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# Assessing postharvest handling practices and reframing losses through a systems approach: the case of "queen" pineapple value chain in Camarines Norte, Philippines

Arjay A. Gerance

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## **THESIS**

### **ASSESSING POSTHARVEST HANDLING PRACTICES AND REFRAMING LOSSES THROUGH A SYSTEMS APPROACH: THE CASE OF 'QUEEN' PINEAPPLE VALUE CHAIN IN CAMARINES NORTE, PHILIPPINES**

**ARJAY ARZOBAL GERANCE**

A Thesis Submitted in Partial Fulfillment of  
the Requirements for the Degrees of

Master of Science in Applied Economics for Agriculture and Environment  
Graduate School, Kasetsart University, Thailand

Master International en Science, Technologie, Santé, Mention : Sciences et  
Technologie de l'agriculture, de l'alimentation et de l'environnement  
(*Master of Science, Technology, and Health in Agronomy and Agrifood Sciences*)  
Institut des Régions Chaudes, L'Institut Agro Montpellier, France

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THESIS

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Arjay Arzobal Gerance: Assessing Postharvest Handling Practices and Reframing Losses through a Systems Approach: The Case of 'Queen' Pineapple Value Chain in Camarines Norte, Philippines. Master of Science (Applied Economics for Agriculture and Environment), Major Field: Applied Economics for Agriculture and Environment, Department of Agricultural and Resource Economics.  
Thesis Advisor: Associate Professor Isriya Bunyasiri, Ph.D.  
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The 'Queen' Pineapple (*Ananas comosus* L. cv. Formosa) is a vital economic driver in Camarines Norte, Philippines, yet losses in the value chain pose a significant challenge. This study employs a comprehensive systems approach to investigate losses and management practices in the 'Queen' pineapple value chain. Through surveys primarily involving 211 farmers supplemented with key interviews with other stakeholders, the study identifies key players, their functions, and loss factors. The value chain comprises several systems including commodity, activity, and actor networks, with farmers and traders playing pivotal roles. Pre-harvest losses are high at 14.93% emphasizing the need for mitigation measures. Postharvest loss estimates account for 47.81% – 12.71% for non-marketable and 35.10% for marketable rejects – mainly due to rough handling and sorting issues translating to economic losses. In assessing loss factors, smallholder farms with less than 1.0 hectare experience significantly higher losses while topography, distance from collection centers, and harvesting practices also impact farm losses. Regression analysis highlights the significance of farming experience, farm size, location, land ownership, and pineapple yield indicating that experienced farmers, larger landholders, landowners, and higher-yielding farms exhibit significantly lower farm losses. To address these problems, improvements in handling and management practices emphasizing the role of collaboration and adherence to recommended practices, regulatory measures, and postharvest technologies are recommended. Government involvement is vital for standardization, infrastructure development, extension support, and market access. This research highlights the urgency of addressing postharvest losses in the 'Queen' pineapple value chain, urging policymakers, agricultural authorities, and industry stakeholders to prioritize handling and distribution improvements, sustainable practices, technology adoption, and collaboration among value chain participants.

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Student's signature

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## TABLE OF CONTENTS

	<b>Page</b>
ABSTRACT.....	C
ACKNOWLEDGEMENTS.....	D
TABLE OF CONTENTS.....	F
LIST OF TABLES.....	I
LIST OF FIGURES.....	L
INTRODUCTION.....	1
1.1 Background of the Study.....	1
1.2 Statement of the Problem.....	3
1.3 Research Questions.....	6
1.4 Research Objectives.....	6
1.5 Scope and Limitation of the Research.....	6
1.6 Significance of the Research.....	7
REVIEW OF RELATED LITERATURE.....	9
2.1 Systems Approach to Postharvest Systems Improvement along Horticultural Value Chains.....	9
2.2 Loss Assessment Studies: Global and Local Food Scenario.....	12
2.3 Reframing Losses within the Postharvest Handling System.....	15
2.4 Pineapple Industry in the Philippines.....	16
2.4.1 Crop Industry Performance and Economic Importance.....	16
2.4.2 Production and Cultural Management Practices.....	17
2.4.3 Postharvest Handling and Quality Management.....	18
2.4.4 Pineapple Value Chain.....	21
2.5 Determinants of Postharvest Losses.....	23
2.6 Identification of Gaps and Research Opportunities.....	25
CONCEPTUAL FRAMEWORK.....	26
RESEARCH METHODOLOGY.....	29

4.1 Study Area .....	29
4.2 Data Collection and Sampling Procedure.....	31
4.3 Data Analysis .....	33
4.3.1 Descriptive Analysis.....	33
4.3.2 Value Chain Mapping .....	33
4.3.3 Loss Estimation and Critical Loss Points Identification .....	34
4.3.4 Assessment of Loss Factors among Farmers.....	36
RESULTS AND DISCUSSION.....	37
5.1 Farmers' Profile and Farm Characteristics .....	37
5.2 The Systems Approach through Value Chain Analysis.....	43
5.3 Activity System.....	44
5.3.1 Production System.....	45
5.3.2 Postharvest Handling System.....	59
5.3.2.1 Harvesting .....	61
5.3.2.2 Hauling from Farm to Collection Area.....	75
5.3.2.3 Packinghouse Operations .....	82
5.3.2.4 Loading onto Transport Vehicles.....	101
5.3.2.5 Transport to Destination Markets .....	105
5.3.2.6 Wholesale and Retail Practices .....	109
5.4 System of Actors.....	110
5.5 Pricing System .....	112
5.5.1 All-in Pricing System ( <i>Arasar</i> or <i>Syember</i> ) .....	113
5.5.2 Ladderized Pricing System ( <i>Klase-klase</i> or <i>Tamanyuhan</i> ) .....	114
5.6 Relational Flows .....	115
5.6.1 Information Flow.....	116
5.6.2 Product Flow .....	118
5.6.3 Horizontal and Vertical Relationships .....	122
5.7 Value Chain Map .....	123
5.8 Loss Estimates along the Value Chain.....	125

5.9 Critical Loss Points along the Value Chain .....	126
5.10 Factors affecting Losses among ‘Queen’ Pineapple Farmers .....	128
5.11 Interventions and Best-Fit Solutions to Improve the System .....	132
5.11.1 Improvement in Practices and Creating an Enabling Environment .....	134
5.11.2 Development of Simple and Cost-effective Postharvest Technologies .....	138
5.11.3 Actual Loss Assessments and Pilot Demonstration of Technologies ...	139
5.11.4 Capacity Building of Stakeholders .....	140
5.11.5 Institutional and Industry Support .....	140
SUMMARY AND CONCLUSION .....	143
LITERATURE CITED.....	148
CURRICULUM VITAE .....	158

## LIST OF TABLES

	<b>Page</b>
Table 1. High value crops in the Philippines with their estimated losses, implicated causes, and postharvest interventions. ....	13
Table 2. Peel color indices of ‘Queen’ pineapple based on Philippine National Standards.....	20
Table 3. Production volume of pineapple in Bicol Region, by province, 2016-2020..	30
Table 4. Area planted to ‘Queen’ pineapple and number of farmers in Camarines Norte, Philippines, 2019. ....	31
Table 5. Number of farmer-respondents, per municipality, Camarines Norte, Philippines, 2023; ( <i>n</i> =211). ....	32
Table 6. Focus group discussions and key informant interviews conducted. ....	32
Table 7. Sample loss estimate indicators, qualitative and quantitative (adopted from FAO & PHTRC, 2018-2019). ....	34
Table 8. Socio-demographic profile of farmer-respondents in Camarines Norte, Philippines, 2023, ( <i>n</i> =211). ....	37
Table 9. Land ownership, topography, and cropping system followed, Camarines Norte, Philippines, 2023. ....	41
Table 10. Soil testing and profiling of ‘Queen’ pineapple plantations, Camarines Norte, Philippines, 2023. ....	42
Table 11. Fruit and leaf characteristics of ‘Queen’ pineapple.....	46
Table 12. Source and method of planting for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	47
Table 13. Water and nutrient management for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	48
Table 14. Pest, disease, and weed incidence among ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	51
Table 15. Pest and disease management strategies of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	54
Table 16. Weed management strategies of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	55

Table 17. Awareness on maturity index set by Philippine National Standards, Camarines Norte, Philippines, 2023. ....	63
Table 18. Peel color indices of ‘Queen’ pineapple based on the Philippine National Standards.....	64
Table 19. Summary of ‘Queen’ pineapple yield, value, and pre-harvest losses reported at the farm-level, Camarines Norte, Philippines, 2023.....	72
Table 20. Postharvest loss estimates during harvesting, Camarines Norte, Philippines, 2023.....	75
Table 21. Summary statistics of hauling distance from farm to collection center, Camarines Norte, Philippines, 2023. ....	77
Table 22. Summary of labor costs during hauling, Camarines Norte, Philippines, 2023.....	79
Table 23. Postharvest loss estimates during hauling, Camarines Norte, Philippines, 2023.....	81
Table 24. Summary of labor management during field sorting, Camarines Norte, Philippines, 2023. ....	87
Table 25. Size classification of ‘Queen’ pineapple, Philippine National Standards. ....	87
Table 26. General size classification of ‘Queen’ pineapples set by traders, Camarines Norte, Philippines, 2023. ....	88
Table 27. Nature of losses after field sorting, Camarines Norte, Philippines, 2023....	90
Table 28. Postharvest loss estimates during sorting, Camarines Norte, Philippines, 2023.....	93
Table 29. Willingness to adopt postharvest (PH) technologies, Camarines Norte, Philippines, 2023. ....	99
Table 30. Loading capacity of different transport vehicles for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	102
Table 31. Nature of losses after transport, Camarines Norte, Philippines, 2023. ....	108
Table 32. Postharvest loss estimates during transport, Camarines Norte, Philippines, 2023.....	109
Table 33. Sorting and retail practices by farmer-retailers, Camarines Norte, Philippines, 2023. ....	109
Table 34. Different sorting classification in ladderized pricing system, Camarines Norte, Philippines, 2023. ....	114

Table 35. Pricing system for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. .....	115
Table 36. Horizontal and vertical relationships of primary actors in the ‘Queen’ pineapple’ value chain, Camarines Norte, Philippines, 2023. ....	122
Table 37. Summary of loss estimates along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023. ....	125
Table 38. Identified critical loss points along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023. ....	127
Table 39. Summary statistics for average farm losses based on selected farm and farmer characteristics, Camarines Norte, Philippines, 2023.....	129
Table 40. Regression results for factors affecting farm losses among farmers in Camarines Norte, Philippines, 2023. ....	131

## LIST OF FIGURES

	<b>Page</b>
Figure 1. ‘Queen’ or ‘Formosa’ variety.....	17
Figure 2. Peel color index for ‘Queen’ pineapple.....	20
Figure 3. Conceptual framework on postharvest handling practices and reframing losses in ‘Queen’ pineapple value chain in Camarines Norte, Philippines.....	28
Figure 4. Geographical map of Camarines Norte, Bicol Region, Philippines.....	30
Figure 5. Value chain mapping for selected tomato value chains in the Philippines...34	
Figure 6. Postharvest loss assessment for selected tomato value chains in Laguna and Nueva Vizcaya, Philippines (adopted from FAO & PHTRC, 2018). ....	35
Figure 7. Other on-farm activities of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	39
Figure 8. Farm size allocation for (a) overall production and (b) solely for pineapple, Camarines Norte, Philippines, 2023. ....	40
Figure 9. ‘Queen’ pineapple plantations in (a) flat terrain and (b) sloping areas; Camarines Norte, Philippines. ....	41
Figure 10. Farm tools and equipment used and owned by farmer-respondents, Camarines Norte, Philippines, 2023. ....	43
Figure 11. Interaction of systems involved in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023. ....	44
Figure 12. General activity system along the production-postharvest-consumption continuum, Camarines Norte, Philippines, 2023. ....	45
Figure 13. ‘Queen’ pineapple cultivar grown in Camarines Norte, Philippines.....	46
Figure 14. Single-row pineapple plantations intercropped with coconut, Camarines Norte, Philippines, 2023. ....	48
Figure 15. Common fertilizers used by farmer-respondents, Camarines Norte, Philippines, 2023. ....	49
Figure 16. Common plant growth regulators (PGRs) used by farmer-respondents, Camarines Norte, Philippines, 2023. ....	50
Figure 17. Problems encountered in nutrient management and fertilization, Camarines Norte, Philippines, 2023. ....	51

Figure 18. Common pests in ‘Queen’ pineapple plantations, Camarines Norte, Philippines, 2023. ....	52
Figure 19. Common diseases in ‘Queen’ pineapple plantations, Camarines Norte, 2023.....	53
Figure 20. Common weeds in ‘Queen’ pineapple plantations, Camarines Norte, Philippines, 2023. ....	54
Figure 21. Common chemicals used in controlling insect pests, diseases, and weeds in ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	56
Figure 22. Problems encountered in insect pest, disease, and weed management, Camarines Norte, Philippines, 2023. ....	57
Figure 23. Labor input for production-related activities for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	58
Figure 24. Problems encountered during labor management in production-related activities, Camarines Norte, Philippines, 2023.....	59
Figure 25. Overview of postharvest handling system along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.....	60
Figure 26. Maturity index followed by ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	62
Figure 27. Reasons for following the harvest maturity index for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	63
Figure 28. Peel color index chart for ‘Queen’ pineapple. ....	64
Figure 29. Manual harvesting method of ‘Queen’ pineapples, by snapping and use of harvest tools ( <i>bolo</i> ), Camarines Norte, Philippines, 2023. ....	66
Figure 30. Problems reported with the harvesting method, Camarines Norte, Philippines, 2023. ....	67
Figure 31. Field harvest containers used, Camarines Norte, Philippines, 2023. ....	67
Figure 32. Common field harvest containers for ‘Queen’ pineapple: (a) bamboo crates, (b) <i>kareta</i> , (c) <i>sagad</i> , and (d) directly in the field, Camarines Norte, Philippines, 2023. ....	68
Figure 33. Problems reported on the use of harvest containers, Camarines Norte, Philippines, 2023. ....	69
Figure 34. Time of harvest operations for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	69

Figure 35. Problems encountered with the harvesting time for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	70
Figure 36. Provisions to avoid sun exposure of pineapples, Camarines Norte, Philippines, 2023. ....	71
Figure 37. Provision of field shade on harvested pineapples using coconut leaves, Camarines Norte, Philippines, 2023. ....	71
Figure 38. Nature and causes of pre-harvest losses in ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	73
Figure 39. ‘Queen’ pineapple fruits considered as pre-harvest losses, Camarines, Norte, Philippines, 2023. ....	74
Figure 40. Nature of non-marketable rejects at harvest: (a) fruit cracking and severe compression, (b) detached crown, Camarines Norte, Philippines, 2023. ....	74
Figure 41. Management of hauling operations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	75
Figure 42. Common collection area for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	76
Figure 43. Mode of hauling for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.....	77
Figure 44. Hauling containers for harvested pineapples, (a) <i>kareta</i> and (b) <i>sagad</i> or <i>hilada</i> . ....	78
Figure 45. Labor management during hauling, Camarines Norte, Philippines, 2023. ....	78
Figure 46. Hauling practices for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.....	80
Figure 47. Problems encountered during hauling, Camarines Norte, Philippines, 2023. ....	82
Figure 48. Rough handling during hauling (e.g., throwing of pineapples).....	82
Figure 49. General packinghouse operations for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	83
Figure 50. Field sorting of pineapples (Tag. <i>tamanyo</i> ), Camarines Norte, Philippines, 2023.....	84
Figure 51. Types of field containers used during sorting, Camarines Norte, Philippines, 2023. ....	85

Figure 52. Use of <i>tiklis</i> and gloves during field sorting of ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	85
Figure 53. Problems with field containers used for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	86
Figure 54. General classification for ‘Queen’ pineapple: (L) butterball and (R) good. ....	88
Figure 55. Type of losses (non-marketable rejects) after field sorting and grading. ...	92
Figure 56. Non-marketable rejects after sorting, Camarines Norte, Philippines, 2023. ....	92
Figure 57. Farmer’s perception on butterball or <i>buraot</i> as postharvest losses, Camarines Norte, Philippines, 2023. ....	94
Figure 58. Reasons for performing cleaning on ‘Queen’ pineapples ( $n=32$ ), Camarines Norte, Philippines, 2023. ....	95
Figure 59. Reasons for performing trimming on ‘Queen’ pineapples ( $n=28$ ), Camarines Norte, Philippines, 2023. ....	96
Figure 60. Bundle packs by ten for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.....	97
Figure 61. Types of transport vehicles for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023. ....	101
Figure 62. Manual loading of bamboo baskets in transport vehicle, Camarines Norte, Philippines, 2023. ....	102
Figure 63. Typical transport vehicle (10-wheeler truck) for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	103
Figure 64. Slatted bamboo used as protective barriers within the transport vehicle, Camarines Norte, Philippines, 2023. ....	103
Figure 65. Loading practices of ‘Queen’ pineapples in winged trucks, Camarines Norte, Philippines, 2023. ....	104
Figure 66. Market destinations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.....	105
Figure 67. Key player for transport operations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	106
Figure 68. Common problems encountered during transport, Camarines Norte, Philippines, ( $n=71$ ), 2023. ....	107

Figure 69. System of actors within the activity system in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.....	110
Figure 70. Common types of traders after harvesting pineapples, Camarines Norte, Philippines, 2023. ....	112
Figure 71. Pricing system followed by farmers in Camarines Norte, Philippines, 2023. ....	113
Figure 72. Sources of technology and information of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	116
Figure 73. Price information of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023. ....	117
Figure 74. Different product flows in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023. ....	118
Figure 75. Product Flow 1 .....	118
Figure 76. Product Flow 2 .....	119
Figure 77. Product Flow 3 .....	120
Figure 78. Product Flow 4 .....	121
Figure 79. Product Flow 5 .....	121
Figure 80. ‘Queen’ pineapple value chain map, Camarines Norte, Philippines, 2023. ....	124
Figure 81. Farmer’s perception on the efficiency of the handling system of ‘Queen’ pineapples, Camarines Norte, Philippines, 2023. ....	133
Figure 82. Farmer’s willing to adopt interventions for systems improvement in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.....	134

# INTRODUCTION

## 1.1 Background of the Study

The global challenge of food loss and waste (FLW) is intricately linked to the United Nations' Sustainable Development Goals (SDG), specifically SDG 12, which emphasizes responsible production and consumption. SDG 12 even sets a specific target 12.3 stating that “by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses. Globally, approximately one-third of the total food produced is lost or wasted throughout the supply chain (FAO, 2013). In the case of fruits and vegetables, losses and wastes can reach up to 50%, resulting in a staggering economic loss of US\$750 billion. Notably, in developing nations, losses perishable commodities are higher than in developed nations, accounting for 44% of the overall food losses (Parfitt et al., 2010; Lipinski et al., 2013).

In the Philippines, efforts to combat FLW date back to the 1970s, with a focus on assessing losses in horticultural chains. The primary objective of these measures was to systematically identify the extent, causes, and nature of such losses with the end view of developing strategies to reduce losses. A multitude of initiatives utilized both qualitative and quantitative assessments of postharvest losses within specific value chains (Pantastico, 1979; Serrano, 1998; Esguerra, 1999; Nuevo & Apaga, 2010; Apaga et al., 2018; FAO & PHTRC, 2018; FAO & PHTRC, 2019; FAO & PHTRC, 2020). These initiatives were designed to provide various stakeholders in the value chain with valuable insights and opportunities to improve the postharvest handling systems, to ensure the safety and quality of fresh produce and eventually reduce losses.

In the Philippines, the pineapple industry holds great economic importance due to its significant contributions to the country's gross domestic product (GDP), with 7.2% shares to the Agriculture, Fishery, and Forestry sector in 2021 (Reinhardt & Rodriguez, 2009; Balito, 2011; Hossain, 2016, PSA, 2022). Pineapple (*Ananas comosus* L.), a perennial herb of the Bromeliaceae family, is extensively cultivated in the country and the crop's yield and fruit quality are influenced by complex interactions of abiotic and biotic factors like the environment and soil condition, cultural

management practices, postharvest handling system, and extra-technical factors like logistics support and infrastructure (Bartholomew et al., 2003; Troger et al., 2020).

