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Supply Chain Analysis of Carabao Milk from Smallholder Farms in the Province of Nueva Ecija: Basis for Strategic Plan

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Abstract. The carabao milk supply chain in the Philippines remains underdeveloped, indicating a 45% decline in regional milk output from 1.26 to 1.04 thousand metric tons between 2022 and 2023 (PSA, 2023). In this context, the study aimed to profile smallholder farmers, analyze the factors influencing the supply chain, identify the challenges within the carabao milk supply chain, and propose a strategic plan for efficient and effective management. This research employed data collection through one-on-one interviews and analysis using frequency distribution and means to identify key factors and indicators affecting the overall supply chain. It reveals that smallholder carabao farmers is predominantly aging with limited youth involvement. The majority are married and have attained a high school level of education. Typically, they own only a few carabaos and belong to the low-income class. In terms of supply chain inputs, farmers strongly agree that they have adequate access to pasture, water, and veterinary services, but minimal in practicing grazing methods and concentrate feeding. Meanwhile, the overall production practices were rated lower than the average, with insufficient use of modern technologies and skilled laborer, despite recognizing feed quality as essential. Milk processing practices were relatively strong in hygiene standards, although on-site pasteurization is less commonly practiced. Accordingly, the distribution aspect showed mixed results, with delivery and logistics systems performing well, but access to markets and business engagement are limited. This underscores the need for stronger market linkages. Key issues includes limited feed resources, poor market access, lack of training, inefficient logistics, and low productivity. To address these gaps, a strategic plan is proposed, emphasizing improved resource management, milk quality enhancement, logistics upgrades, market expansion, and capacity building. These interventions aim to build a more resilient and competitive carabao milk supply chain, ultimately contributing to increased milk sufficiency and farmer livelihood in the Philippines.

Keywords: Carabao Milk Production; Carabao Milk Processing; Carabao Milk Distribution; Smallholder Farmers; Strategic Plan

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1. Introduction

Carabaos (Bubalus bubalis) have long supported smallholder farmers in the Philippines as draft animals and more recently as reliable sources of milk, meat, and by-products, offering both economic and nutritional benefits (Palacpac, 2022; Tsuji, 2021). Their adaptability to tropical climates makes them integral to the dairy sector, particularly in Central Luzon, which contributes nearly half of the national carabao milk production. However, recent reports indicate a 45% decline in regional milk output from 1.26 to 1.04 thousand metric tons between 2022 and 2023 (PSA, 2023), signaling systemic inefficiencies and challenges in the supply chain.

Nueva Ecija, a key player in the dairy buffalo sector, is dominated by smallholder, family-run farms facing challenges such as disease prevalence (e.g., mastitis), outdated management practices, and limited access to modern technologies (Waminal et al., 2021; Santos-Recto, 2018). Studies show that milk yield and quality are influenced by environmental and seasonal factors (Yilmaz et al., 2016), while inefficiencies among different farm categories—smallholder, family module, and semi-commercial—underscore the need for targeted improvements (Palacpac & Valiente, 2023).

Despite growing demand for carabao milk, market access remains difficult for smallholders due to fragmented supply chains, limited resources, and lack of infrastructure (Cruz & Dizon, 2023; Cabading et al., 2024). Socio-cultural dynamics also affect commercialization strategies, as seen in similar contexts abroad (Kembe et al., 2016). While international models highlight the value of cooperatives, digital innovation, and governance structures (Jachimczyk et al., 2021; Amentae et al., 2015), these are not fully adopted locally.

Given these constraints, there is a pressing need for a localized, strategic framework to optimize supply chain management in carabao milk production. This study aims to assess the farming profile and supply chain practices of smallholder farmers in Nueva Ecija, identify key constraints, and propose a strategic plan to enhance operational efficiency and market integration.

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2. Methodology

This study employed a descriptive research design to examine the current supply chain practices of smallholder carabao farmers, aiming to provide a comprehensive overview of operational factors influencing carabao milk production. Similar descriptive approaches have been effectively used by Santos-Recto (2018), Lantican et al. (2017), and Ricalde et al. (2014) to analyze dairy value chains and supply chain dynamics.

2.1. Sampling Procedure

The study followed a structured process starting with defining the research problem, including farmers' demographics, supply chain factors, and challenges. A sample size was determined using the Raosoft calculator with a 10% margin of error and stratified random sampling. Data collection involved one-on-one interviews using survey questionnaires, conducted after obtaining approval from cooperatives. The survey covered farmer profiles, farmers supply chain practices, and challenges. Data were analyzed using frequency distribution, means, and Likert scale to identify key supply chain factors.

2.2. Respondents

A sample of 68 farmers was selected from a total population of 228, ensuring that all cooperatives were represented. Respondents came from five cooperatives: Catalanacan Multi-Purpose Cooperative, Licaong Agriculture Cooperative, Eastern Primary Multi-Purpose Cooperative, Simula ng Panibagong Bukas Multi-Purpose Cooperative, and Delaen Farmers Agriculture Cooperative.

