This situation is made harder by the farmers' background: they run small businesses with low income and mostly secondary education. This means they likely lack money for technology and training, and may not see the need for complex planning tools. As a result, farmers tend to manage their businesses by reacting to what happens, rather than planning ahead based on what the market needs. This lack of clear planning and organized stock control directly explains why their Resource Performance was only moderately good. It suggests that inefficiencies and potential waste can increase costs for resources, distribution, and storing products. This problem is similar to what other studies have found about inefficiencies in supply chains that hurt small

farmers' long-term success, pointing to limited digital tools and money access as big barriers (Fernando et al., 2026). The fact that farmers don't use past sales to manage stock is especially worrying for bananas, which spoil quickly. This matches research showing that poor data and storage cause big losses after harvest. This situation highlights a gap between the government's plans for 'Agriculture 4.0' in the Philippines (Cordero and Park, 2023) and what is actually happening with small farmers. While new digital tools could help fix these problems (Quayson et al., 2020; Lubag et al., 2023), their actual use is held back by current economic and structural issues.

Finally, the study found a third set of practices that are moderately developed but not fully optimized. This includes Procurement and Manufacturing, Warehousing, Material Handling, and Packaging, Relationship Management, and Customer Accommodation. This shows that farmers are involved in these areas, but their methods are often informal and based on personal relationships, rather than being organized and highly efficient. For instance, in Relationship Management, farmers felt they had built close connections with customers. However, they disagreed that they had formal ways to measure or improve customer dealings. This means personal ties are more important than official performance checks. While these personal connections can offer stability, they might also make it harder for farmers to join bigger, modern supply chains that often have stricter rules and fewer personal interactions (KC et al., 2023). The informal nature of these practices also suggests that certain skills are not fully developed. These skills could be improved through group efforts like buying together or sharing storage facilities, which might help farmers save money and grow (Gold et al., 2026). This situation can lead to different goals between farmers and others in the supply chain, a problem also seen in other farming areas in the Philippines. This can ultimately limit farmers' access to better markets and earning potential (Tan et al., 2025).

These findings have important practical implications. For small banana farmers, even though their experience helps them operate well, they need easy-to-use tools and training. This would help them move from simply reacting to problems to actively planning their inventory and operations. Government and agencies like the Department of Agriculture need to recognize the difference between national plans for 'Agriculture 4.0' (Cordero and Park, 2023) and the reality for small businesses. Help should focus on affordable digital solutions, basic money management skills, and training in supply chain management that builds on their current strengths. Investing in important things like cold storage systems is also a practical step to reduce losses after harvest and increase the product's value. For other businesses involved, the study suggests working together with farmers. This means creating ways to include farmers in more organized supply chains. It also means respecting their current ways of working and helping with their specific problems.

Beyond practical concerns, this study adds significantly to the academic understanding of Supply Chain Management. The strong performance in Logistics and Transportation, driven by farmers' experience in a low-tech environment, offers a fresh perspective to current SCM theories. These theories often focus too much on advanced technology. The study shows that informal, experience-based SCM can indeed lead to good operations and high output. This challenges the idea that technology is always the main driver. Furthermore, the identified problems in planning and the moderate use of other practices highlight ongoing social and economic difficulties (Mina, 2023). These include not having enough money or education. These issues prevent farmers from fully using formal SCM methods in developing farming areas (Fernando et al., 2026). This supports the call for SCM models that are specific to the local situation. These models should also prioritize building skills in areas where resources are limited (Gold et al., 2026).

This study offers several important contributions. The local banana industry in Nueva Ecija, it provides clear, factual insights that can guide action. By clearly showing the operational strengths (like Logistics, Transportation, and strong Output Performance) and strategic weaknesses (such as in Integrated Operations Planning and Inventory), it gives a precise guide for groups like local government, extension services, and farmer cooperatives. This guide can help them plan specific actions to improve efficiency and reduce losses (Mina, 2023). For the academic field of Supply Chain Management, this study adds a key real-world view. It shows that even without advanced technology, strong operational results and high output can come from informal, experience-based SCM. This challenges the common idea in SCM theory that technology is always the main driving force. Instead, it highlights how practical knowledge and flexible strategies play a nuanced role in small-scale farming. It also helps us understand the social and economic challenges that stop formal SCM methods from being used in developing countries.

While providing valuable insights, the study has a few limitations to consider. First, the results come from only 53 banana farmers in four specific towns in Nueva Ecija. This means the findings might not apply to the entire banana industry in the Philippines or to other types of farming. Second, the study relied on farmers reporting their own practices. This self-reported information might be influenced by what they think researchers want to hear, or they might not fully be aware of their own methods. Based on these limits and what we learned, we suggest several areas for future research. To understand why strategic weaknesses exist, a deeper look using methods like in-depth interviews or group discussions with farmers and other people in the supply chain could be very helpful.

These low-technology environments need more exploration into how decisions are made. Also, studies that follow farmers over time (longitudinal studies) could show how SCM practices and performance change, especially after new programs or tools are introduced. Expanding the study to more banana-growing areas in the Philippines, or comparing it with other farm products, would help make the findings more widely applicable. Finally, research should look into how practical and affordable new SCM technologies or group efforts (like shared buying models) could actually benefit micro-enterprises in farming. This would give valuable advice for real-world improvements.

5. Conclusion

This study analyzed the supply chain management practices and performance of the banana industry in Nueva Ecija. The findings revealed a clear and consistent pattern: the surveyed banana farmers, operating as small-scale sole proprietorships, excel in the physical and operational execution of their supply chain but lack strength in strategic, information-driven planning. Their extensive practical experience results in strong performance in Logistics and Transportation, leading to high ratings for Output Performance and Flexibility Performance. However, this is contrasted by significant deficiencies in Integrated Operations Planning and Inventory management, which are rooted in limited technology adoption and resource constraints.

A critical gap exists between the farmers' practical capabilities and their adoption of formal, strategic SCM practices. While their experience makes them effective at the day-to-day tasks of getting products to market, their lack of systematic planning and inventory control likely leads to inefficiencies that suppress their profitability and limit their ability to scale. This informal, experience-driven approach, while a strength in some areas, represents a key vulnerability in a modernizing agricultural sector.

Based on these conclusions, targeted recommendations are proposed for various stakeholders. For farmers, it is essential to leverage their operational strengths by adopting simple, low-cost tools for inventory tracking and basic operational planning, and to explore cooperative models for purchasing and training. Policymakers and government agencies, such as the Department of Agriculture, should focus interventions on bridging the technology and planning gap by providing accessible training on SCM principles and supporting affordable digital solutions tailored for small-scale agriculture. Investments in crucial infrastructure like cold storage facilities are also recommended to mitigate post-harvest losses. Finally, for industry stakeholders and future researchers, there are opportunities for collaborative models that integrate smallholder farmers into structured supply chains, and for studies that quantify the cost-benefit of specific SCM technologies in this unique agricultural context.

List of abbreviations

α	Cronbach's alpha
DA	Department of Agriculture
ICT	Information and communication technology
IT	Information technology
M	Mean
N	Number of respondents
PHP	Philippine peso
ROI	Return on investment
SCM	Supply chain management
SD	Standard deviation
S&OP	Sales and operations planning

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Compliance with ethical standards

Ethical considerations

An ethical consideration in this study is ensuring the confidentiality and voluntary participation of all respondents, with informed consent obtained prior to data collection to protect the privacy and rights of banana farmers involved in the research.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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