Postharvest handling represents a dynamic and intricate network of activities that takes place from the time of harvest to the moment of sale to the final consumer. This intricate process comprises a multitude of crucial operations, including harvesting, field handling, packinghouse operations such as sorting, grading, packaging, and efficient storage. Additionally, it involves the aspects of transportation, distribution, and marketing of produce, both at the wholesale and retail levels. Nonetheless, the global agri-food landscape has undergone significant transformations in recent years, adding layers of complexity to the postharvest handling system. To effectively reduce losses and enhance the overall efficiency of the value chain, a profound understanding of this evolving complexity is imperative (Grolleaud, 2002; Troger et al., 2020). In contrast to traditional postharvest loss assessment methods, a more holistic understanding of losses can be attained by extending the boundaries of the system. This expansion encompasses not only the people, activities, and operations within the value chain but also the interrelationships among these elements. The value chain approach views the entire system as a network of interconnected, purposeful human activities. By focusing on these activities that create and maintain value, we can pinpoint areas for improvement. This approach encourages a holistic perspective, acknowledging that every step in the postharvest handling system is critical in improving the efficiency of the chain.

Within the context of postharvest losses, value chain analysis (VCA) aids in pinpointing the specific points at which losses occur and suggests potential measures for their reduction (Kaufmann & Hulsebusch, 2015). By incorporating this approach into current research, a more comprehensive understanding of the system and the factors related to FLW issues can be achieved, enabling the development of more effective loss reduction strategies. Reassessing how we evaluate food losses becomes imperative in catalyzing innovative pathways for enhancing value chains and effectively addressing postharvest losses with tailored and appropriate solutions for the agro-food industry.

## 1.2 Statement of the Problem

In diverse agricultural products and within various country-specific settings, gathering additional primary data on postharvest losses is crucial in formulating policy initiatives and strategies aimed at diminishing losses at critical points in the handling system. Moreover, research should extend beyond mere quantification. It should focus also on aspects concerning the destinations of food that is lost, the interrelation of activities, and the understanding of the economic trade-offs and impacts of reducing FLW (Chaboud, 2017; Chaboud & Daviron, 2017).

The conventional approach to addressing postharvest losses primarily centers on commodity-specific measures, often leading to technology-driven interventions that advocate for the adoption of ‘modernized’ postharvest management systems. This approach tends to criticize ‘inefficient’ and ‘inadequate’ handling practices, particularly in the Global South (Troger et al., 2020). Oftentimes, the incorporation of new technologies into existing systems lacks alignment with the system’s objectives or is not applicable on a commercial setting. This limitation is largely due to the narrow focus when framing the issue of losses. Consequently, the objective of reducing losses may not effectively materialize or cater to its intended beneficiaries.

The process of postharvest handling for fresh produce is perceived as complex, as it involves various operations, including harvesting, pre-cooling, sorting and grading, packaging, storage, transportation, and marketing (Banks, 2009). Effective management of postharvest handling system should also consider other factors such as quality, traceability, food safety considerations, processing, labeling, customer service, information and price management, as well as compliance with policies and regulations (Berruto & Busato, 2009). Therefore, it is imperative that postharvest research incorporates contemporary approaches that span the entire production-postharvest-consumption continuum (Kader & Yahia, 2011).

In the Philippines, postharvest losses remain significant, particularly within localized value chains. A distinct characteristic of horticultural chains is their context-specific nature, meaning that addressing these challenges necessitates a commodity-, location- and situation-specific approach. This is because conditions, encompassing

physical, social, environmental, climatic factors, the activity system, the actors involved, transportation, and market dynamics, tend to vary across different areas and crop types under assessment. Apart from the inherent perishable nature of horticultural crops, postharvest losses in the country predominantly stem from the inadequate adoption of proper postharvest handling practices by smallholder farmers (Mopera, 2016). These practices encompass aspects like availability of packinghouse facilities, the cold chain and the associated logistic support, packaging, and marketing systems. Additionally, the country's climatic conditions, which are conducive to spoilage and diseases, further contribute to high food losses.

Pineapple plays a vital role in the Philippine economy, impacting its GDP, with its yield and fruit quality subjected to multifaceted factors, including cultural management, postharvest handling, and environmental influences (Bartholomew et al., 2003; Reinhardt & Rodriguez, 2009; Balito, 2011; Hossain, 2016; Troger et al., 2020). Being a non-climacteric fruit, pineapples need to be harvested at the near-ripe and table-ripe stages (Kader & Yahia, 2011). Being a perishable crop, postharvest changes such as over-ripening, onset of decay and susceptibility to mechanical damage can impact on fruit quality, leading to substantial losses within the pineapple value chain in the country, often amounting to 30% to 40% (Mopera, 2016).

In the case of 'Queen' pineapples, a predominant cultivar in Camarines Norte province, the challenge of postharvest handling and management persists, as highlighted in the study of Serrano (1998), revealing that losses along the handling chain can range from 20% to 30%. The industry faces a substantial hurdle due to the high perishability of pineapples, as they ripen within two days, limiting their suitability for long-distance market transportation, resulting in a 24% price reduction after one day of delivery to major wholesale markets. Additionally, 'Queen' pineapples are vulnerable to insect infestations, pests, and diseases, with postharvest diseases presenting a particularly troublesome issue. Improper harvesting and handling can lead to substantial fruit damage, potentially serving as an entry point for pathogens, especially if no protective coating is applied.

In the study of Balito (2011), significant concerns and challenges within the pineapple handling chain were discussed, including insufficient infrastructure, poor

transportation and storage facilities, the impact of seasonal harvesting, price fluctuations during trade, and marketing-related issues, which encompass high capital investments and labor-intensive operations. Frequently, individuals directly engaged in activities like harvesting, packaging, transportation, and marketing in developing nations lack awareness of quality maintenance practices (Kader, 2010).

Key participants in the pineapple value chain in Camarines Norte include farmers, agents, wholesalers, retailers, and processors (Campita et al., 2022). Furthermore, a significant proportion of farmers in the area, approximately one-third, are still below the poverty threshold, underscoring that income from pineapple cultivation falls short. Within the network of value chain stakeholders, farmers receive comparatively smaller profit shares for their roles in pineapple production and marketing (Gessesse et al., 2019; Vidanapathirana et al., 2020). These challenges persistently hinder local pineapple growers from accessing improved farming opportunities. Therefore, the overarching challenge revolves around increasing their profitability through the improvement of postharvest handling operations and the integration of technically-feasible, economically-viable, and socially-acceptable loss-reduction methods and technologies.

Therefore, the study primarily focuses on key features of the ‘Queen’ pineapple value chain in Camarines Norte, Philippines with a particular emphasis on the postharvest handling practices of major stakeholders in the region. It aimed to comprehensively examine the system within the local pineapple value chain, striving to shed light on the dynamics behind how and why losses occur and pinpoint the specific factors and practices within the activity system that significantly contribute to these losses. The ultimate goal is to identify critical control points where potential interventions can be effectively integrated. Subsequently, the study seeks to recommend well-suited and meaningful solutions for an efficient and effective pineapple value chain, ensuring economic, environmental, and social sustainability, and ultimately minimizing losses to the greatest extent possible.

### **1.3 Research Questions**

The study focused on four relevant questions needed to understand the postharvest management and losses in the ‘Queen’ pineapple value chain in the study area of Camarines Norte, Philippines. Main research questions include:

1. What are the main features of the ‘Queen’ pineapple value chain in the area, especially in terms of the function of key players and handling routes?
2. What are the existing postharvest handling and management practices in the area?
3. From these identified activities, how and why are losses incurred at the different stages of the value chain?
4. What constraints does the industry face and what potential improvement opportunities exist for stakeholders in the value chain?

### **1.4 Research Objectives**

The general objective of the study is to assess the handling practices and management system that influence postharvest losses in the ‘Queen’ pineapple value chain in Camarines Norte, Philippines. Specifically, it aims:

1. To identify the major players in the ‘Queen’ pineapple value chain and their functions;
2. To characterize the postharvest handling practices and management system along the value chain;
3. To determine the nature, cause, extent, and the factors affecting losses at different stages of the chain; and
4. To identify critical control points along the value chain where possible improvement opportunities can be integrated.

### **1.5 Scope and Limitation of the Research**

The research specifically concentrated on ‘Queen’ pineapple farmers in Camarines Norte, Bicol Region, Philippines. The selection of municipalities—Basud, San Lorenzo Ruiz, Labo, and San Vicente—was deliberate, as these areas are prominent

for pineapple cultivation. Further, the assessment of practices and loss estimates along the value chain focused on fresh ‘Queen’ pineapples. The research methodology encompassed a combination of qualitative and quantitative tools for analysis. The scope of the study was confined to the farmer and trader levels within the value chain, with field surveys at the wholesale and retail levels being omitted due to time constraints. Nevertheless, key informant interviews served as a supplement to provide insights and develop an overall understanding of the value chain activities in these levels.

Several constraints governed the study, including limitations in terms of human resources and time. Data collection through key informant interviews and surveys was conducted over a two-month period, from July to August 2023. While these constraints led to reduced sampling and responses, the study still came up with valuable insights on the handling system, postharvest losses, and factors influencing the losses within the local pineapple value chain.

### **1.6 Significance of the Research**

Over the years, various tools have been devised to gauge postharvest losses, encompassing both qualitative and quantitative approaches for assessment. This research, employing a systems approach, provided thorough and intricate insights into postharvest handling practices and loss evaluation within the ‘Queen’ pineapple value chain in Camarines Norte. Furthermore, this study offered a comprehensive analysis of the activity system, emphasizing postharvest handling systems, information and marketing flows, the networks of the various stakeholders, and the relationships among these components.

Despite available literature adopting similar frameworks and approaches, there is a notable limitation of research that delves into the comprehensive exploration of factors like postharvest handling and management practices, as well as other relevant determinants, and their substantial impacts on losses. Although numerous studies have examined the specificities of horticultural value chains in the Philippines, the challenge of relating these factors persists within the research domain. Through a deeper understanding of the interrelationships among these diverse elements in the value chain, farmers and stakeholders can effectively identify and alleviate the root causes of losses.

This, in turn, makes them empowered and will enable them to enhance their profitability by implementing tailored best practices and other opportunities for improvement.

Although several studies in the country have extensively described and assessed location-specific pineapple value chains (Henery & Chato, 2019; Campita et al., 2022; Carbonell, 2015; Galvez, 2019; Lacaden, 2019), still, limited literatures employ a similar framework and systems approach for this particular commodity. The study's outcomes are intended to contribute to a deeper understanding of the crucial handling practices within the pineapple value chain. Furthermore, the study has aided in identifying techniques and strategies aimed at reducing postharvest losses, thereby improving the handling system for fresh pineapples in the region. This information has been instrumental in identifying practical and well-suited solutions, including cost-effective adjustments to postharvest practices, technological options for reducing food losses, and profitable investments in postharvest agri-business. Ultimately, these improvements can benefit local farmers and other stakeholders by integrating efficient handling practices and appropriate loss reduction strategies and technologies whenever feasible. Additionally, reevaluating the assessment of food losses through a systems approach has the potential to stimulate alternative avenues for upgrading value chains and addressing postharvest losses.

Furthermore, the study's findings can serve as a foundation for government authorities, policymakers, and stakeholders in shaping supportive initiatives and formalizing policies aimed at improving handling systems, reducing losses, and setting industry standards. In partnerships with industry collaborators, organizations, research, extension, the academe, and local government units, the research aspires to replicate successful practices in selected horticultural value chains nationwide, with the overarching goal of diminishing postharvest losses, guaranteeing the quality and safety of fresh produce, bolstering food and nutrition security, and enhancing the competitiveness of the horticulture industry.

## REVIEW OF RELATED LITERATURE

### 2.1 Systems Approach to Postharvest Systems Improvement along Horticultural Value Chains

The postharvest sector primarily focused on a technical approach towards reducing losses and recently, the sector has evolved to a more holistic approach. This approach is aimed at connecting on-farm activities with the postharvest, processing, marketing, and distribution activities in the agri-food system (PHTRC & DOST-PCAARRD, 2022). Assessing postharvest losses are usually commodity-oriented and strategies tend to rely mostly on technological interventions for improving product handling and quality along horticultural chains (Troger et al., 2020).

The conventional approach primarily revolves around measures specific to commodities, which frequently result in interventions heavily focused on technology and the promotion of ‘modernized’ postharvest management systems, often with a negative perception of ‘poor’ and ‘inadequate’ handling practices, particularly in the Global South (Troger et al., 2020). Many times, the integration of new technologies into existing systems does not align seamlessly with the system’s objectives or may not be suitable for the particular context. This issue arises because the perspective on losses is often limited to a narrow range of approaches. Consequently, the goal of reducing losses frequently falls short of its intended realization and may not effectively cater to its target beneficiaries.

The global issue on food loss and waste is embedded in the context of the UN-FAO’s Sustainable Development Goals, particularly SDG 12 aimed at responsible production and consumption (FAO, n.d.). SDG 12 even sets a specific target related to the reduction of FLW. The specific target 12.3 states that: *“By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.”*

Generally, FLW is understood as the decrease in quantity or quality of food along supply chains (FAO, 2019) and globally, several measures and interventions were implemented to achieve these goals, more importantly on postharvest loss reduction.

However, the complexity of postharvest losses made it difficult for international action to achieve reducing losses and develop effective solutions (Grolleaud, 2002). Along with this complexity, agricultural intensification during the global economic crisis from 2006 to 2008 provided the political momentum for global food loss assessment initiatives and heightened societal awareness to initiate multi-level actions to reduce postharvest losses, especially in developing nations (MacIntyre et al., 2009; Rosin et al., 2012; Gustavsson et al., 2011; Stuart, 2009; UN, 2015, European Commission, 2015).

As a system comprising interconnected processes, the postharvest system forms a complex network that extends from the time of harvesting to the point of sale to the ultimate consumer. This system plays a crucial role in ensuring that food remains safe, nutritious, and readily available to consumers. These activities encompass various stages, such as harvesting, on-field handling, packinghouse operations involving sorting, grading, packaging, and storage, as well as transportation, distribution, and marketing (both at the wholesale and retail levels) of food products. In essence, the postharvest system encompasses all the phases in the chain that occur after production and are intended to contribute value to the final product (Goletti & Samman, 2002).

As defined by FAO & UNEP (1981), “postharvest period starts when a crop intended for human consumption is removed from the plant and ends when the food has reached the final consumer.” Further, postharvest handling as a system is viewed as “a purposeful collection of participants, facilities, technologies and processes that deliver harvested products to their consumers” (Prussia et al., 1986; Prussia & Mosqueda, 2006).

The use of a holistic or systems approach for reducing postharvest losses and identifying improvement opportunities has been widely acknowledged (Shewfelt et al., 2014). The systems approach theory is founded on the principle that “a system consists of interconnected and interdependent elements, each fulfilling a function that contributes to the overall functioning of the whole system, recognizing that not all components contribute equally to the system’s stability” (Sullivan & Thompson, 1991). Ackoff (1971) further explains that a common aspect of the systems approach is the understanding that systems are part of a larger system, and their characteristics emerge

from the interactions of their elements. To gain a systematic understanding of a phenomenon, it is essential to establish the nature of the relationships while considering the context in which the phenomenon occurs. Simultaneously, a comprehension of how the individual components relate to each other and to the entire system should be realized (Bateson, 1987; Ackoff, 1995).

In this context, the effectiveness of a postharvest handling system is contingent on the performance of its most vulnerable component. Enhancements made to one segment of the system will not translate into overall efficiency unless all parts are considered (Bautista & Maunahan, 2007). Given that postharvest handling plays an integral role in the production-consumption continuum, a systems approach is essential to tackle these issues. Specifically, a value chain approach is required to gain insights into the status, requirements, and potential solutions and interventions for a particular industry.

Value chain is generally regarded as a system of human activities that are interconnected and purposeful. Value chain analysis (VCA) serves as a tool to explore the mechanisms and drivers facilitating the efficient distribution of fresh produce to its end market (Turnier, 2011). VCA assesses a sector's potential, identifying constraints and opportunities for realizing that potential. This approach fosters competitiveness and equitable value distribution along the chain, while promoting increased participation. Addressing organization, coordination, strategies, and power relationships among chain actors, value chains present complexities in the value chain (Kaplinski & Morris, 2001). Analyzing them requires a comprehensive examination of actors' interactions, shared information, evolving relationships, and more.

In the context of postharvest losses, VCA plays a crucial role in identifying the areas where losses occur and devising strategies for their reduction (Kaufmann & Hulsebusch, 2015). Research on fruit and vegetable value chains has been conducted, with Kitinoja et al. (2018) revealing that several significant challenges demand a systems approach to provide effective solutions. Furthermore, contemporary food loss reduction initiatives adhere to the principle that interventions should be devised within the context of pertinent value chains, employing a systems approach (AUC & FAO, 2012).

Amid the recent transformations in global agri-food chains, postharvest systems become increasingly more complex. To effectively mitigate losses, it is imperative to comprehend this complexity, encompassing the various stages and levels within the value chain where opportunities for enhancement and solutions must be integrated. Therefore, when striving to reduce losses, particularly in horticultural value chains, it is essential to adopt a comprehensive or systems approach rather than focusing solely on its fragmented components.

## **2.2 Loss Assessment Studies: Global and Local Food Scenario**

According to FAO (2013), almost one-third of the total food produced is lost and wasted along food supply chains. Globally, between 40% to 50% of fruits and vegetables are lost and wasted. From this, 54% occurs during cultivation, handling, storage, and postharvest stages, while 46% occurs during the distribution, processing, and consumption stages amounting to an economic loss of US\$750 billion. Moreover, in developing nations, perishables, such as fruits and vegetables, are often lost at a higher rate than developed nations. In fact, weight loss in perishables accounts for the largest share (44%) of all food lost (Parfitt et al., 2010; Lipinski et al., 2013).

Aligned with global endeavors to tackle the challenge of FLW and considering the Philippines' substantial production of horticultural crops, the country has been actively assessing food losses since the 1970s. This concerted effort aimed to determine the scope, characteristics, and underlying causes of losses in various horticultural chains. Pantastico (1979) referred to average loss estimates of approximately 28% for fruits and 42% for vegetables, as documented in studies conducted by the Postharvest Horticulture Training and Research Center (PHTRC), College of Agriculture and Food Science (CAFS), University of the Philippines Los Baños (UPLB) since 1977. PHTRC, a prominent research institution in the Philippines, plays a pivotal role in implementing a comprehensive program aimed at enhancing the postharvest systems for horticultural crops.

Building upon these early initiatives, numerous loss assessments were carried out utilizing a diverse array of approaches, encompassing both qualitative and quantitative methods, to gauge losses at different points within various supply chains.

A significant feature of horticultural chains is their context-specific nature. These loss assessment studies are typically tailored to the particular location, situation, and commodity being assessed. This is due to the substantial variations in conditions—including physical, social, environmental, climatic factors, the activity system, the actors involved, transportation, and market dynamics—across different regions and the types of crops being examined.

Esguerra (1999) documented mango losses spanning from 4% to 80% within the Philippines. These losses were attributed to improper handling conditions, high temperatures during transportation, and variations in practices across mango supply chains in Luzon, Visayas, and Mindanao. Between 2008 and 2010, a comprehensive study utilizing the commodity systems approach was carried out by PHTRC in collaboration with the Department of Agriculture-Philippine Center for Postharvest Development and Mechanization (DA-PhilMECH) for major commodities. Nuevo & Apaga (2010) revealed postharvest losses for these commodities, ranging from 3% to 33%. Specific findings indicated losses of 3% to 30% for bananas (Saba and Latundan varieties), 27% to 42% for papaya, 5% to 32% for calamansi, and 2% to 33% for mango. Other studies investigating postharvest losses in economically important crops reported substantial losses, including 20% to 30% for ‘Queen’ pineapple, 27.7% to 29.3% for tomatoes, and 53% for eggplant (Serrano, 1998; FAO & PHTRC, 2018; Apaga et al., 2018). Additionally, Mopera (2016) consolidated these estimates from value chain studies conducted in the country (Table 1). The study focused on assessing the magnitude, nature, and root causes of losses, as well as proposing interventions for loss reduction across significant horticultural value chains in the Philippines.

Table 1. High value crops in the Philippines with their estimated losses, implicated causes, and postharvest interventions.