Table 1 Distribution of Respondents

Set of Respondents	Population	Sample
Catalanacan Multi-Purpose Cooperative	61	18
Licaong Agricultural Cooperative	22	7
Eastern Primary Multi-Purpose Cooperative	69	21
Simula ng Panibagong Bukas Multi-Purpose Cooperative	65	19
Delaen Farmers Agriculture Cooperative	11	3

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2.2.1 Research Site

The study was conducted in the Science City of Muñoz and San Jose City, Nueva Ecija, focusing on farmers from five Philippine Carabao Center–assisted cooperatives. These cooperatives are based in Barangays Catalanacan, Licaong, Porais, Sibut, and Abar 2nd, with specific farmer locations identified during the survey.

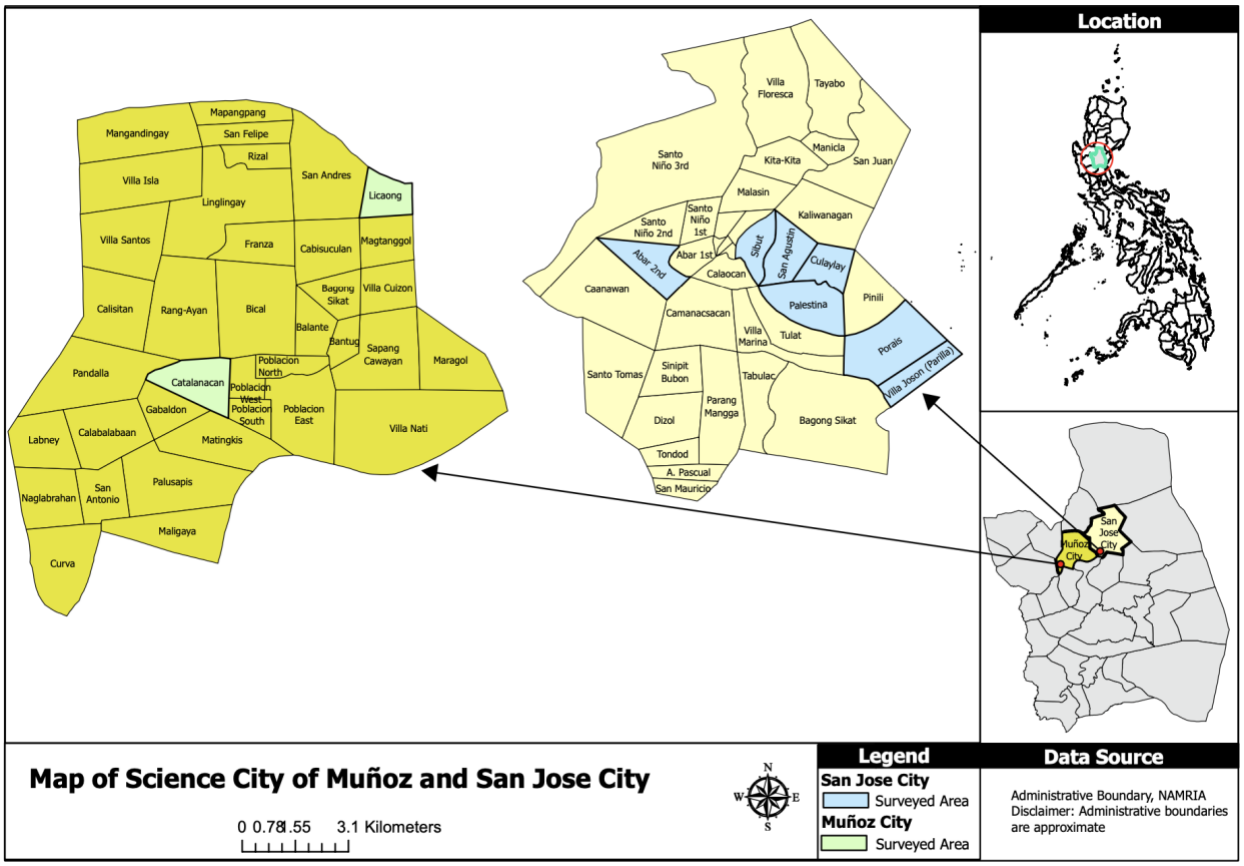

Figure 1 Map of Science City of Muñoz and San Jose City, Nueva Ecija.

3. Results and Discussion

3.1. Profile of Smallholder Farmers

3.1.1. Age

The farmer population is aging, with the majority over the age of 46, indicating a looming generational gap. Only 1% are aged 15–25, indicating minimal youth participation, which poses risks to sustainability and innovation in carabao farming (Fischer, 2017).