Crop	Loss Estimates (%)	Causes	Technologies/Intervention
Banana	3-30	premature ripening, weight loss, mechanical damage, disease, and rotting	use of ethylene adsorbents, careful handling, alum treatment
Calamansi	5-32	disease, olleocellosis, yellowing	curing, modified atmosphere packaging
Mango	2-33	cracking, disease, latex damage	hot water treatment, careful handling, alum treatment
Papaya	27-44	disease, mechanical damage	wrapping of fruits, hot water treatment

Table 1. *continued...*

Crop	Loss Estimates (%)	Causes	Technologies/Intervention
Carrot	7-12	crack/cut, soft rot, punctures, abrasion, cuts, forking, damaged top leaves	use of plastic crates as packaging material, surface drying or air drying after washing, use of refrigerated trucks for transport
Cabbage	29	disease, mechanical damage	use of refrigerated trucks, careful handling, passive cooling using block ice or evaporative coolers
Eggplant	10-40	insect damage, weight loss	careful handling
Tomato	11-38	rotting, disease, weight loss	modified atmosphere packaging and ethylene adsorbents, careful handling, use of plastic crates
Onion	35 (5% farm, 12% wholesale, 18% retail)	disease, mechanical damage	curing, careful handling, cold storage

Source: Mopera, 2016

Applying a similar methodology, recent studies on loss assessment were conducted by FAO & PHTRC (2018, 2019, 2020) through case studies in selected supply chains. Postharvest losses were estimated to range from 10% to 15% for tomatoes and from 14.33% to 19.44% for mangoes, based on insights gathered from stakeholders' interviews. These findings were then validated through actual loss measurements, leading to the identification of critical loss points. Within mango supply chains, the most significant losses occurred at the levels of farmers and retailers, with the primary causes of losses attributed to quality defects identified during the sorting process at the farm, such as insect damage, latex staining, and tree-ripened fruits. Additional losses were observed at the retail levels, primarily due to compression, abrasion, and decay. In the case of tomatoes, the key points of losses in the Laguna supply chain, characterized by shorter handling chain, were during harvesting, sorting, and packaging, while for Nueva Vizcaya representing longer supply chains, harvesting, field sorting, and washing were the primary loss points.

Consistent with these observations, Bautista & Maunahan (2007) confirmed the general estimates of postharvest losses where highly perishable crops like fruits and vegetables may experience losses ranging from under 10% to over 50% across different segments of the supply chain. As noted by Mopera (2016), the primary contributors to postharvest losses in the Philippines are the absence of proper postharvest handling practices among small-scale farmers. These practices encompass the absence of or poorly equipped packinghouse facilities, poorly managed cold chains, inappropriate

packaging, and multi-layered marketing systems. Additionally, the country's climatic conditions, which are conducive to spoilage and diseases, further aggravate food losses.

### **2.3 Reframing Losses within the Postharvest Handling System**

In diverse commodity types and within various national settings, the accumulation of additional primary data concerning postharvest handling losses can serve as a valuable foundation for shaping policy measures and strategies aimed at curtailing losses within specific handling chains. Moreover, research should extend beyond mere quantification. It should delve into the destinations of lost food, unveil the interconnectedness of activities, and attain a deeper comprehension of the economic trade-offs and consequences associated with reducing FLW (Chaboud, 2017; Chaboud & Daviron, 2017).

The evaluation of intervention programs has highlighted the complexities of implementing postharvest technology and handling recommendations in resource-limited environments, particularly in developing countries (Kitinoja et al., 2011; Lipinski et al., 2013). While the efficacy of these technologies in minimizing losses has been demonstrated, their adoption is not assured unless the intended users perceive them as economically viable, profitable, and suitable for the local context, ensuring long-term sustainability. Resource-constrained farmers often exhibit reluctance to deviate from their traditional practices because the adoption of new techniques or technologies typically entails expenses and additional capital resources (del Carmen, 2019). Furthermore, greater success has been observed when technologies are simplified and seamlessly integrated into existing value chains (Kitinoja, 2013).

Research concentrating on technology-centered farming frequently oversimplifies the complex social dynamics involved in the production, management, and marketing of agricultural products. This can result in a limited comprehension of how individuals navigate and uphold systems in resource-limited settings and the connections essential for their continuity (Troger et al., 2020). In contrast to conventional postharvest loss assessment methods, a more comprehensive understanding of losses can be attained by broadening the system boundaries to encompass not only individuals, activities, and operations within the value chain but

also the intricate interconnections among these elements. A holistic approach of the contributing factors to losses will facilitate the formulation of more effective strategies for mitigation.

Over time, various tools have been developed to gauge postharvest losses. Nonetheless, there is a pressing need for more detailed, standardized, and science-based data concerning the extent of losses at specific points within the value chain, as well as the underlying reasons and origins of these losses. This information will be instrumental in pinpointing suitable solutions, such as cost-effective changes to postharvest practices, technology options for reducing food loss, and investments in postharvest agri-business. Furthermore, reevaluating the assessment of food losses is of paramount importance. By implementing these approaches, we can stimulate innovative avenues for upgrading value chains and addressing postharvest losses.

A systems approach can be deployed to reassess how losses are addressed by scrutinizing the activities within the postharvest handling system at distinct chain levels. The objective is to identify critical points where interventions can be introduced to enhance the existing system. Consequently, this study seeks to delve into the complexities of the value chain within the local context, aiming to devise fitting and appropriate solutions for the enhancement of the current system.

## **2.4 Pineapple Industry in the Philippines**

### **2.4.1 Crop Industry Performance and Economic Importance**

Pineapple (*Ananas comosus* L.) belongs to the Bromeliaceae family and is classified as a perennial herb (Bartholomew et al., 2003). In the Philippines, pineapple holds a prominent position as one of the major crops, endorsed as a national flagship and regional priority crop by government entities like the Department of Agriculture (DA) and the Department of Science and Technology (DOST). This recognition is primarily rooted in the crop's economic significance, as it makes a substantial contribution to the country's GDP. Furthermore, the Philippines is widely recognized as one of the leading global exporters of pineapples (Reinhardt & Rodriguez, 2009; Balito, 2011; Hossain, 2016).

The pineapple industry plays a significant role in bolstering the Philippine economy, accounting for 7.2% of the Agriculture, Fishery, and Forestry sector. In 2021, the country achieved an impressive pineapple production of approximately 2.86 million metric tons, valued at PhP 26.1 billion. This positions the Philippines as the third largest pineapple producer globally, after Costa Rica and Brazil. Pineapples also rank among the leading export commodities, with exports totaling US\$281 million in 2021, as reported by PSA (2022) and FAO (2023).

#### 2.4.2 Production and Cultural Management Practices

In the local market, four cultivars of pineapple are commercially available. These are: (1) Smooth Cayenne, also known as the ‘Hawaiian’ variety is the most popular cultivar known for its sweet, juicy flesh; (2) Queen, also known as the ‘Formosa’ variety is slightly smaller than the Smooth Cayenne but is the sweetest cultivar (Figure 1); (3) ‘Red Spanish’ variety is native to the Philippines and has a reddish-brown skin, sweet and juicy flesh, and an excellent source of piña fiber; and, (4) ‘Cabezona’ is native to Brazil and has a large, round head with a sweet, juicy flesh and mild pineapple flavor (Balito, 2011; Campita et al., 2022).



Photo from DOST-PCAARRD <https://ispweb.pcaarrd.dost.gov.ph/queen-pineapple/>

Figure 1. ‘Queen’ or ‘Formosa’ variety.

The majority of pineapple production in the Philippines is concentrated in the Northern Mindanao region, known for its extensive pineapple plantations operated by companies like DOLE and Del Monte. These corporations primarily focus on pineapple production for export, with the United States and Japan being their main overseas

markets. Additionally, CALABARZON and Bicol regions in Luzon also stand out as major pineapple-producing areas. These regions contribute to both the local and international pineapple markets. The predominant variety grown in Bicol region is the ‘Queen’ pineapple, primarily intended for domestic consumption (Henry & Chato, 2019; Carbonell, 2015; Galvez, 2019; Campita et al., 2022).

The pineapple industry in the Philippines exhibits diversity, with various production practices, cultural management approaches, and distinct farmer characteristics across different production sites. Northern Mindanao, for instance, has a pineapple supply chain marked by a significant prevalence of small-scale, low-skilled, labor-intensive, and inadequately compensated workers (Henry & Chato, 2019). On the other hand, in Camarines Norte, the cultivation of ‘Queen’ pineapples is traditionally carried out within an intercropping system alongside coconut, although farmers are gradually shifting towards low external input agriculture, diversification, and the optimal utilization of local resources and natural processes (Carbonell, 2015). In CALABARZON, the utilization of crowns as planting material is common in commercial farms, while slips and suckers are preferred for planting in smaller farms. In Isabela, pineapple farmers engage in a comprehensive 24-month cultivation process, encompassing activities like land preparation, planting, fertilizer application, weed control, cover hay usage, and harvesting (Galvez, 2019). In Nueva Vizcaya, flower induction techniques are employed by pineapple farmers as part of their cultivation practices (Lacaden, 2019).

#### 2.4.3 Postharvest Handling and Quality Management

Postharvest handling refers to both science and technology, covering principles that explain the behavior and changes as well as the series of operations a harvested crop undergoes to maintain its desired quality until it reaches the consumers (Bautista & Maunahan, 2007). The main goal is to maintain the quality and ensure safety of commodities while being brought to consumers on time. This includes meeting buyers’ specifications and trade requirements.

The combination of attributes, properties, or characteristics that gives value to a commodity in terms of its intended use is referred as ‘quality’ or the ‘degree of excellence or superiority’ and any changes in the quality and quantity are considered losses (Shewfelt, 1999; Kader & Rolle, 2004; Kader & Yahia, 2011). Postharvest loss is defined as any change in the availability, edibility, acceptability, and quality of the produce. Losses can be caused by a variety of factors, including insect pests, diseases, poor handling, and inadequate storage, among others. In particular, reducing postharvest losses in perishable crops highlights that successful marketing relies on the supply of high-quality produce (Kitinoja & Kader, 2003).

Pineapple yield and fruit quality are influenced by complex interactions of production practices like planting density, cultural management, postharvest handling, as well as environmental and other factors (Troger et al., 2020). Pineapples, which are non-climacteric fruits, must be harvested when they are ripe and ready to eat (Kader & Yahia, 2011). However, after harvest, pineapples undergo changes that can affect their quality. They should be picked or cut and placed in suitable containers to protect them from injury and sun exposure. Harvested pineapples should be cooled quickly, and fruits with high flesh translucency should be separated. These fruits are more fragile and have a shorter shelf life and are prone to fermentation caused by yeasts. Pineapples are typically graded according to market requirements. Fungicides and waxes are commercially used mainly for export to protect fruits from postharvest diseases, water loss, and internal browning. Rough handling at harvest, packaging, and transport can cause mechanical damage and bruising, which can allow disease-causing microorganisms to enter the fruit and cause an undesirable change in flesh color. On storage, temperature between 7.5°C and 12°C and a relative humidity of between 70% and 90% are generally recommended (Bartholomew et al., 2003; Lobo & Paull, 2017).

In the Philippines, comprehensive standards, recommended protocols, and technologies related to production, handling and distribution, and processing for pineapples are readily available (DOST-PCAARRD, 2014). Specifically, the ‘Queen’ pineapple has witnessed remarkable advancements in the industry (Campita, 2021). By implementing these measures, the pineapple industry in the Philippines, especially the

‘Queen’ pineapple in the Bicol Region, can thrive and maintain its reputation for producing high-quality pineapples.

*Maturity Determination.* Fruit maturity at harvest influences the quality of pineapples. Pineapple exhibits slight ripening changes after harvest. This means that fruits will not sweeten or ripen after harvest. Thus, it is important to harvest pineapple at the right maturity for its intended use. Maturity is usually based on days after flower induction or by using peel color indices. Peel color index (Table 2 & Figure 2) has been established for ‘Queen’ pineapple since right timing is crucial in harvesting to prolong the fruit’s shelf-life. ‘Queen’ pineapples are normally harvested at PCI 2 and 3 (DOST-PCAARRD, 2014).

Table 2. Peel color indices of ‘Queen’ pineapple based on Philippine National Standards.

Peel Color Index (PCI)	Description
PCI 1	All eyes are dark green; greenish bracts cling tightly to the eyes (immature)
PCI 2	All eyes are green; whitish bracts are dry; grooves between eyes show separation and yellowing
PCI 3	About 2-3 layers of the eyes at the base show yellowing
PCI 4	Fifty percent (50%) of the eyes are yellow
PCI 5	More than 75% of the eyes are yellow (overripe)
PCI 6	Full yellow (overripe)

Source: PNS/BAFPS 09:2004

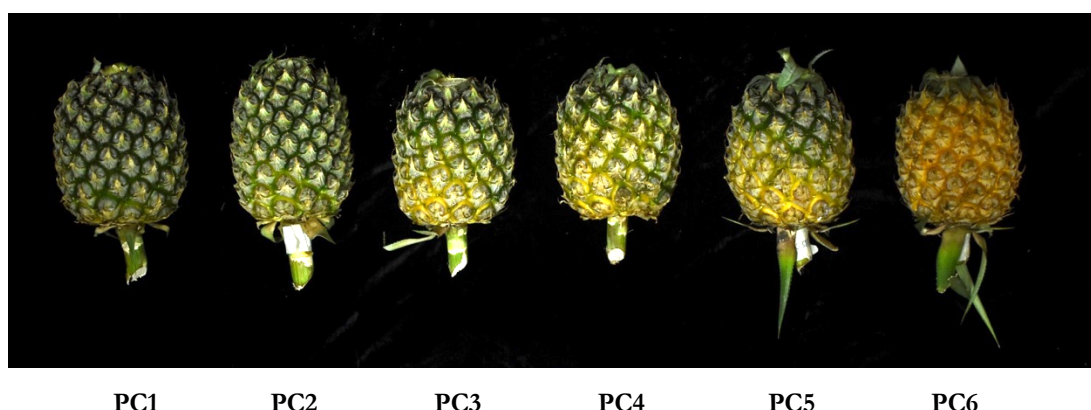


Figure 2. Peel color index for ‘Queen’ pineapple.

*Harvesting.* Many handling problems start at harvest. The use of appropriate tools and harvest containers and the method of harvesting are important considerations in minimizing these problems. ‘Queen’ pineapple is generally harvested manually using a ‘twist and bend’ technique (DOST-PCAARRD, 2014; Campita, 2021).

*Packinghouse Operations.* Fruits must be prepared for the market and different operations are usually performed in packinghouses. These operations are hauling, trimming, cleaning, sorting and grading, postharvest disease control, waxing, packaging and transport (DOST-PCAARRD, 2014).

#### 2.4.4 Pineapple Value Chain

As outlined in the preceding section, horticultural value chains exhibit variability contingent on the particular context. Pineapple value chains, for instance, have been found to encompass diverse postharvest handling practices and management strategies in location-specific chains. These practices, concerning quality management, displayed varying degrees and impacts on losses, thereby facilitating the identification of opportunities for improvement that can bring added value to the stakeholders. In the Philippine context, postharvest losses in pineapple value chains are typically high, often ranging from 30% to 40% (Mopera, 2016).

The study of Lacaden (2019) highlighted some practices and prevailing problems in pineapples produced from Nueva Vizcaya. For their hauling practice, large-scale farmers allowed traders to pick and harvest their produce while some manually fill-in their sacks and carry them to the roadsides before hauling. Small-scale farmers used tricycles to haul pineapples and deliver them to roadside stalls, public markets and even directly to consumers. However, damage to fruits caused by insect pests and diseases are the problems in the area. The following activities contribute to value creation in the chain: hauling and assembly, sorting, shipping, re-assembly and grading, displaying, and wholesaling. These activities indicate that postharvest handling is one of the specific strategies for value chain improvement.

In Isabela province, Galvez (2019) discussed the existing pineapple value chain as characterized by four intermediaries and six marketing channels. The study found that price and quality are important factors for the choice of marketing channels. Main factors in determining pineapple quality are size and taste. Aside from size, physical appearance is a reason for fruit rejection. Therefore, the challenge is to maintain

produce quality so that competitive pricing on good quality pineapples can be one of the strategies for increasing farmer's profit share in the value chain.

In the province of Camarines Norte, the 'Queen' variety is particularly produced mostly for domestic consumption. The variety is popularly known for its very sweet taste and crunchiness. In the study of Campita et al. (2022), five marketing channels are existing having farmers, agent, wholesaler, retailer, and processors as major players in the pineapple value chain. However, a major problem is that the fruit is highly perishable and ripens within only two days, preventing it from distant market shipments. With this problem, price is already reduced by 24% after one day of delivery to major wholesale markets. Further, marketing of pineapples is labor-intensive and entails high capital requirements.

Currently, the constraints in the pineapple value chain are besetting local growers in realizing better farming opportunities. Balito (2011) enumerated key issues and problem in the handling chain such as inadequate infrastructure, poor transport and storage facilities, seasonality of harvest and unstable prices during trading, and problems on marketing of fresh pineapple because of its highly perishable nature. Improvement in packaging, storage and handling facilities must also be addressed. Proper handling is necessary to avoid any injury to fruits while transporting to major consumption centers as well as to reduce spoilage or losses due to bruising and injury. In the study of Das et al. (2016), major constraints in the marketing system of pineapples include: (1) supply of quality pineapple is for a short period due to poor storage and lack of cool chain facilities and (2) packinghouse facility for grading and packaging is not available. Moreover, a quality control system is needed to meet consumer's requirements. As Kader (2010) mentioned, concerns relating to better handling practices, inadequate marketing systems and transportation, lack of communication, information and enforcement of food safety regulations, unavailability of tools and equipment, poor maintenance of facilities and "human aspect" greatly influence on how produce quality is maintained. In addition, most handlers involved directly in harvesting, packaging, transporting, and marketing in developing countries have limited or no appreciation for the need for, or how to maintain quality.

Studies showed that among value chain stakeholders, pineapple farmers received relatively lower profit shares for producing and marketing pineapples (Gessesse et al., 2019; Vidanapathirana et al., 2020). Hence, the challenge is to increase farmer's profit share along the chain through improving the handling system by reducing losses and integrating efficient postharvest loss reduction strategies and technologies whenever possible. To achieve this goal, first, we need to completely understand the system within the context of relevant pineapple value chain in the area. Subsequently, assess how and why losses are incurred and identify what relevant factors and specific practices from these activities significantly contribute to losses. From these, critical control points can be established where interventions can be potentially integrated. Therefore, suited solutions can be recommended in strengthening the pineapple value chain in an economically, environmentally, and socially sustainable way so that losses will be decreased to a minimum.

## **2.5 Determinants of Postharvest Losses**

Numerous scholarly works have employed a variety of analytical approaches to explain the factors contributing to losses, particularly postharvest losses. These studies have demonstrated that socio-demographic factors, specific postharvest handling and management practices, and other pertinent variables can exert a notable influence on the extent of losses. Gaining insight into these interrelations can provide valuable guidance to value chain stakeholders, particularly farmers, in recognizing and addressing the underlying causes of these losses.

In the study of Begum et al. (2022) on pineapples, losses incurred especially at farm-levels were shown to be strongly associated to socio-demographic and farm characteristics. Using chi-square analysis, education level, farm size, farming experience, and yield were found to be associated to losses. Farmers with formal or more years of education had lower postharvest losses and farm experience had beneficial impact on fruit loss quantity. More experienced farmers are more likely to have developed good practices for handling and storing pineapples. Likewise, increasing the amount of volume handled, such that operating on larger farms and having higher yields, increased the likelihood of poor handling, management and

storage leading to high levels of losses. This indicates that it is more difficult to ensure proper handling and storage when dealing with large volumes of fruit.

Employing regression models, additional socio-demographic characteristics were identified to have significant influences on losses and their potential mitigation. As indicated by Ssebagala et al. (2017), household attributes such as household size were found to have a positive impact, particularly on farmers' capacity to reduce losses. Farmers with larger households are more likely to have access to a greater pool of family labor, which can be harnessed to diminish postharvest losses, particularly in labor-intensive activities like harvesting. Moreover, Rijal et al. (2021) underscored gender, ethnicity, education, demand information, and household type as pertinent factors that affect postharvest losses in vegetable production. Among these variables, gender displayed a negative correlation, signifying that male farmers are more inclined to curtail losses compared to their female counterparts. Furthermore, Begum & Marium (2022) conducted an assessment of loss determinants in the context of lemon production and identified total production, labor, transportation, storage, distance, and market location as factors that positively impacted postharvest losses. Conversely, farming experience was found to exert a negative influence on farmers' losses.