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3.1.2. Sex

The respondents are predominantly male (87%), reflecting traditional gender roles and physical demands of the work. This imbalance may limit women's participation and influence in decision-making and access to resources (Doss, 2018).

3.1.3. Civil Status

A vast majority of the respondents are married (93%), indicating strong household support systems for labor and resource pooling. However, the lack of young single farmers may reduce innovation adoption and flexibility in farming operations.

3.1.4. Educational Attainment

Most respondents have formal education, with 72% completing high school or higher, which supports their capacity to understand and adopt modern practices and technologies (Setianto et al., 2025). Only 4% have no education, indicating generally literate farming communities.

3.1.5. Number of Carabao

Half of the respondents (50%) own 1-5 carabaos, reflecting small-scale operations. A minority own over 20 carabaos, showing limited scalability.

3.1.6. Monthly Income

The 75% earn below Php 20,000, showing that many farmers operate under economic constraints. Low-income limits reinvestment in farm improvement, technology, and productivity-enhancing practices (Bacalia et al., 2017).

3.1.7 Years in Farming

The 81% have over 6 years of experience, with 34% farming for 11-20 years, indicating a mature and experienced workforce. However, knowledge transfer to younger generations is limited due to the aging demographic. (Ulrich et al., 2019).

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3.1.8. Training/s related to dairy farming

Farmers have undergone various training, especially in carabao raising (39%) and animal health (20%), but participation in other areas like waste management, milk processing, and AI remains low.

3.2. Factors Influencing the Supply Chain

3.2.1. Input

Farmers generally have access to basic resources like pasture, water, and veterinary services, and use a variety of feeds. However, issues remain with limited grazing areas and affordability of concentrates.

3.2.2. Production

Feed quality is seen as the biggest factor affecting milk yield. Most farmers still use hand milking, and few use machines. Seasonal changes reduce milk production, and there is a need for better technology, feeding systems, and training.

3.2.3. Processing

Farmers show strong commitment to milk quality, with proper handling and storage practices. However, very few practice on-site pasteurization due to limited equipment and infrastructure. More support is needed for certification and facility upgrades.

3.2.4. Distribution/ Marketing

While farmers are confident in timely delivery and coordination, they struggle to access both nearby and major markets. Direct sales and market engagement are low. Participation in government programs is high, but broader market linkages are lacking.

3.3. Challenges in the Supply Chain

3.3.1. Resource Management

Farmers lack access to quality feed, equipment, and training. Manual milking remains the norm, and there are few milk processing facilities.

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3.3.2. Product Quality

Poor forage quality and climate-related challenges reduce milk yield. Many farms lack accredited facilities, limiting market access.

3.3.3. Logistics

Milk delivery is consistent, but access to markets is weak. Limited collection frequency and poor transport infrastructure reduce efficiency and income.

3.3.4. Competition

Farmers are poorly connected to markets and unaware of trends, making them vulnerable to pricing issues and market exclusion.

3.3.5 Operational Efficiency

Outdated practices, limited infrastructure, and poor buyer engagement hinder productivity and profitability. Many farmers are not equipped to meet market standards or demands.

3.4. Proposed Strategic Plan

A strategic plan is proposed to address these issues through: (1) better resource access; (2) improved milk quality; (3) upgraded logistics; (4) expanded market access; (5) enhanced capacity building.

By implementing targeted actions such as subsidies for feed, improved milk collection systems, and market linkages with institutional buyers, the framework seeks to increase productivity, ensure higher milk yields, and strengthen farmers' participation in profitable markets. Through collaborative efforts between government agencies, cooperatives, and Non-Governmental Organizations, the plan is designed to support long-term sustainability and growth within the carabao farming sector, ultimately benefiting farmers' profitability and contributing to the sector's viability.

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4. Conclusions

This study significantly contributes to understanding the challenges and potential of smallholder carabao farmers in Nueva Ecija, particularly in the areas of milk production and supply chain management. To address these issues, a strategic plan was proposed that emphasizes improved resource management, enhanced milk production practices, upgraded logistics systems, and stronger market linkages to support long-term productivity and sustainability in the carabao milk supply chain.

Based on the findings, several key recommendations are presented. Cooperatives may offer zero-interest loan programs for portable milking machines to help modernize production and improve efficiency. To maintain consistent milk quality, the distribution of milk testing kits to smallholder farmers through local government units or relevant government agencies is recommended. Additionally, organizing provincial carabao milk fairs can promote local products, establish business linkages, and connect farmers with potential buyers and distributors. It is also advised that mandatory training programs be implemented—through agencies such as Technical Education and Skills Development Authority (TESDA) and Agricultural Training Institute (ATI)—to educate farmers on proper feed systems and animal care, thereby improving herd health and milk yield. Finally, future research may focus on value chain analysis and the adoption of more effective feeding strategies to further enhance carabao milk production among smallholder farmers.

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