In the same study of Begum et al. (2022) focusing on pineapples, Principal Component Analysis (PCA) and factor loadings were employed to identify specific handling practices that impact postharvest losses. Through PCA, the key postharvest handling activities were ranked based on their influence on postharvest losses. Harvesting emerged as the most critical factor, followed by sorting, grading, packaging, storage, transport, and marketing practices. This finding aligns with the results of a study by Ssebagala et al. (2017) concerning rice, which utilized the same approach. In this study, six principal component factors were extracted as determinants in farmers' efforts to reduce postharvest losses. Additionally, it was revealed that losses were particularly significant during the harvesting stages at the farm level.

In the same study, factor analysis was employed to assess specific practices within each principal component, taking into account their significant factor loadings. In the case of harvesting, it was observed that rough handling and the employment of

skilled harvesters had a substantial impact on pineapple quality. Sorting practices played a vital role in reducing losses by identifying and removing low-quality pineapples. Grading practices, considering size, maturity (color index), shape, and the availability of grading machines, also had a significant influence on postharvest losses. Proper packaging materials and their availability and use were crucial factors in minimizing losses during the packaging stage. Similarly, storage practices, including the availability of appropriate facilities and storing produce in shaded areas or away from direct sunlight, significantly affected losses (Begum et al., 2022).

## **2.6 Identification of Gaps and Research Opportunities**

Despite a body of literature with similar framing and approaches, there remains limited research that has thoroughly examined the influences and repercussions of various factors, including socio-demographics, postharvest handling and management practices, and other pertinent elements that can have a notable impact on losses to a certain degree. While many studies have delved into the specificities of horticultural value chains in the Philippines, the emphasis on correlating these factors with losses continues to pose a challenge in the research domain. Gaining a comprehensive understanding of these relationships can empower stakeholders within the value chain, particularly farmers, to determine and alleviate the root causes of these losses.

In the Philippine context, numerous studies have described and evaluated localized pineapple value chains (Henry & Chato, 2019; Campita et al., 2022; Carbonell, 2015; Galvez, 2019; Lacaden, 2019). However, there are still few literatures employing similar approaches to assess the impacts of socio-demographic factors on postharvest losses, particularly at each level of the handling chain. Additionally, there are limited studies that have thoroughly evaluated postharvest handling practices and management, which can significantly impact pineapple losses at the farm-levels, while also measuring the associated challenges faced by stakeholders in the region. The results of this research are intended to contribute to a deeper understanding of the critical practices within the value chain. Furthermore, it aims to formulate suitable interventions, techniques, and strategies to mitigate losses and enhance the postharvest system for fresh pineapple within a specific locality.

## CONCEPTUAL FRAMEWORK

The conceptual framework for this study is based on the systems approach in assessing postharvest handling practices and losses along the ‘Queen’ pineapple value chain in Camarines Norte, Philippines.

The systems approach theory is based on the premise that “a system is made up of interrelated and interdependent elements, each performing a function that contributes to the operation of the whole and acknowledges that not all parts contribute to the stability of the whole system” (Sullivan & Thompson, 1991). Common to a systems approach is an understanding that they are part of a much larger system and their properties come from how their elements interact. To understand a phenomenon systematically, the nature of its relationships needs to be established while considering the context in which the phenomenon occurs. Simultaneously, an understanding of how its parts relate to each other and to the whole should be realized. (Bateson, 1987; Ackoff, 1971; Ackoff, 1995).

As a system of interconnected activities, the postharvest system is a complex network that takes place from the time of harvest to the moment of sale to the final consumer. The system ensures that food is safe, nutritious, and available to consumers. These activities include harvesting, field handling, packinghouse operations like sorting, grading, packaging, and storage, transporting/distribution, and marketing (wholesale and retail) of food. In general, the postharvest system includes all stages in the chain that occurs after production where the activity or service is intended to contribute value to the final product (Goletti & Samman, 2002). Further, postharvest handling as a system is viewed as “a purposeful collection of participants, facilities, technologies and processes that deliver harvested products to their consumers” (Prussia et al., 1986; Prussia & Mosqueda, 2006).

In the context of postharvest handling, a systems approach can be used to identify the causes of losses and their estimates at different handling stages, the factors that influence these losses, and critical control points where appropriate and best-fit solutions can be integrated in the system with the aim of improving the system and reduce losses.

The conceptual framework for this study is shown in Figure 3. The figure highlights the different systems involved in the fresh 'Queen' pineapple value chain. These are the commodity system, activity system (with focus on postharvest handling and management), the system and network of actors involved, product and information flows in the production-postharvest-consumption continuum, and other relevant features of the chain that supports the facilitation of the overall operations and management of 'Queen' pineapples in the area.

From this context, making improvements in one part of the postharvest handling system will not make the whole system efficient unless all parts are considered (Bautista & Maunahan, 2007). Since postharvest handling is an integral component in the production-consumption continuum, a systems approach is needed to address the problems on postharvest losses. A value chain approach is needed to understand the status, needs, and possible solutions and interventions for the 'Queen' pineapple industry.

By understanding the interrelationships among different features in the value chain, causes, nature and extent of losses can be identified. From these, critical control points can be identified where appropriate and best-fit solutions can be recommended in the system. Moreover, improvement opportunities in the postharvest handling will translate to a more efficient system. From these, farmers and other industry players can mitigate their losses, ensure the quality and safety of their produce and efficiency in handling their produce, and increase their incomes. Ultimately, this will impact on food and nutrition security, poverty alleviation and sustainable practices towards a more competitive 'Queen' pineapple industry.

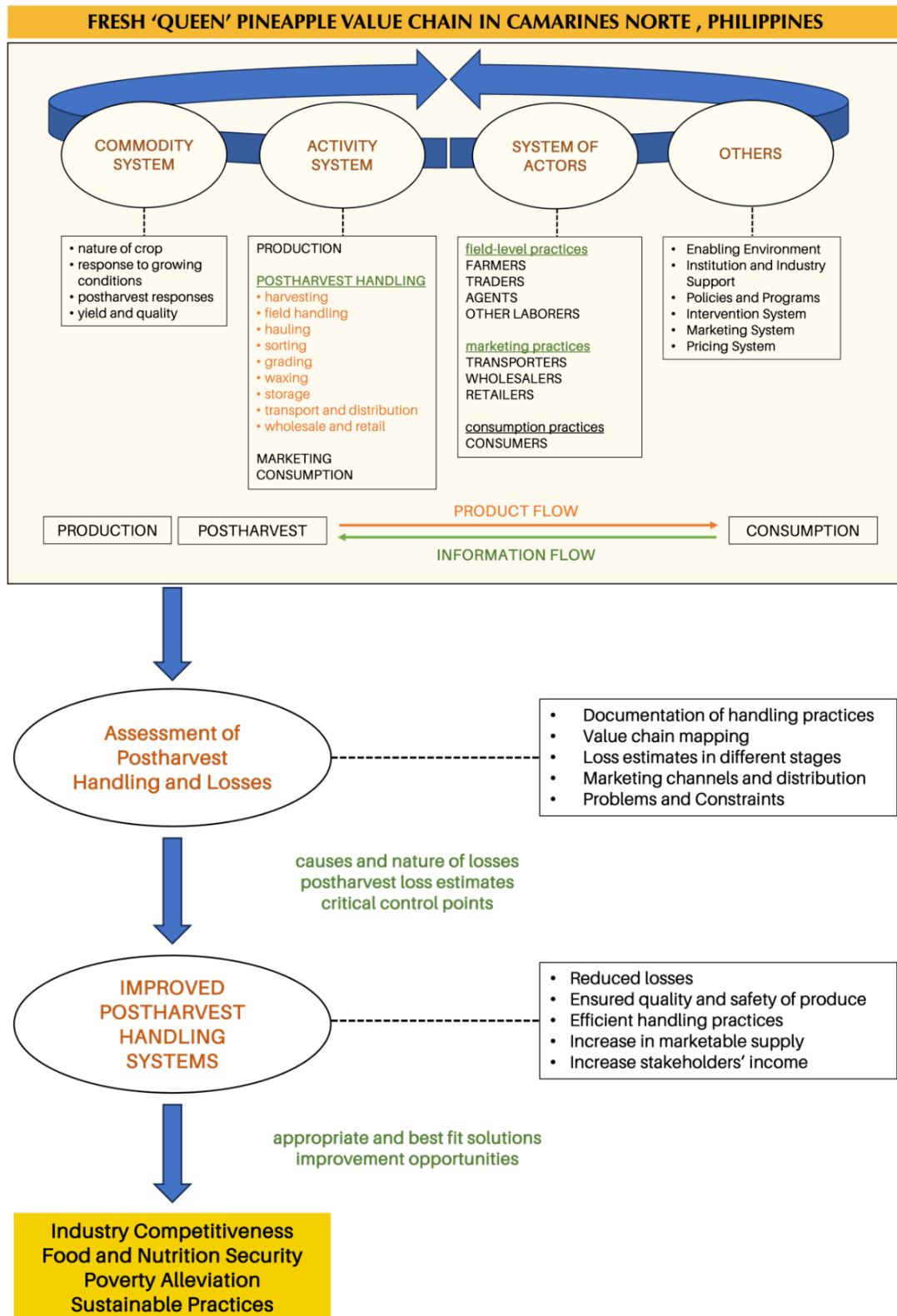


Figure 3. Conceptual framework on postharvest handling practices and reframing losses in 'Queen' pineapple value chain in Camarines Norte, Philippines.

## RESEARCH METHODOLOGY

### 4.1 Study Area

Pineapple holds a prominent status as an economically important crop in the Philippines and plays a significant role in the country's agricultural sector. Its economic importance is underscored by its substantial contribution to the nation's agriculture industry. Pineapples are also a leading export commodity, with the United States and Japan serving as major export destinations. Notably, in 2021, pineapple production in the Philippines achieved an impressive volume of 2.86 million metric tons, translating to a production value of PhP 26.1 billion (FAO, 2021; PSA, 2022).

Between 2016 and 2020, the Northern Mindanao and SOCCSKSARGEN regions, where multinational corporations like DOLE and Del Monte are situated, consistently maintained their positions as the top pineapple-producing regions in the Philippines. These regions collectively contributed 40.31% and 36.93% to the total pineapple production in the country during this period. Notably, Northern Mindanao and SOCCSKSARGEN regions primarily focused on cultivating Smooth Cayenne and other cultivars developed by the multinational companies, which are well-suited for the fresh export markets and for processing. Following closely behind are the Bicol and CALABARZON regions in Luzon, which accounted for 7.13% and 6.36% of the total production, respectively.

Bicol Region, also known as Region 5, is an administrative region in the southern part of Luzon, Philippines. It comprises six provinces: Albay, Camarines Norte, Camarines Sur, Catanduanes, Masbate, and Sorsogon (Figure 4). Recognizing the significance of the pineapple industry, the Philippine Rural Development Project (PRDP) has identified pineapple as one of the five 'priority commodities' in the region. The region predominantly grows the 'Queen' pineapple primarily for domestic consumption. The region dedicated 4,609.43 hectares to pineapple cultivation in 2020, resulting in a production of 164,162 metric tons. From 2016 to 2020, the province of Camarines Norte consistently played a pivotal role in the region's pineapple production, contributing 97% of the overall production. On average, approximately 4,166 hectares

were allocated for pineapple cultivation during this period, resulting in a total production volume of 143,851.94 metric tons.

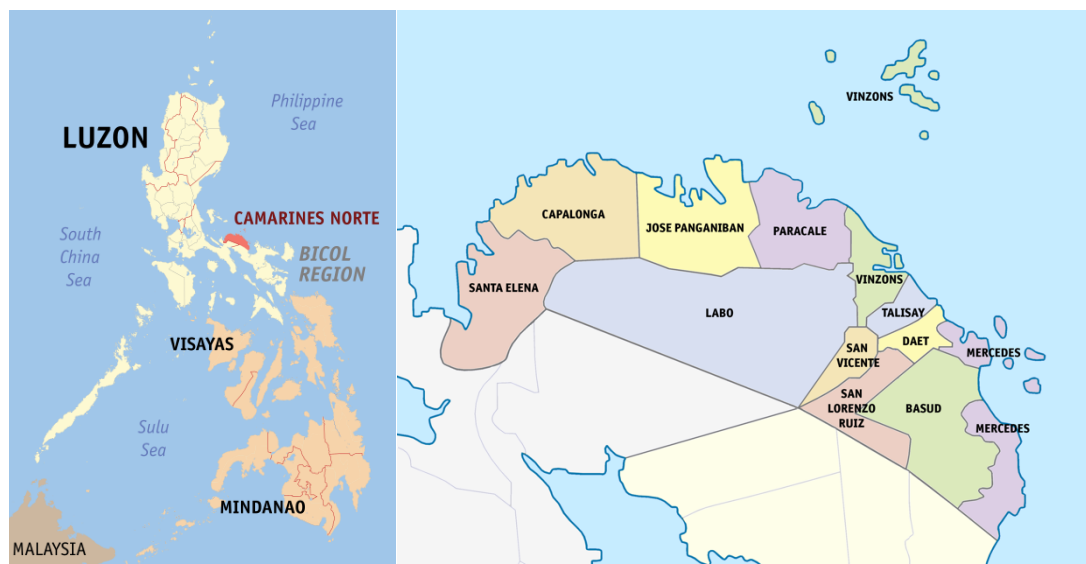


Figure 4. Geographical map of Camarines Norte, Bicol Region, Philippines.

Table 3. Production volume of pineapple in Bicol Region, by province, 2016-2020.

Rank	Province	Production Volume (in metric tons)						Ave. Growth Rate (%)
		2016	2017	2018	2019	2020	Ave.	
1	Camarines Norte	133,114	122,606	146,052	158,315	159,173	143,852	5.04
2	Camarines Sur	2,825	2,911	3,210	3,110	3,357	3,082	4.53
3	Sorsogon	1,377	1,402	1,428	1,309	1,107	1,325	-5.02
4	Albay	560	455	418	424	415	454	-6.90
5	Masbate	102	104	101	108	103	104	0.22
6	Catanduanes	13	10	8	8	8	10	-11.29
<b>Total</b>		<b>137,991</b>	<b>127,489</b>	<b>151,216</b>	<b>163,275</b>	<b>164,162</b>	<b>148,826</b>	<b>4.88</b>

Source: Philippine Statistics Authority, 2021

In 2019, the province had a total of approximately 2,265 pineapple farmers. Among this farming population, 70% of the farmers were concentrated in the municipalities of Basud, San Lorenzo Ruiz, Labo, and San Vicente (Table 4). The majority of these pineapple farms were relatively small, typically spanning one hectare or less in size, and were commonly situated in coconut-based agricultural areas.

Table 4. Area planted to ‘Queen’ pineapple and number of farmers in Camarines Norte, Philippines, 2019.

Rank	Municipality	Area Planted		Number of Farmers	Average Area per farmer (hectares)
		Hectares	%		
1	Basud	916	46.9	933	0.98
2	San Lorenzo Ruiz	460	23.6	649	0.71
3	Labo	156	8.0	217	0.72
4	San Vicente	106	5.4	117	0.91
5	Daet	85	4.4	88	0.97
6	Paracale	58	3.0	41	1.41
7	Sta. Elena	53	2.7	49	1.08
8	Jose Panganiban	45	2.3	67	0.67
9	Capalonga	43	2.2	58	0.74
10	Mercedes	17	0.9	25	0.68
11	Talisay	7	0.4	15	0.47
12	Vinzons	4	0.2	6	0.67
Total		1950	100	2,265	0.86

Source: Department of Agriculture - Philippine Rural Development Project, 2022

## 4.2 Data Collection and Sampling Procedure

To gather essential data on handling practices, challenges, and losses, a rapid appraisal was conducted. This involved key informant interviews (KIIs), focus group discussions (FGDs), and on-site observations at various points of the handling chain, including farms, packinghouses or collection centers, and destination markets for ‘Queen’ pineapple. In addition, a comprehensive survey was carried out, targeting various operations within the value chain. The survey involved face-to-face interviews and utilized pre-tested structured questionnaires and guide questions.

The survey questionnaire, designed to capture comprehensive information regarding the practices of various stakeholders within the value chain, is structured as follows:

- A. General Information
- B. Farm Profile
- C. Cultural Management
- D. Pest, Disease, and Weed Management
- E. Labor Management
- F. Harvesting
- G. Field Handling and Sorting
- H. Precooling
- I. Hauling or Transport from Farm to Collection Area
- J. Market Preparations or Packinghouse Operations
  - J.1. Availability of Facilities or Equipment
  - J.2. Sorting and Grading
  - J.3. Trimming
  - J.4. Cleaning

- J.5. Waxing
- J.6. Packaging
- J.7. Storage
- K. Transport from Collection Area to Destination Market
- L. Information and Product Flows

A sample of pineapple farmers was selected using a simple random sampling technique from the population. The study focused on the four municipalities with the highest number of farmers, namely Basud, San Lorenzo Ruiz, Labo, and San Vicente, which collectively had 1,916 pineapple farmers. Other municipalities were also included in the documentation of handling practices to map the entire value chain. In total, 211 farmers participated in the study from the selected population (Table 5).

Table 5. Number of farmer-respondents, per municipality, Camarines Norte, Philippines, 2023; ( $n=211$ ).

Municipality	Villages	Number of Respondents	Percentage
Basud	San Jose, Binatagan, Oliva, Guinatungan	65	30.81
San Lorenzo Ruiz	Daculang Bolo, Laniton, Dagotdotan, Maisog, Mampurog, Matacong	36	17.06
Labo	Lugui, San Antonio, Matanlang	32	15.17
San Vicente	Fabrica, Iraya Sur, San Jose, Asdum, Man-ogob, Cabanbanan, Calabagas	78	36.97
<b>TOTAL</b>		211	100.00

To identify various key players within the ‘Queen’ pineapple value chain, KIIs and FGDs were conducted. These activities aimed to pinpoint traders, agents, and other stakeholders involved in the ‘Queen’ pineapple industry in the region. The insights gained from these KIIs and FGDs complement the data gathered from farmers and are outlined in Table 6.

Table 6. Focus group discussions and key informant interviews conducted.

Focus Group Discussions
Farmer-leaders and members of cooperatives: Labo Progressive Multi-Purpose Cooperative (LPMPC), Caayunan Multi-Purpose Cooperative
Queen Pineapple Research and Development Center (QPRDC)
DA – Camarines Norte Lowland Rainfed Research Station (DA-CNLRRS)
Camarines Norte State College - Office of the Vice President for Research and Extension
Key Informant Interviews
Provincial Agriculture Office of Camarines Norte
Municipal Agricultural Offices of Basud, San Lorenzo Ruiz, Labo, San Vicente
QP-NICER Project Leader on ‘Gender division of labor of ‘Queen’ Pineapple Farmers

### 4.3 Data Analysis

#### 4.3.1 Descriptive Analysis

The study employed descriptive analysis to characterize the key features of the ‘Queen’ pineapple value chain, with a focus on the handling system and losses in the region. This analysis encompassed a comprehensive description of data gathered through KIIs, FGDs, surveys, and documentation of actual field practices. Relevant information were examined, including farmer profiles and characteristics, various methods and practices within each system, the nature and causes of pineapple losses, product and information flows, marketing flows, and other relevant details.

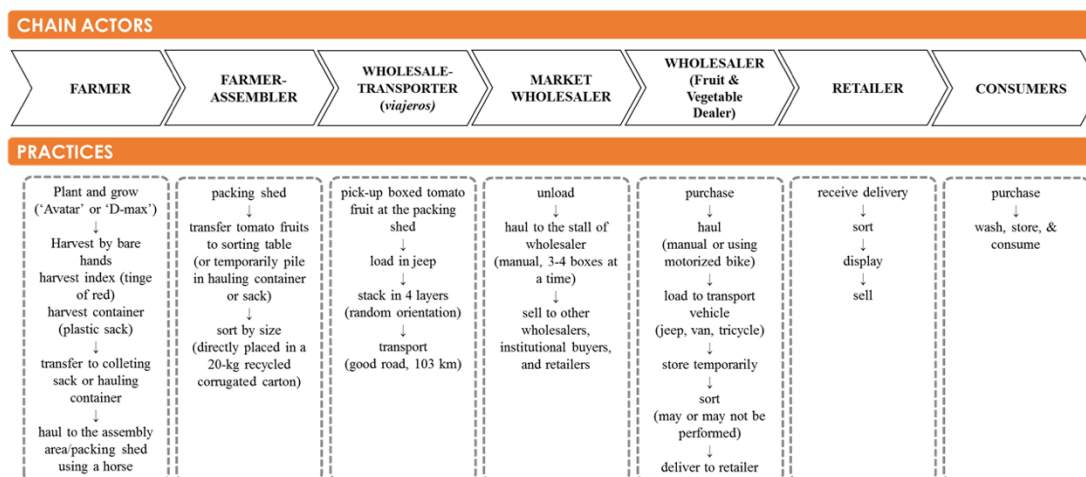
#### 4.3.2 Value Chain Mapping

Given the recognized complexity of the activity system involved in postharvest handling, a value chain map was created for this study. The map was based on primary data collected from key participants in the ‘Queen’ pineapple value chain in Camarines Norte. While existing value chain maps from the Philippine Rural Development Project (PRDP) were available, a modified version was developed to emphasize the key players and various operations within the postharvest handling system. Additionally, the map provided estimates of losses at different stages of the chain.

The approach employed in this study was adapted from previous research conducted by PHTRC & FAO in their 2018 and 2019 assessments of postharvest handling practices and associated losses within context-specific value chains in the Philippines as shown in Figure 5. Mapping of the value chain served to identify the chain actors and to trace information flows pertaining to ‘Queen’ pineapple within the study area. Practices, commencing at the farm level and encompassing postharvest handling and marketing operations, were highlighted in the value chain map. This process assisted in identifying the various issues and limitations along the chain, as well as in establishing estimates of losses and their underlying causes at each step of the chain.

The study also involved mapping the various product flows within the value chain to establish the geographical routes and channels through which ‘Queen’

pineapples travel, starting from production to consumption. Understanding the different product flows and marketing channels in the value chain is crucial in assessing the efficiency of product distribution.



(Source: FAO & PHTRC, 2018-2019)

Figure 5. Value chain mapping for selected tomato value chains in the Philippines.

#### 4.3.3 Loss Estimation and Critical Loss Points Identification

Using the data gathered from interviews, the study pinpointed the specific areas in the ‘Queen’ pineapple value chain where losses were reported. Quantitative losses were estimated based on the information provided by the respondents, while qualitative losses were determined by the practices described during the interviews. An illustration of loss estimation at various handling points was evaluated using the following criteria in Table 7.

Table 7. Sample loss estimate indicators, qualitative and quantitative (adopted from FAO & PHTRC, 2018-2019).

Nature of Losses	[ ] Marketable Reject		Farmgate price with reduction	[ ] Non-marketable Reject		
	Rejects after sorting			Nature of Losses	Loss estimates after sorting	
	in kg	in %			in kg	in %
[ ] ripe				[ ] overripe		
[ ] deformed				[ ] severe insect damage		
[ ] mechanical damage				[ ] severe deformation		
[ ] undersized				[ ] decay		
[ ] slight insect damage				[ ] _____		
[ ] _____				[ ] _____		

Critical loss points are specific stages in the food supply chain where food losses have the most significant magnitude, the greatest impact on food security, and the most substantial effect on the economic performance of the food supply chain (FAO, 2016). The study determined critical loss points in the handling chain by identifying the stages with the highest loss estimates from the survey. This approach, as well as the estimation of both pre- and postharvest losses, was adapted from previous studies conducted by PHTRC and FAO in 2018 and 2019 as shown in Figure 6.

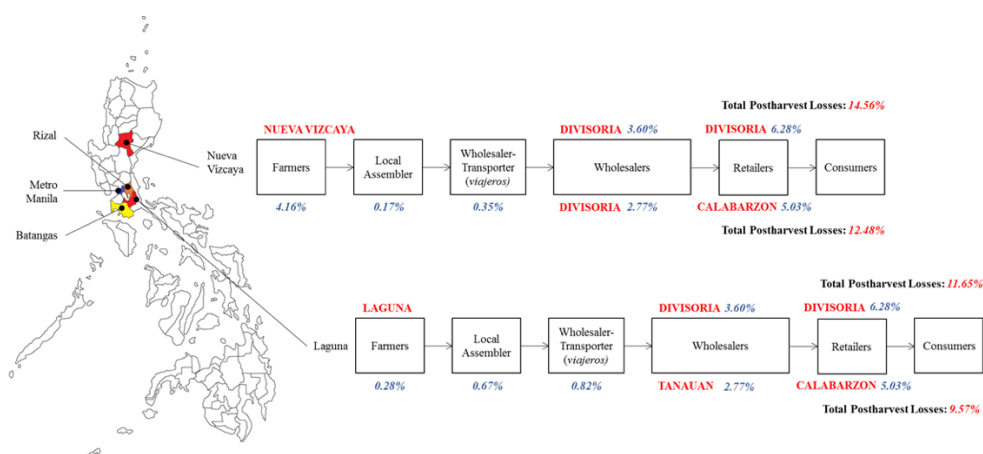
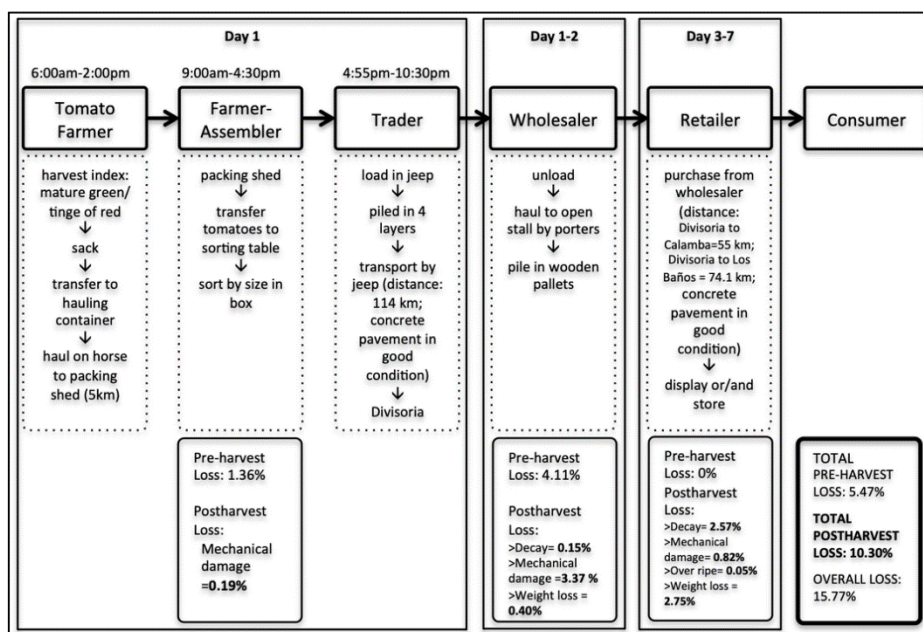


Figure 6. Postharvest loss assessment for selected tomato value chains in Laguna and Nueva Vizcaya, Philippines (adopted from FAO & PHTRC, 2018).

#### 4.3.4 Assessment of Loss Factors among Farmers

In assessing the influence of selected socio-demographic profiles, farm characteristics, and practices on losses incurred by farmers, the study employed regression analysis. To estimate the significance of these factors in relation to farmers' losses in the region, the regression model is expressed as:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \dots + \beta_nX_n + \varepsilon$$

where  $Y$  represents farmer's loss estimates,  $\beta_0$  is the constant term,  $\beta_1$  to  $\beta_n$  are the coefficient estimates,  $X_1$  to  $X_n$  are the explanatory variables, and  $\varepsilon$  is the error term.

The study employed a multiple linear regression model to assess farm losses, considering a range of socio-demographic and farm-related variables. In terms of farm-level operations, losses were categorized into pre-harvest losses and losses after harvesting, commonly referred to as harvest losses. The socio-demographic characteristics included in the analysis comprised age, gender, education, and farming experience. Additionally, farm characteristics such as size, location, land ownership, cropping period, and yield per hectare were considered to provide a comprehensive understanding of the factors affecting farm losses among farmers in the region. The variables used in evaluating the factors affecting farmer's losses is described as:

Variable	Description
Dependent	
farmlosses	farmers' loss estimates at the farm-level including pre- and harvest losses
Independent	
yearfarming	total farming experience in years
dsmall	farm size, 1 if size is less below 1.0 hectare, 0 otherwise
labo	farm location: 1 if Labo, 0 otherwise
down	land ownership: 1 if farmer owns the land, 0 otherwise
yieldperha	total yield per hectare of land
age	farmer age in years
gender	farmer gender: 1 if male, 0 if female
cropperiod	total cropping period in months
edu1	education level: 1 if farmers receive primary education, 0 otherwise

## RESULTS AND DISCUSSION

### 5.1 Farmers' Profile and Farm Characteristics

The socio-demographic profile of 211 'Queen' pineapple farmers who participated in the study, from the four leading municipalities in Camarines Norte, appears in Table 8. The predominant age of farmers ranges from 41 to 60 years old, constituting a majority at 57.82%. On average, these farmers are approximately 50 years old. This data underscores the aging demographic of the farming population and highlights the need of integrating a younger workforce to ensure the continued vitality of agricultural activities, particularly within the pineapple industry in the region.

Table 8. Socio-demographic profile of farmer-respondents in Camarines Norte, Philippines, 2023, ( $n=211$ ).

Characteristics	Frequency	Percentage	Mean	Std. Dev.	Min	Max
Age						
20 and below	1	0.47				
between 21 to 40	49	23.22	50.114	11.901	20	86
between 41 to 60	122	57.82				
61 and above	39	18.48				
Gender						
Male	103	48.42	-	-	-	-
Female	108	51.18				
Town or Village						
San Lorenzo Ruiz	36	17.06				
Labo	32	15.17	-	-	-	-
Basud	65	30.81				
San Vicente	78	36.97				
Type of Farmer						
Farmer	200	94.79				
Farmer/Trader	10	4.74	-	-	-	-
Farmer/Agent	1	0.47				
Education						
Elementary	71	33.65				
Secondary	94	44.55	-	-	-	-
Tertiary	37	17.54				
Others	9	4.27				
Household Size						
4 and below	110	52.13	4.583	1.961	1	10
5 to 7	83	39.34				
8 and above	18	8.53				

Table 8. *continued...*

Characteristics	Frequency	Percentage	Mean	Std. Dev.	Min	Max
Years in Farming						
<i>General</i>						
10 and below	62	29.38				
11 to 20	66	31.28	20.270	12.714	2	60
21 to 30	47	22.27				
31 and above	36	17.06				
<i>Pineapple</i>						
10 and below	93	44.08				
11 to 20	65	30.81	15.820	11.015	1	60
21 to 30	37	17.54				
31 and above	16	7.58				
Membership in Organization						
Yes	112	53.08	-	-	-	-
No	99	46.92				
Off-Farm Income						
With	79	37.44	-	-	-	-
Without	132	62.56				

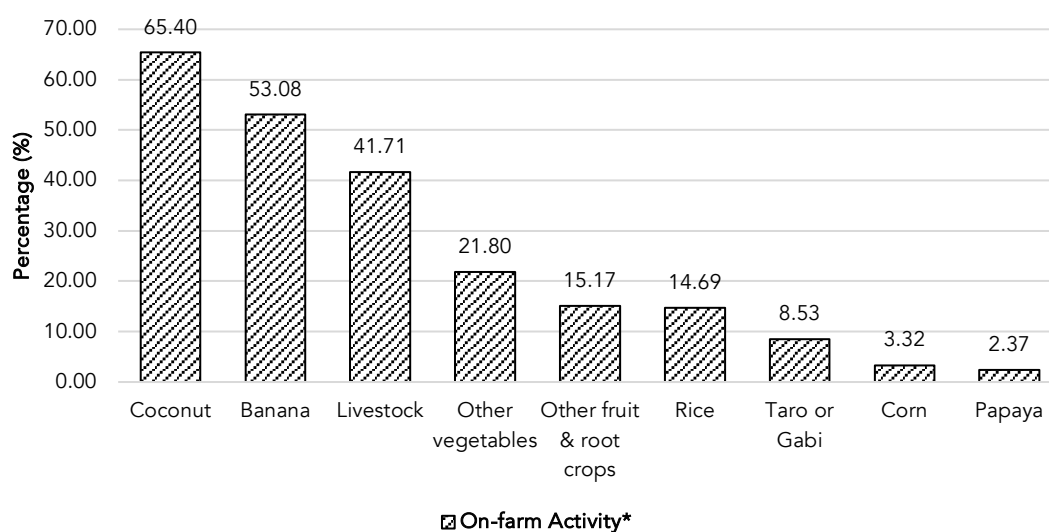
About 95% of the respondents are engaged mainly in farming while a meager 4.74% of the farmers are engaged also in trading. When examining the household and livelihood characteristics, it is evident that family farming holds a prominent position in the area. This strength is illustrated by the active involvement of both husbands and wives in farming, resulting in a gender-based representation among farmer-respondents. Agriculture is predominantly the primary source of livelihood for an average household composed of four to five members.

Regarding access to education, a substantial 78.20% of respondents have received education only up to the primary and secondary levels, with only a small minority having pursued tertiary education. This underscores the limited availability of complete formal education opportunities for farmers in the area.

In the region, farming experience spans a wide range among respondents. A significant majority of farmers have been actively engaged in farming for 11 to 20 years, with an average of 20.3 years. Specifically, within the domain of pineapple cultivation, most farmers are involved in producing the crop for a decade, with 15.8 years of experience on average. Both the years spent in farming and access to formal education play fundamental roles in shaping the overall farming expertise and skills of individuals within this farming community. Furthermore, a portion of these households

are associated with agriculture-based organizations operating within the local community (53.08%). Additionally, it is common for households to supplement their income through various off-farm activities (37.44%). This diversification in income sources underlines the adaptability and resilience of the farming households in managing their livelihoods.

While pineapple farming continues to provide the primary livelihood in the locality, majority of the farmers also practiced on-farm diversification (Figure 7). In Camarines Norte, farm diversification ranges from fruits, vegetables, root and plantation crops, and livestock production. Notably, plantation crops such as coconut (65.40%) and banana (53.08%) augment the farmers' earnings. Further, backyard livestock production (41.71%) including swine, cattle, chicken, and poultry contributes to income diversification of the farmers. These diversified farm-related activities provided livelihood strategies in enhancing their financial stability.



\*with multiple responses

Figure 7. Other on-farm activities of 'Queen' pineapple farmers, Camarines Norte, Philippines, 2023.

In general, farmers in the area tend to have relatively large total farm sizes, with over 3.1 hectares of land, as shown in Figure 8. However, the majority of these farmers (79.62%) designate 1.0 hectare or less exclusively for pineapple production. On average, each farmer owns approximately 3.62 hectares of land for various agricultural

activities, allocating an average of 1.10 hectares for pineapple cultivation. This allocation characterizes pineapple farmers in the province as generally falling under the category of smallholder farms. In addition, the total landholdings showed variability, ranging from as little as 0.25 hectare to as much as 25.0 hectares. Similarly, the production area for ‘Queen’ pineapples in Camarines Norte spans from 0.25 hectare to 7.0 hectares, reflecting the diverse scales of pineapple farming in the region.

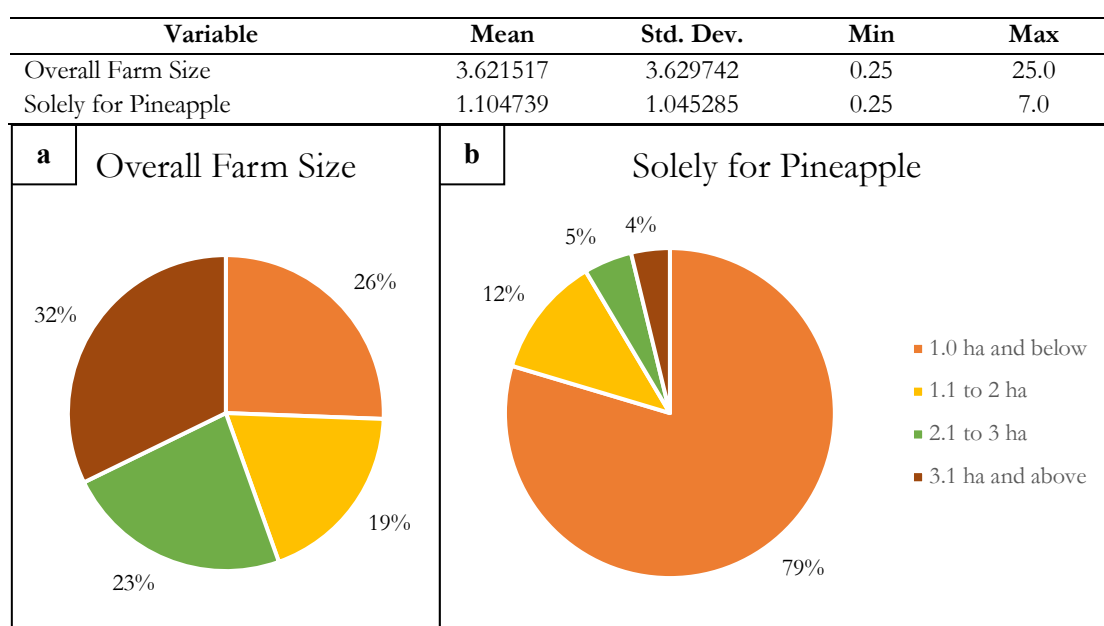


Figure 8. Farm size allocation for (a) overall production and (b) solely for pineapple, Camarines Norte, Philippines, 2023.

When it comes to land tenure and ownership, majority of farmers (54.50%) in the area are classified as farm tenants (Table 9). This means they do not have ownership of the land they cultivate and operate on plots they do not own. However, it is a common practice in Camarines Norte for farmers to operate on a certain plot without the need for leasing or renting agreements. In cases where a plot is leased or rented (9.95% of the cases), a farmer usually pays PhP 3,000.00 or US\$ 54.55 per hectare (conversion rate of US\$ 1.00 = PhP 55.00) of land used for each cropping year. Approximately 40% of the farmers in the area own the land they cultivate.

Table 9. Land ownership, topography, and cropping system followed, Camarines Norte, Philippines, 2023.

Farm Characteristics	Frequency	Percentage
Land Ownership		
Owned	82	38.86
Leased or rented	21	9.95
Tenant	115	54.50
Farm Topography		
Flat	79	37.44
Slope	95	45.02
Both	37	17.54
Cropping System		
Monocropping	46	21.80
Multiple Cropping	164	77.73
Crop Rotation	1	0.47

In the area, the predominant practice is multiple cropping (77.73%), followed by monocropping. ‘Queen’ pineapple plantations in Camarines Norte are frequently intercropped with coconut and banana. These pineapple plantations are situated either in flat terrain (37.44%) or sloping areas (45.02%) (Figure 9).



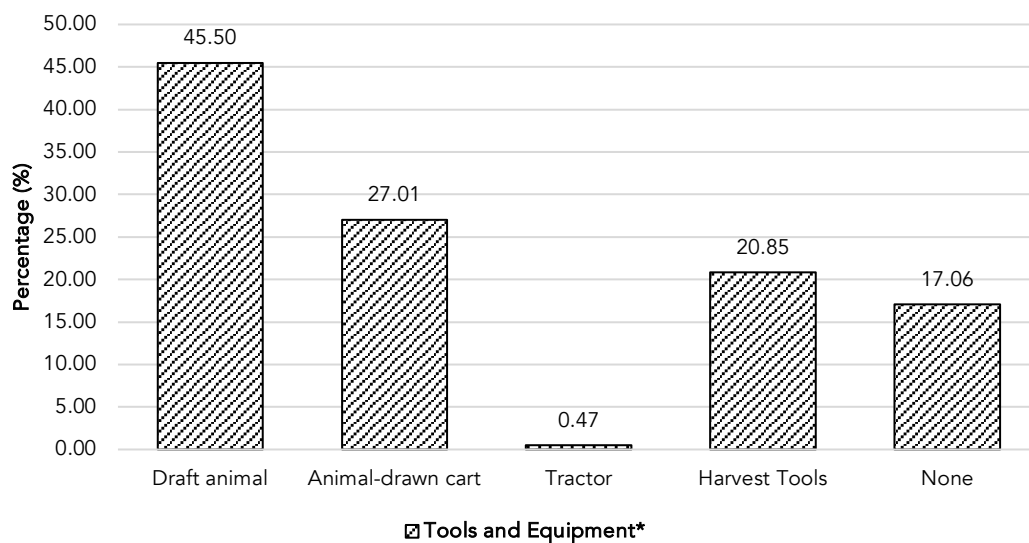
Figure 9. ‘Queen’ pineapple plantations in (a) flat terrain and (b) sloping areas; Camarines Norte, Philippines.

While majority of ‘Queen’ pineapple farms are distributed across both sloping and flat areas, waterlogging is not a problem (90.52%). In terms of soil profiling, a significant portion of farms have not undergone any soil testing (75.83%) leaving most farmer-respondents with limited knowledge of the characteristics of their soil, whether it is high in organic matter or is deficient in certain nutrient elements. Although some farmers have received assistance and had their soils tested, a vast majority (97.63%) have no knowledge on the soil profile in the area, especially on soil type and pH levels (Table 10). One contributing factor is the lack of feedback from their local agriculture officers, who often fail to transmit back the test results. Soil testing and profiling are critical for meeting the nutrient requirements and accurately determining the quantity of fertilizer needed for a given plantation.

Table 10. Soil testing and profiling of ‘Queen’ pineapple plantations, Camarines Norte, Philippines, 2023.

Item	Frequency	Percentage
Soil Testing		
Tested	51	24.17
Not tested at all	160	75.83
Soil Profile		
Known	5	2.37
Unknown	206	97.63

Regarding farm assets, majority of farmers own draft animals (carabaos) and animal-drawn carts since these are essential for day-to-day operations on pineapple farms (in Figure 10). Farmers frequently use harvest and plow tools such as the harvesting knife (referred to as *karet* in Tagalog [abbreviated as Tag.] or local term), the dagger (Tag. *sundang*), and the crowbar (Tag. *bareta*). These are the conventional tools among farmer-respondents in their farming activities.



\*with multiple responses

Figure 10. Farm tools and equipment used and owned by farmer-respondents, Camarines Norte, Philippines, 2023.

## 5.2 The Systems Approach through Value Chain Analysis

The systems approach theory is based on the premise that “a system is made up of interrelated and interdependent elements, each performing a function that contributes to the operation of the whole and acknowledges that not all parts contribute to the stability of the whole system” (Sullivan & Thompson, 1991). From the conceptual framework, the different systems in the ‘Queen’ pineapple value chain within the study area is shown in Figure 11. These components encompass the commodity system, the activity system (with a specific focus on postharvest handling and management), the system and network of actors engaged in the value chain, product and information flows throughout the production-postharvest-consumption continuum, as well as other pertinent features contributing to the effective functioning and management of ‘Queen’ pineapples in the region.

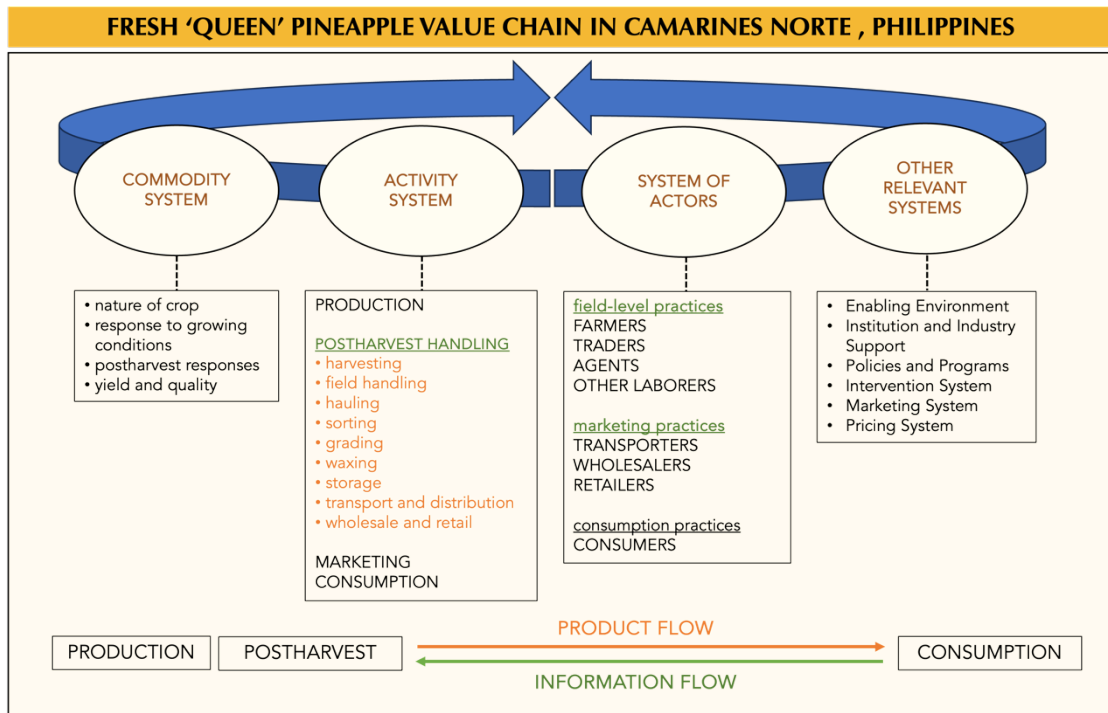


Figure 11. Interaction of systems involved in the 'Queen' pineapple value chain, Camarines Norte, Philippines, 2023.

### 5.3 Activity System

The general activity system for 'Queen' pineapples across the entire production-postharvest-consumption continuum is presented in Figure 12. The system encompasses various activities carried out by various stakeholders throughout the 'Queen' pineapple value chain. The entirety of this activity system is central to the successful production, handling, and consumption of 'Queen' pineapples in the region.

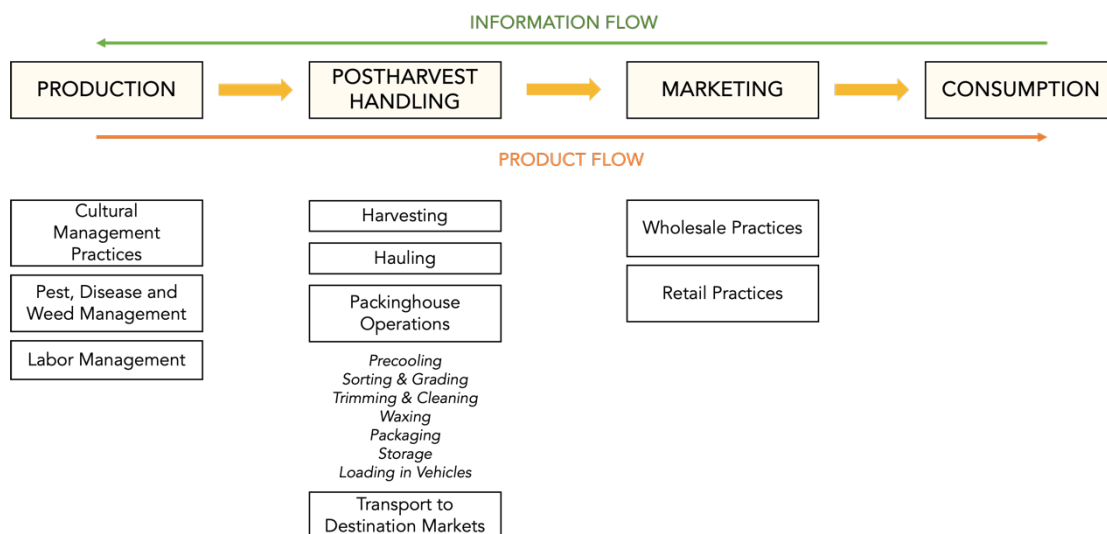


Figure 12. General activity system along the production-postharvest-consumption continuum, Camarines Norte, Philippines, 2023.

The activity system within the value chain not only encompasses the practical steps and processes but also serves as a framework for understanding relational flows, including the exchange of information and products. It is within this system that we can assess the horizontal and vertical relationships among various actors in the chain. These relationships may vary in strength, ranging from strong linkages to weak connections, and they play a crucial role in determining the efficiency and effectiveness of the entire value chain.

### 5.3.1 Production System

#### Cultural Management Practices

Four cultivars of pineapple are commercially available in local markets and among them, the ‘Queen’ or Formosa variety (Figure 13) is preferred by Camarines Norte farmers. This cultivar, although slightly smaller than the Smooth Cayenne, stands out for its exceptional sweetness and overall taste quality. In terms of physical features, the ‘Queen’ pineapple is typically conical in shape, featuring a deep-yellow and distinctively deep eyes. The fruit’s weight falls within the range of 250 grams to 1.13 kilograms, making it a convenient choice among consumers. Moreover, it has lower fiber content than Smooth Cayenne. One of its most noteworthy attributes is its enticing fragrance, which adds to the fruit’s overall appeal. The fruit itself is exceptionally juicy

and is further distinguished by a relatively small, tender core, enhancing the overall eating experience (DOST-PCAARRD, 2014).



Figure 13. 'Queen' pineapple cultivar grown in Camarines Norte, Philippines.

The Philippine National Standards (PNS) provides a thorough characterization of the common pineapple cultivars grown in the country. The standards describe the typical fruit and leaf characteristics of the 'Queen' pineapple grown in the Philippines as follows:

Table 11. Fruit and leaf characteristics of 'Queen' pineapple.

	Characteristics	Description
Fruit		
	Size	450 to 950 grams
	Core size	small
	Eyes	deep
	Shape	tapering
	Flesh color	deep yellow
	Flavor	very sweet and aromatic
	Texture	crisp
	Rind color	yellow
Leaf		
	Spiniess	spiny
	Length (mature)	68 to 86 cm
	Color	greenish

Source: PNS/BAFPS 09:2004

Pineapples are conventionally propagated using crown and shoots found along the stem either under (known as suckers) or above ground (referred to as slips). These shoots typically begin to develop upon flowering and fruiting. A single plant typically yields one crown, along with three to seven slips, and potentially up to three suckers. Crown cuttings are predominantly favored in commercial farming operations while

smaller-scale farms utilized slips and suckers for propagation (DOST-PCAARRD, 2014).

In the study area, ‘Queen’ pineapple farmers use suckers (Tag. *saha*) as their primary planting material. Majority of these farmers (81.99%) sourced their planting materials from their own plantations, which were produced from the previous cropping year. Additionally, some farmers chose to procure their planting materials from fellow farmers in the area (Table 12). Typically, the price of planting material falls within the range of PhP 1.00 to 1.50 (US\$ 0.018 to 0.027) per sucker.

Table 12. Source and method of planting for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

Item	Frequency	Percentage
Source of planting material <sup>1</sup>		
own seed	173	81.99
buy from fellow farmer	40	18.96
local agriculture office	4	1.90
private companies	-	-
Method of planting <sup>1</sup>		
single-row	210	99.53
double-row	1	0.47
intercropping	71	33.65

<sup>1</sup>with multiple responses

For the planting method, there are two primary options: single-row or double-row method, both of which require uniform plant spacing. In the study area, the prevalent method is the single-row planting (99.53%) (Figure 14). Additionally, pineapples are commonly planted as intercrop with banana or coconut, a practice adopted by 33.65% of the farmer-respondents. Regarding planting density and spacing, practices are somewhat varied and dispersed. Nevertheless, farmers typically adhere to the recommended planting density of around 30,000 plants per hectare.



Figure 14. Single-row pineapple plantations intercropped with coconut, Camarines Norte, Philippines, 2023.

### Water and Nutrient Management Practices

In terms of water management, most of the farmer-respondents (94.31%) primarily relied on rainfall and do not irrigate the pineapple plots (Figure 13). When it comes to nutrient management, all farmers fertilize the plants mainly with synthetic fertilizers to meet the nutrient requirements of the crop.

Table 13. Water and nutrient management for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

Management Practice	Frequency	Percentage
Water Management or Irrigation		
Practiced	12	5.69
Not Practiced or Rainfed	199	94.31
Nutrient Management or Fertilization		
Practiced	211	100.00
Not Practiced	-	-

To ensure optimal growth and development of pineapple plants, farmers in the study area rely on specific fertilizers containing essential nutrients, primarily nitrogen (N), phosphorus (P), and potassium (K). These nutrients play a crucial role in various aspects of pineapple cultivation, such as promoting lush green foliage, increasing leaf count, enhancing fruit size and weight, increasing total sugars, and intensifying both flesh and peel color (DOST-PCAARRD, 2014). In the region, farmers commonly apply three kinds of fertilizers: 46-0-0 (urea), 14-14-14 (complete), and 16-20-0 (ammonium phosphate), as shown in Figure 15. Urea provides a high concentration of nitrogen,

while complete fertilizer offers a balanced mix of N-P-K. Ammonium phosphate, on the other hand, provides both nitrogen and phosphorus which are vital elements for robust plant growth and fruit development.

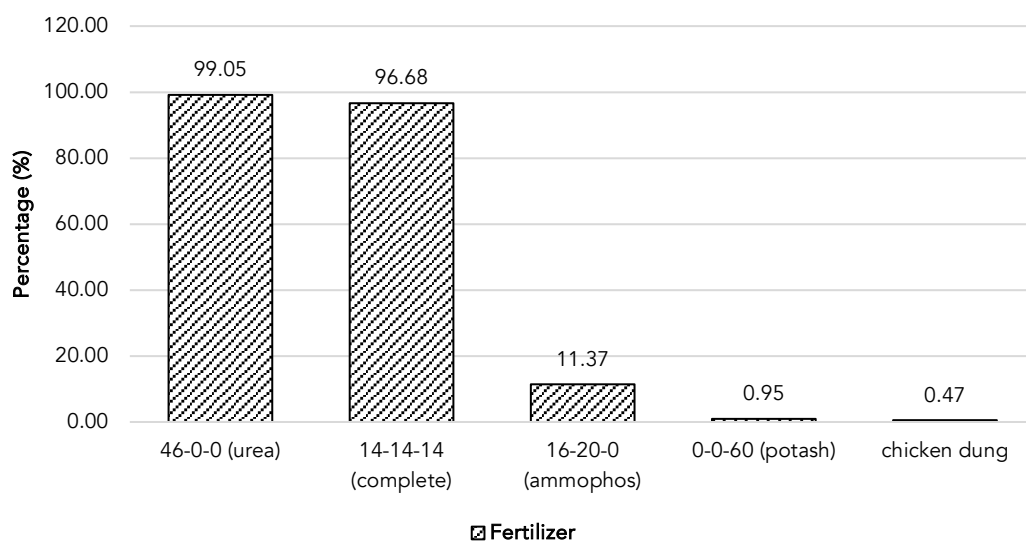


Figure 15. Common fertilizers used by farmer-respondents, Camarines Norte, Philippines, 2023.

The application methods and concentrations of these fertilizers may vary among farmers, but the prevailing practice is to apply synthetic fertilizers approximately three months after planting the suckers. Fertilizers are applied through basal placement or via foliar spraying. Throughout a single cropping year, farmers typically apply fertilizers three to four times, at three-month intervals between each application. These practices are aimed to maintain the nutrient balance required for optimal growth, yield, and fruit quality.

In ensuring year-round pineapple production and consistent flowering and fruiting, farmers in the area employed flower induction techniques. This method not only ensures continuous harvest but also considerably boosts income, especially during off-season periods. In Camarines Norte, a considerable number of farmers utilize plant growth regulators (PGRs) like ethephon and gibberellic acid ( $GA_3$ ) for increased productivity (Figure 16).

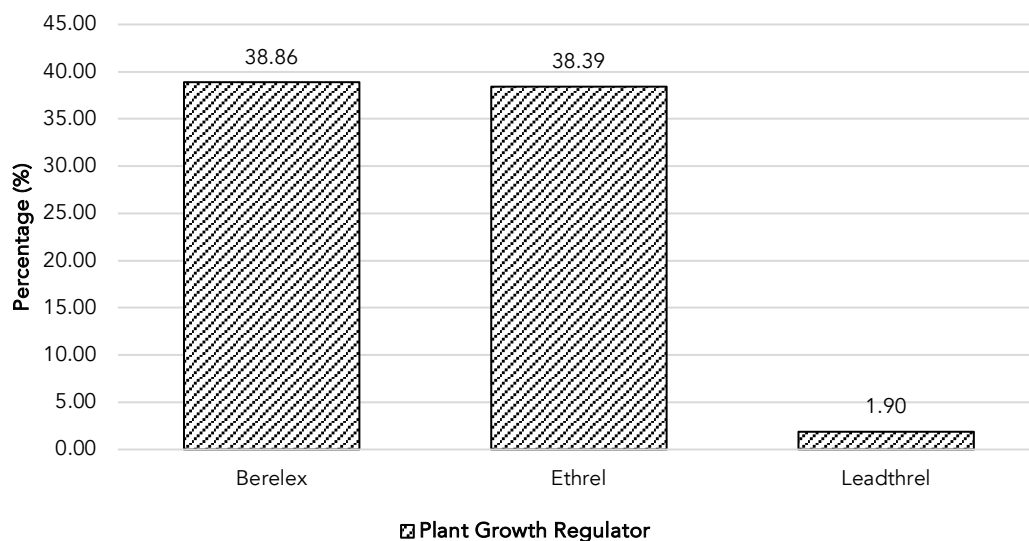
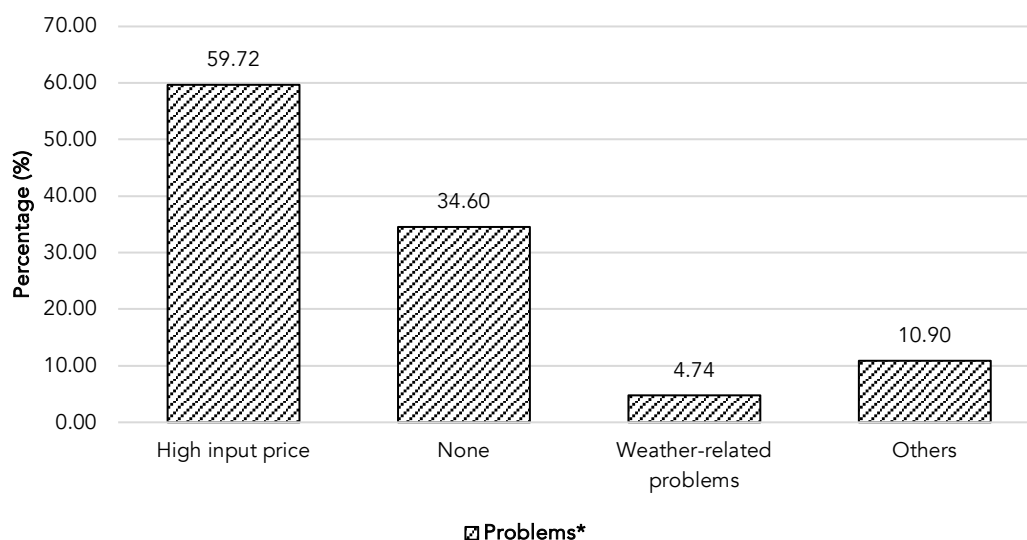


Figure 16. Common plant growth regulators (PGRs) used by farmer-respondents, Camarines Norte, Philippines, 2023.

Ethephon, commercially available as Ethrel® or Leadthrel®, is an ethylene-releasing compound that stimulates fruit ripening, abscission, sprouting, and senescence (Serrano & Bautista, 2007). This is a commonly used PGR for flower induction of pineapples (Namuco & Protacio, 2010). On the other hand, GA<sub>3</sub> promotes fruit growth and increases fruit size, significantly contributing to improved yield and quality. GA<sub>3</sub> is marketed under the brand name Berelex®.

Application methods and concentration of these PGRs exhibit variability among farmers, reflecting the diverse agricultural practices in the region. Nevertheless, a prevailing method involves the application of the ethephon solution approximately 8 to 10 months after planting. Subsequently, farmers follow up with the application of GA<sub>3</sub> solution, typically administered 10 to 12 months after planting. Both PGRs are applied as spray using a 16L-capacity knapsack sprayer. The use of PGRs ensures consistent supply of pineapple fruits, thereby enhancing the economic stability of the farming communities and sustaining the local agricultural sector.

When it comes to challenges related to nutrient management and fertilization, the majority of respondents have expressed their major concerns about the high costs of these inputs (Figure 17). Over the past three years, there has been a substantial increase in input prices, nearly doubling the previous rates.



\*with multiple responses

Figure 17. Problems encountered in nutrient management and fertilization, Camarines Norte, Philippines, 2023.

Additionally, weather-related issues pose significant challenges, particularly during rainy seasons when applying inputs becomes a difficult task. The additional labor required during rainy conditions and the dependence on synthetic inputs further compound the difficulties faced during production. It is worth noting that there is a trade-off between input levels. Using too little can result in undersized and malformed fruits, affecting the overall quality of the crop. However, a significant proportion of farmers did not experience these challenges, suggesting a degree of resiliency or adaptability within the farming community.

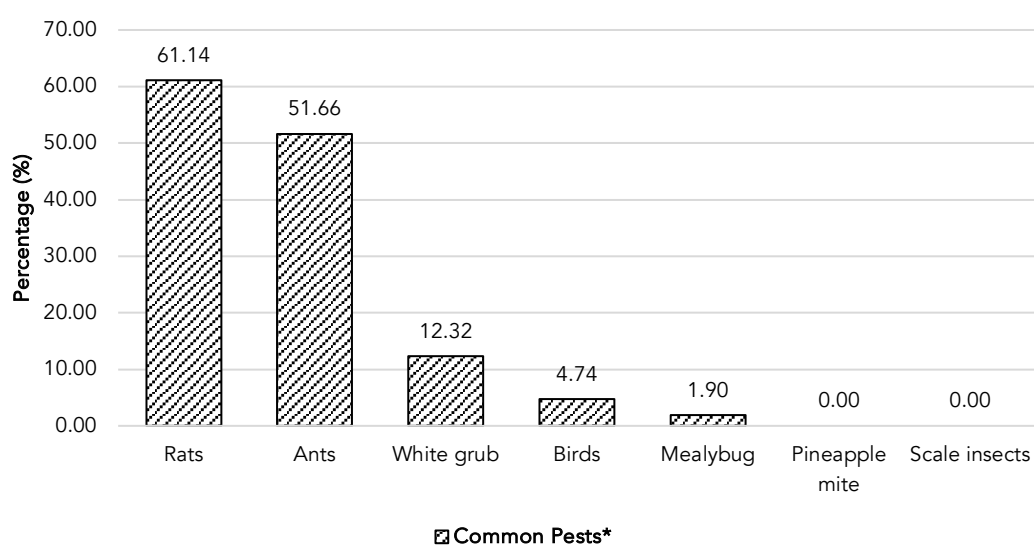
#### Pests, Disease, and Weed Management

Insect pests, diseases, and weeds tend to proliferate in pineapple plantations during growth and maturation of the crop, which pose a major challenge for the farmers. In Camarines Norte, almost all farmers reported high incidence of pests, diseases, and weed in their plantations (Table 14).

Table 14. Pest, disease, and weed incidence among 'Queen' pineapple farmers, Camarines Norte, Philippines, 2023.

Pests	Frequency	Percentage
Insect Pest and Disease	204	96.68
Weeds	206	97.63

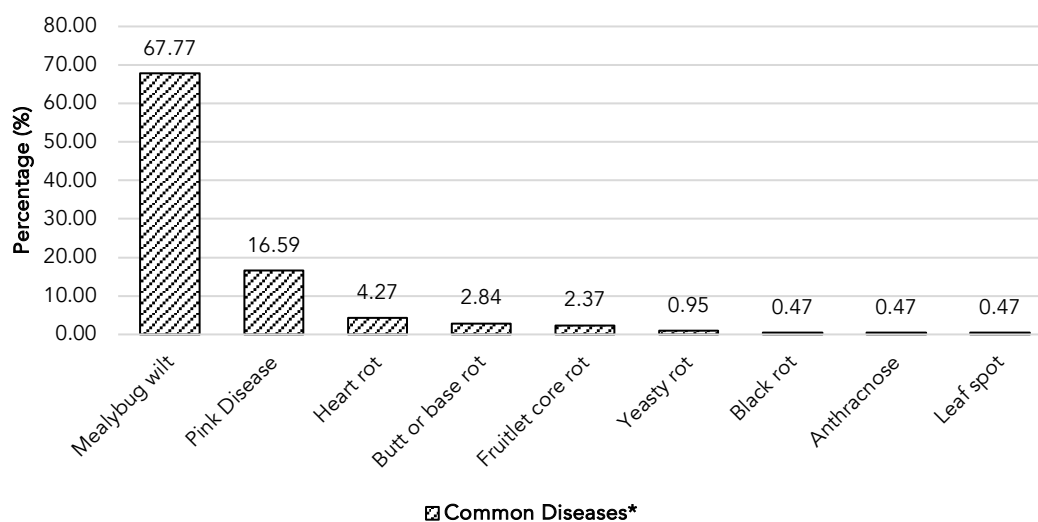
Plantations are often infested with animals like rats and birds that damage the crop leading to notable crop losses (Figure 18). Among the insect pests, ants are major concern with about one-half of the farmers reporting. Furthermore, insect pests such as white grub (*Leucopholis irrorata*) and pineapple mealybug (*Dysmicoccus brevipes*) exacerbates the situation by inflicting severe infestations on the crops (DOST-PCAARDD, 2014). These prevalent pests in plantations significantly affect pineapple production, posing as major challenges for producers.



\*with multiple responses

Figure 18. Common pests in ‘Queen’ pineapple plantations, Camarines Norte, Philippines, 2023.

In Camarines Norte, ‘Queen’ pineapples are susceptible to several diseases attributed to various pathogens, including fungi, bacteria, nematodes, and viruses. Among these diseases, mealybug wilt disease of pineapples (MWP) is the most prevalent issue, as reported by majority of the farmers (Figure 19). Locally referred to as *tungro*, this disease is caused by ampelovirus transmitted by mealybugs and is characterized by the reddening and yellowing of leaves and the dieback of leaf tips (Joy & Sindhu, 2012).



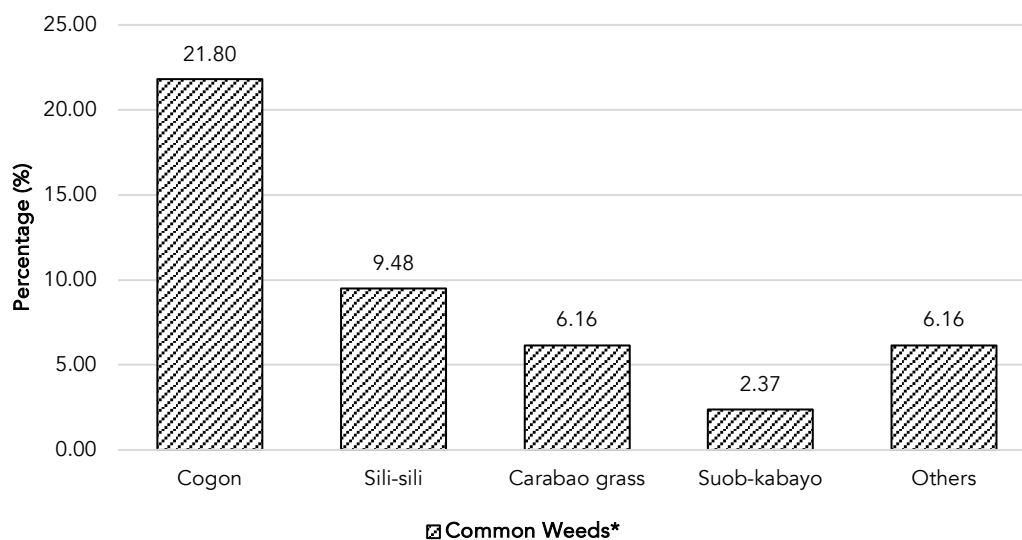
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Figure 19. Common diseases in 'Queen' pineapple plantations, Camarines Norte, 2023.

Another significant concern is the pink disease, a highly destructive postharvest disease that poses diagnostic challenges due to the absence of external symptoms in infected fruits. However, when such fruit is cut, a distinct odor emanates from the affected fleshy tissues. This disease is attributed to *Acetobacter aceti* and *Gluconobacter oxydans*. Heart rot, also known as Phytophthora heart rot, is marked by yellowing or browning with a reddish tinge in the leaves nearest to the apical bud, or 'heart.' This condition is commonly caused by *Phytophthora cinnamomi* and *Phytophthora nicotinae*. Other diseases affecting 'Queen' pineapples in the area include butt or base rot, fruitlet core rot, and yeasty rot (DOST-PCAARRD, 2014; Joy & Sindhu, 2012). Each of these diseases presents distinct challenges to pineapple cultivation and requires appropriate management.

Weeds constitute a significant constraint in pineapple production, particularly when aiming to achieve high yields, as they compete with the crop for essential resources such as nutrients, water, and sunlight. Among the weeds, cogon grass (*Tag. kogan*, *Bicol. gugon*) emerges as the most prevalent in the field (Figure 20). In addition to cogon grass, other commonly encountered weeds in 'Queen' pineapple plantations are locally referred to as *sili-sili*, *suob-kabayo*, *kangkong-kangkungan*, and *kara-*

*kawayan*. These weeds collectively pose challenges for pineapple growers, necessitating effective weed management strategies to optimize crop production.



\*with multiple responses

Figure 20. Common weeds in 'Queen' pineapple plantations, Camarines Norte, Philippines, 2023.

In eliminating pests in the field, farmers in the area employ a range of management practices. For the management of pests and diseases, it is customary for farmers to adopt cultural techniques like field sanitation (Table 15). Additionally, the use of pesticides, such as insecticides and rodenticides, are the common chemical method to combat the pests. Mechanical strategies in managing the pests include manual removal of pests and infected plant parts. These strategies are integrated into various stages of crop production to minimize the adverse impacts of pest and disease on yield and fruit quality.

Table 15. Pest and disease management strategies of 'Queen' pineapple farmers, Camarines Norte, Philippines, 2023.

Pest and Disease Management Strategy	Frequency	Percentage
Cultural	83	39.34
Field Sanitation	80	37.91
Crop Rotation	3	1.42
Biological	-	-
Mechanical	18	8.53
Manual exclusion	13	6.16
Direct killing	4	1.90

Table 15. *continued...*

Pest and Disease Management Strategy	Frequency	Percentage
Trapping system	1	0.47
Bounty system	-	-
Chemical	50	23.70
Insecticides	35	16.59
Rodenticides	18	8.53
Fungicides	-	-
Integrated Pest Management	-	-

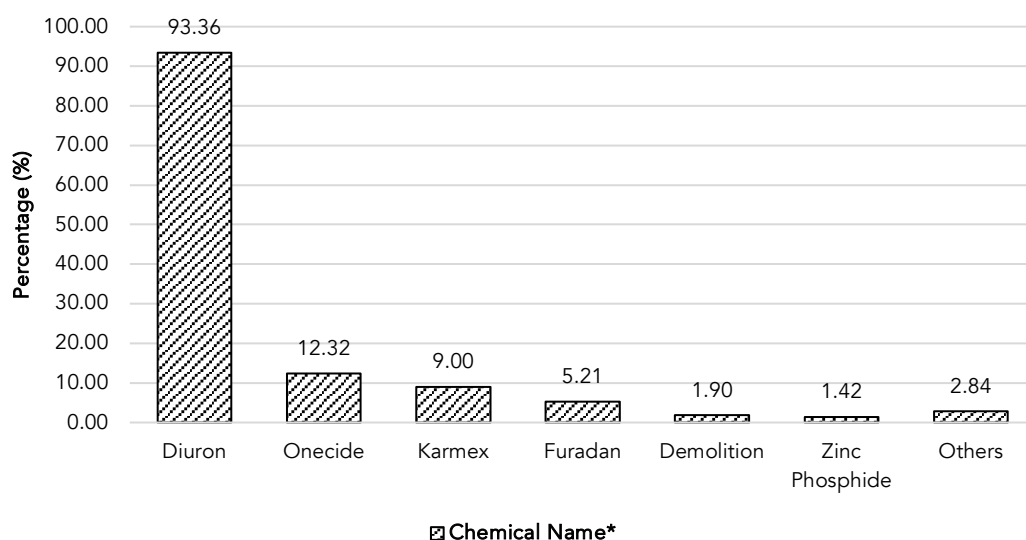
Weed management systems encompass a variety of practices designed to effectively control weed growth in the field. Cultural methods like hand weeding or hoe slashing are widely practiced (Table 16), typically carried out during the early stages of crop growth. In Camarines Norte, traditional tools like *sulisod* or *sundang* are commonly used. The *sulisod* is a single-bladed hoe with an extended handle, designed for efficient weed removal while minimizing strain on the farmer.

Table 16. Weed management strategies of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023.

Weed Management Strategy	Frequency	Percentage
Preventive	-	-
Cultural	90	42.65
Harrowing	-	-
Hand weeding	90	42.65
Mulching	1	0.47
Intercropping	-	-
Mechanical	33	15.17
Cutter	-	-
<i>Sulisod (sundang)</i>	30	14.22
<i>Carmona (karet)</i>	3	1.42
Chemical	204	96.68
Herbicides	204	96.68
Weedicides	-	-
Integrated Weed Management	-	-

The most widely adopted method involves the use of herbicides, chemicals that target and eliminate weeds while causing minimal to no harm to the crop. Herbicides can be categorized based on the timing of their application, with options for both pre-emergence and post-emergence weed control (DOST-PCAARRD, 2014). Diuron, marketed under the brand Diuron 80WP, is a pre-emergence herbicide and is widely applied for controlling weeds in the region (Figure 21). Similarly, Karmex DF, another

pre-emergence herbicide, contains diuron as its active ingredient, offering selective weed control in specific crops. Additionally, Carbofuran (Brand: Furadan) and Fluazifop-P-butyl (Brand: Onecide 15EC), which function as broad-spectrum insecticides and nematicides, effectively targets an extensive range of foliar pests, soil pests, and nematodes (Tu et al., 2001; EPA, 2016). In addressing common field pests such as rats, zinc phosphide is the rodenticide of choice. Application concentrations of these chemicals vary from farm to farm, and the frequency of application depends on the severity of pest, diseases, and weed incidence. Typically, these chemicals are prepared as solutions and applied in the field through foliar spraying using a 16L-capacity knapsack sprayer.

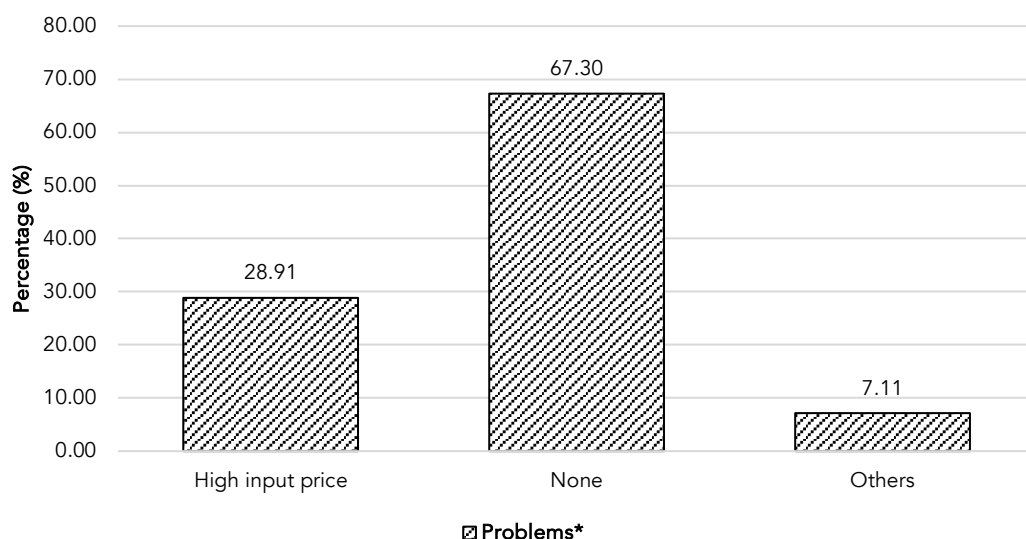


\*with multiple responses

Figure 21. Common chemicals used in controlling insect pests, diseases, and weeds in 'Queen' pineapples, Camarines Norte, Philippines, 2023.

When it comes to managing pests, diseases, and weeds, the majority of respondents (67.63%) reported that they have not encountered significant issues when adopting different management strategies in the field (Figure 22). However, it is important to note that 28.91% of the surveyed farmers highlighted challenges related to input costs. Similar to fertilizers, high input price is a big burden to the farmers considering their limited financial resources. Other problems include the difficulty of implementing management strategies, particularly when using chemical inputs. This challenge is further compounded by labor-intensive operations and adverse weather

conditions, making it harder to apply these strategies effectively. Despite these challenges, the majority of farmers continue to adapt to the evolving pest, disease, and weed management in their fields.

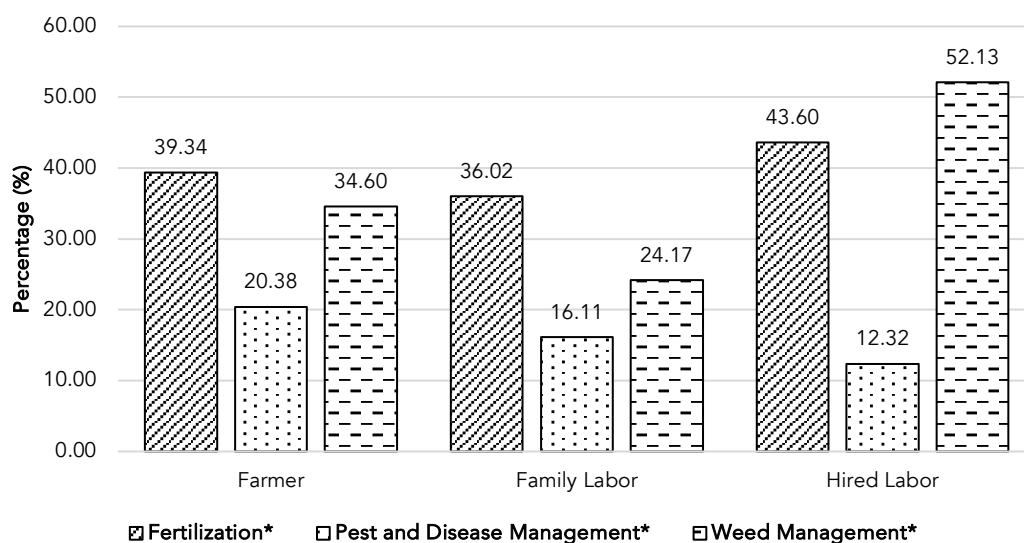


\*with multiple responses

Figure 22. Problems encountered in insect pest, disease, and weed management, Camarines Norte, Philippines, 2023.

### Labor Management

Labor management in pineapple plantations varies depending on the nature and intensity of the field work. Field laborers can be categorized into farmers themselves, family labor, and hired labor, and these labor types can significantly impact field operations. As depicted in Figure 23, hired laborers play a crucial role in labor-intensive activities such as fertilization and weed management, primarily through foliar spraying applications. Conversely, pest and disease management typically require the least labor input and are often neglected by farmers, thus pest problems persist in the field. In cases where manual removal of infected and infested plants is necessary, this is primarily done by farmers and family members.

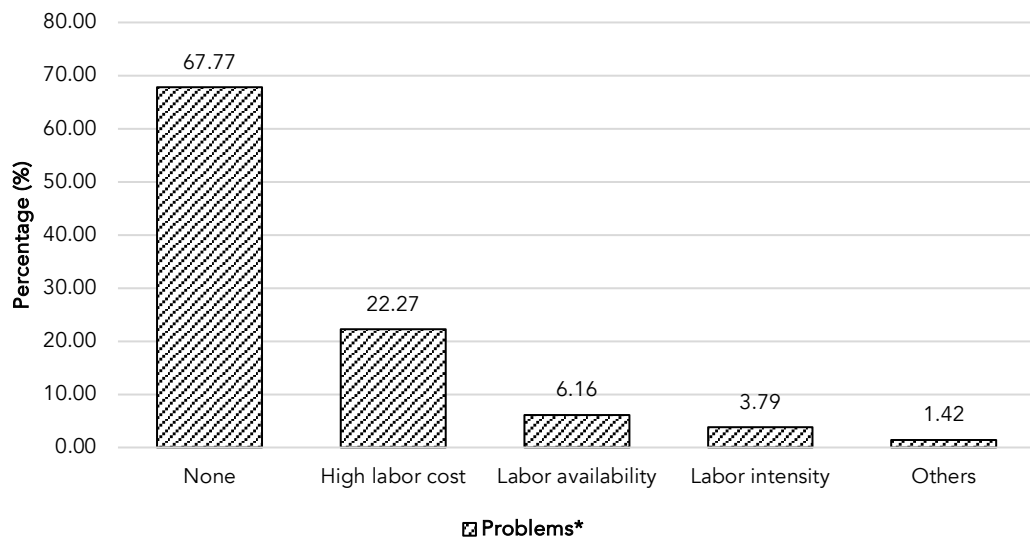


\*with multiple responses

Figure 23. Labor input for production-related activities for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

Family labor also plays a significant role in overall labor management, especially in fertilization and weed management. When hired labor is not available, family members, including spouses and children, contribute to these farming activities. This not only lessens the number of working hours but also reduces the overall costs associated with hiring additional laborers for fieldwork. By strategically allocating labor based on the specific needs of each task and utilizing family labor when needed, farmers can optimize their resources and enhance the efficiency of field operations. This approach allows for better adaptation to the labor demands of production activities, leading to improved productivity and cost savings.

When it comes to labor management challenges, majority of the surveyed farmers reported none to minimal issues in labor inputs for specific activities (Figure 24). However, a substantial portion highlighted a few prevalent problems. High labor costs are primary concern (22.27%), with many farmers struggling with the costs associated with hiring laborers in labor-intensive activities. Another issue frequently cited was the availability of labor, particularly as hired laborers are typically not permanent laborers in the field. The nature of these farm workers disrupts field activities.



\*with multiple responses

Figure 24. Problems encountered during labor management in production-related activities, Camarines Norte, Philippines, 2023.

Additionally, the intensity of labor-related activities posed a significant challenge, encompassing concerns related to the number of working hours and man-days allocated to specific activities. Balancing the demands of different tasks with the available workforce can be a challenge and may require more efficient scheduling and resource allocation. Addressing these labor management challenges may necessitate exploring cost-effective solutions, such as mechanization or improved workforce scheduling, to enhance productivity and mitigate the financial strains associated with labor-intensive pineapple production.

### 5.3.2 Postharvest Handling System

Postharvest handling refers to both science and technology, covering principles that explain the behavior and changes as well as the series of operations a harvested crop undergoes to maintain its desired quality until it reaches the consumers (Bautista & Maunahan, 2007). The main goal is to maintain the quality and ensure safety of commodities while being brought to consumers on time. This also includes meeting buyers' specifications and trade requirements.

As a system of interconnected activities, postharvest handling system is a complex network that takes place from the time of harvest to the moment of sale to the final consumer (Figure 25). These activities include harvesting, field handling, packinghouse operations like sorting, grading, packaging, and storage, transporting/distribution, and marketing (wholesale and retail) of food. In general, the postharvest system includes all stages in the chain that occurs after production where the activity or service is intended to contribute value to the final product (Goletti & Samman, 2002).

In the specific context of ‘Queen’ pineapples in Camarines Norte, the handling system involves a series of planned activities (Figure 25). Starting from harvest, these activities encompass hauling from farms to designated collection areas, market preparations, transport to destination markets, and the interplay of wholesale and retail practices. Along the value chain, the primary focus remains on ensuring the quality of harvested pineapples until they reach their intended markets. The key challenge lies in minimizing postharvest losses while efficiently delivering the produce through the coordination of diverse actors involved in the ‘Queen’ pineapple value chain in the region.

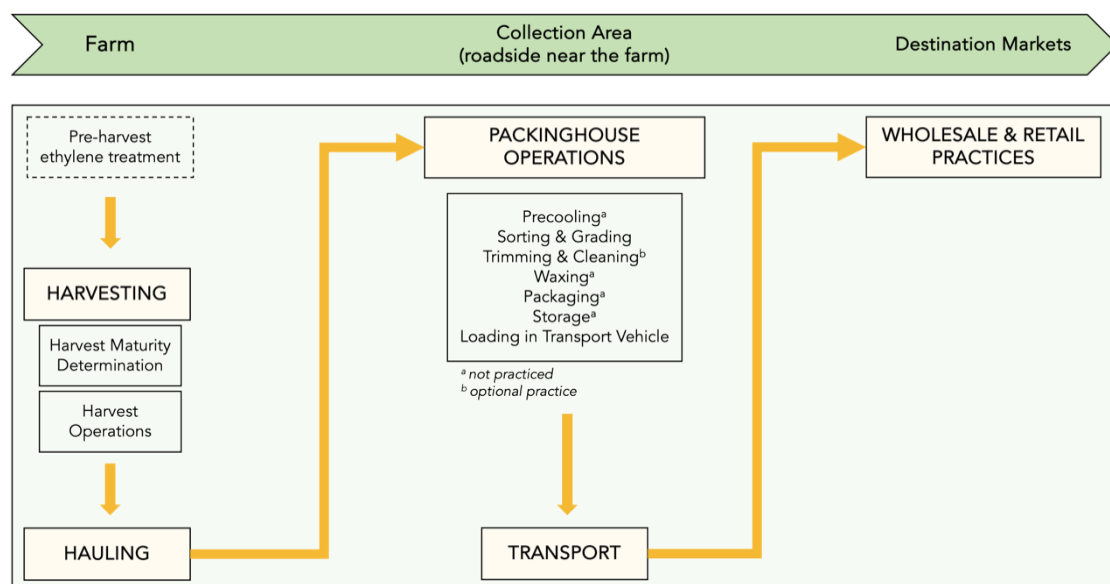


Figure 25. Overview of postharvest handling system along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.

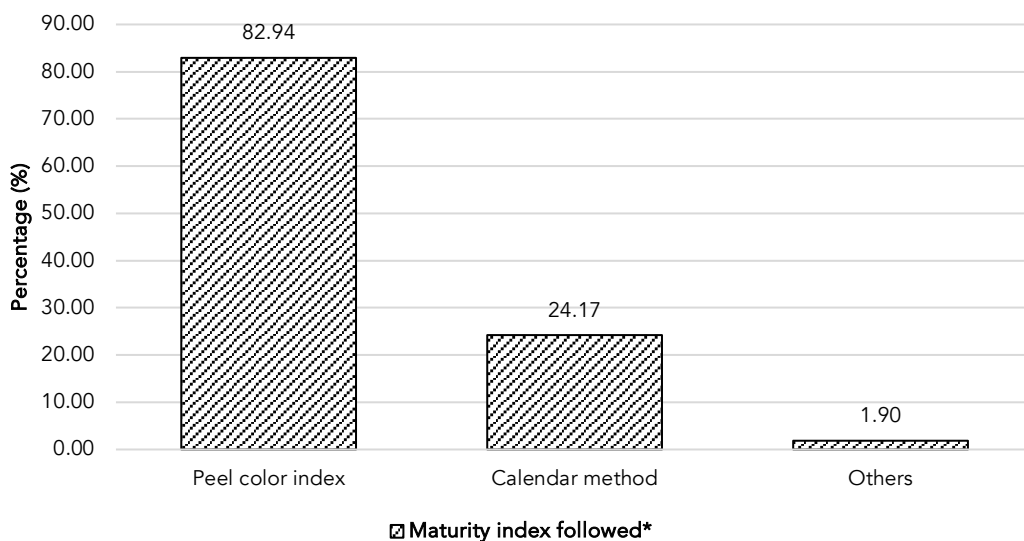
### 5.3.2.1 Harvesting

Pineapples are considered non-climacteric fruits, which signifies that fruits exhibit slight ripening changes after harvest. Therefore, it is important to harvest pineapples at the right stage of maturity and when fruits are ready to be consumed (Kader & Yahia, 2011). In the case of ‘Queen’ pineapples, their eating quality do not improve after harvest. Given that quality is established the moment fruits are removed from the mother plant, right harvest maturity and proper harvesting techniques must be observed.

#### Harvest Maturity Determination

Pineapple, being a compound fruit, exhibits a physiological development pattern where the fruitlets or “eyes” ripen sequentially, starting from the base portion of the fruit and advancing towards the top (Paull & Chen, 2003). Precise harvest maturity indices serve as guides in the decision on when ‘Queen’ pineapples are ready to be picked.

In Camarines Norte, majority of farmers (82.94%) gauge harvest readiness of ‘Queen’ pineapples through the change in peel color using the Peel Color Index (PCI) (Figure 26). Farmers in the region primarily rely on a particular color change, known locally as ‘*silay*’, characterized by the emergence of a subtle yellow tinge from the fruit’s base, as a gauge of harvest readiness. In essence, pineapples are harvested when majority of the fruits in the plantation start exhibiting yellowing within the range of one to three layers of the eyes from the base (1 to 3 *silay*). This perceptible change in peel color, is considered a fundamental parameter.



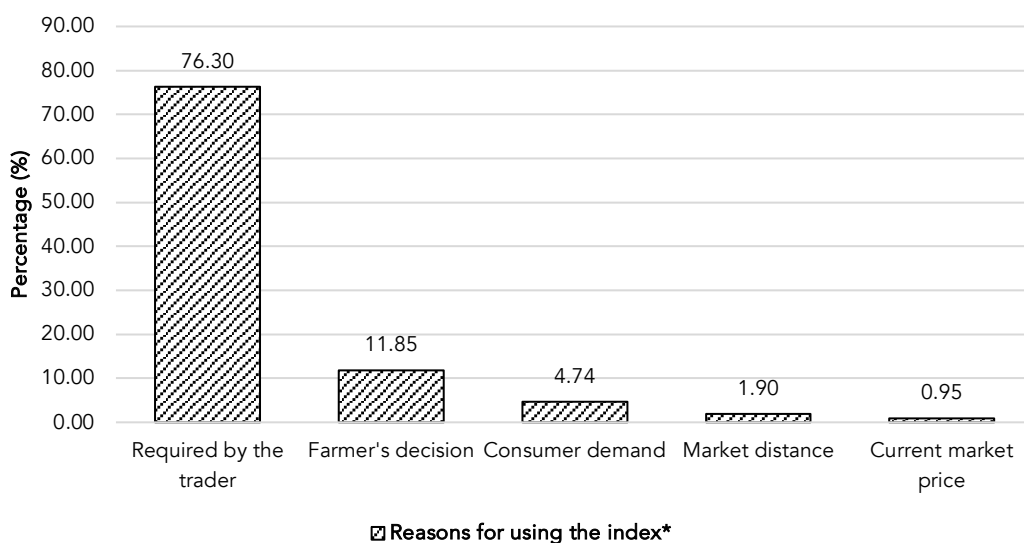
\*with multiple responses

Figure 26. Maturity index followed by ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

In conjunction with PCI, other external quality parameters are also taken into consideration for the precise harvest time. These include evaluating the fruit’s size appropriate with the varietal attributes and the fruitlet’s (“eyes”) flatness or widening. The combination of indices contributes to a more accurate determination of the ideal harvest maturity.

The other maturity index reported by 24.17% if the farmers is based on the calendar method, which relies on the calculation of days or months from flower induction. Notably, among farmers in the region, the method is often applied, with a prevailing consensus to harvest ‘Queen’ pineapples approximately four to five months after the application of GA<sub>3</sub> (Berelex®).

Most commonly, it is the traders who dictate the optimal time for harvesting and the appropriate maturity of pineapples (Figure 27). Moreover, other determinants influencing the harvest timing encompass the farmer’s own judgment, assessing whether the fruits in their plantations have attained the right maturity stage. Consumer demand, market proximity, and the prevailing market prices also influences the decision regarding the right time of harvest.



\*with multiple responses

Figure 27. Reasons for following the harvest maturity index for 'Queen' pineapples, Camarines Norte, Philippines, 2023.

Although a significant portion of the surveyed farmers relies on peel color for assessing pineapple maturity, it is worth noting that still, majority (89.57%) of them are unaware of the Philippine National Standards (PNS) that establish the usage of these indices in evaluating pineapples (Table 17). Table 18 and Figure 28 provide a comprehensive description of the peel color index for 'Queen' pineapples as set in the PNS.

Table 17. Awareness on maturity index set by Philippine National Standards, Camarines Norte, Philippines, 2023.

Item	Frequency	Percentage
Awareness on PNS		
Aware	22	10.43
No idea	189	89.57
Adoption of PNS <sup>1</sup>		
Follows the index	8	36.36
Do not follow	14	63.64

<sup>1</sup>percentage from those who responded 'aware'

Adhering to these standards is recommended in ensuring that quality 'Queen' pineapple is already established at harvest. Harvesting at either the immature or advanced maturity stages can significantly impact the quality of the pineapples. Harvesting immature fruits yields undersized pineapples with white flesh and off-flavor

development, which directly detracts from the expected quality. On the other hand, harvesting at the full yellow or more advanced stages (PCI 6) results in overripe fruits that are more vulnerable to mechanical damages, further compromising their quality.

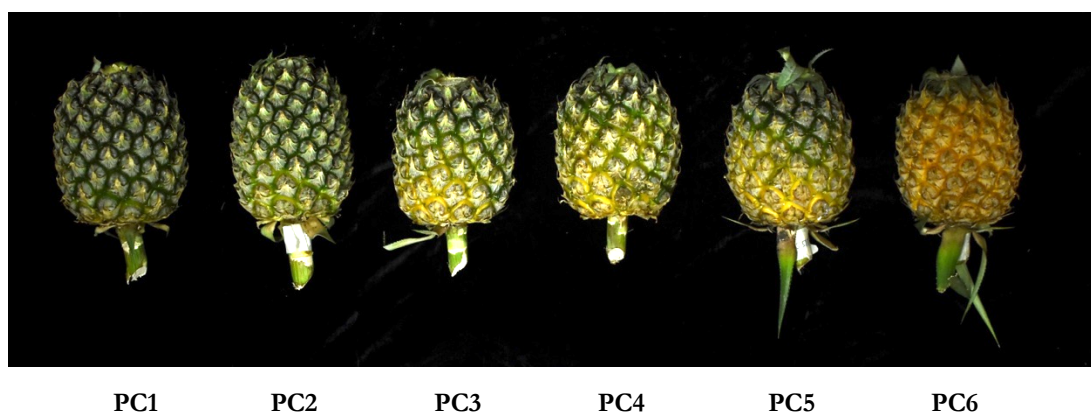


Figure 28. Peel color index chart for 'Queen' pineapple.

Table 18. Peel color indices of 'Queen' pineapple based on the Philippine National Standards.

Peel Color Index	Description
PCI 1	All eyes are dark green; greenish bracts cling tightly to the eyes (immature)
PCI 2	All eyes are green; whitish bracts are dry; grooves between eyes show separation and yellowing
PCI 3	About 2-3 layers of the eyes at the base show yellowing
PCI 4	Fifty percent (50%) of the eyes are yellow
PCI 5	More than 75% of the eyes are yellow (overripe)
PCI 6	Full yellow (overripe)

Source: PNS/BAFPS 09:2004

### Pre-harvest Ethylene Treatment

To facilitate consistent and uniform harvesting, some farmers and traders in the area employ a pre-harvest ethylene treatment. They spray the fruit with ethephon (2-chloroethyl phosphonic acid; Brand name: Ethrel®), an ethylene-releasing compound that induces coloration and ripening in pineapples (Serrano & Bautista, 2007). In this practice, Ethrel® is either sprayed or injected into the pineapple fruits three to five days, or in some cases up to one week before the expected harvest. After this pre-harvest ethephon treatment, traders will then advise that the fruits are ready for harvest. The scheduling of this practice is typically determined by the traders, aiming to achieve uniform degreening and to enable simultaneous harvesting of pineapples from three to

four different plantations within a single day. This strategy ensures maximum or full loading onto transport vehicles, optimizing the efficiency of pineapple distribution.

However, a consequence of this practice is the observation of inferior eating quality, particularly in terms of dissatisfaction with the expected taste of ‘Queen’ pineapples. This concern is especially pronounced at the retail and consumer levels, as noted by the farmers. Even though treated fruits often display a yellow peel color, indicating full ripeness, a common issue with eating quality is the persistence of a sour taste or lack of sweetness. These effects stem from the fact that pineapple fruits are still physiologically immature and do not possess all the chemical attributes responsible for the full development of taste, flavor, and aroma. Pre-harvest ethephon treatment will only induce the change in peel color of immature fruits but will not enhance sweetness.

The existing practice has raised significant concerns within the area, as farmers often perceive it as a potential threat to the industry, Camarines Norte being known as producer of sweet tasting ‘Queen’ pineapples. Given that ‘Queen’ pineapple is renowned for its exceptional sweetness, consumer perceptions, particularly regarding the fruit’s flavor and taste, are exceptionally high. Local regulations in the form of Administrative Order (AO) related to the practice of pre-harvest ethephon treatment can be issued by the local government units of the respective municipalities to ensure that only high-quality pineapples make their way to the end markets, thereby maximizing consumer satisfaction. Ultimately, such a move can be regarded as a safeguard to preserve the region’s reputation of offering top-quality, sweet ‘Queen’ pineapples.

### Harvest Operations

Manual harvesting is the predominant method employed by all farmers in the study area, primarily due to the absence of large-scale commercial plantations that would justify the use of mechanized equipment such as conveyor type harvesters. Hand-harvesting entails gently snapping the fruit from the stalk using a downward motion, commonly referred as the “twist-and-bend” technique (Tag. *pigtas*) (Figure 29). The

fruit's crown is left intact which serves as protection from damage and for the fruit's visual appeal. Removal of crown from the fruit can diminish its overall aesthetic appeal.



Figure 29. Manual harvesting method of 'Queen' pineapples, by snapping and use of harvest tools (*bolo*), Camarines Norte, Philippines, 2023.

Farmers typically use long knives, locally known as '*bolo*' or '*itak*,' as their primary harvesting tools. The process involves making a clean cut just below the base of the fruit, where the peduncle or stalk is already trimmed. However, some farmers adopt a slightly different approach, leaving a significant portion of the stalk intact, approximately 5 to 7 cm in length. This practice is particularly common when the fruit is destined for local markets within the province, such as Daet public market. Leaving a sizeable stalk attached to the fruit allows for easy bundling or packing, typically done in bundles of ten.

The manual harvesting method employed by the farmers generally works well and does not present significant challenges (58.29%). Nonetheless, some farmers have reported instances of pineapple damage resulting from this harvesting method (Figure 30). Mechanical damage during harvesting includes cuts and abrasions due to the use of harvest tools, bruising (Tag. *lanog*), fruit breaking or cracking due to hand pulling, and deformed fruits due to rough handling. Other problem includes fruits unintentionally left in the field, as reported by few farmers (3.32%), leading to yield losses.

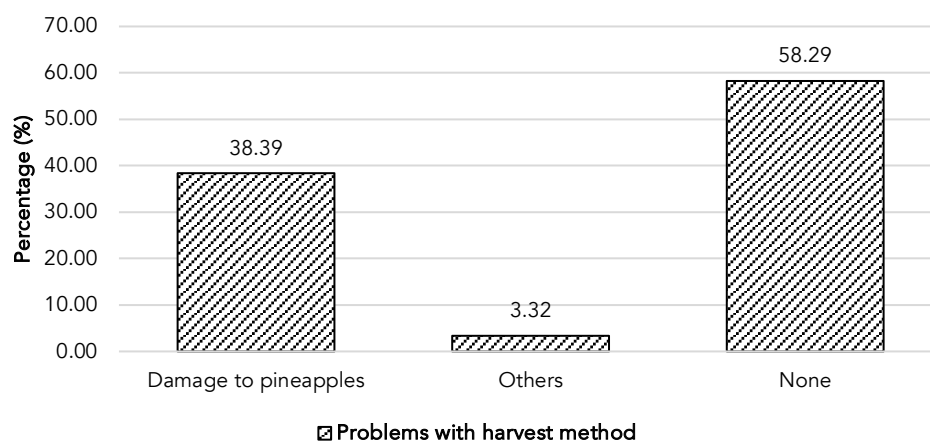
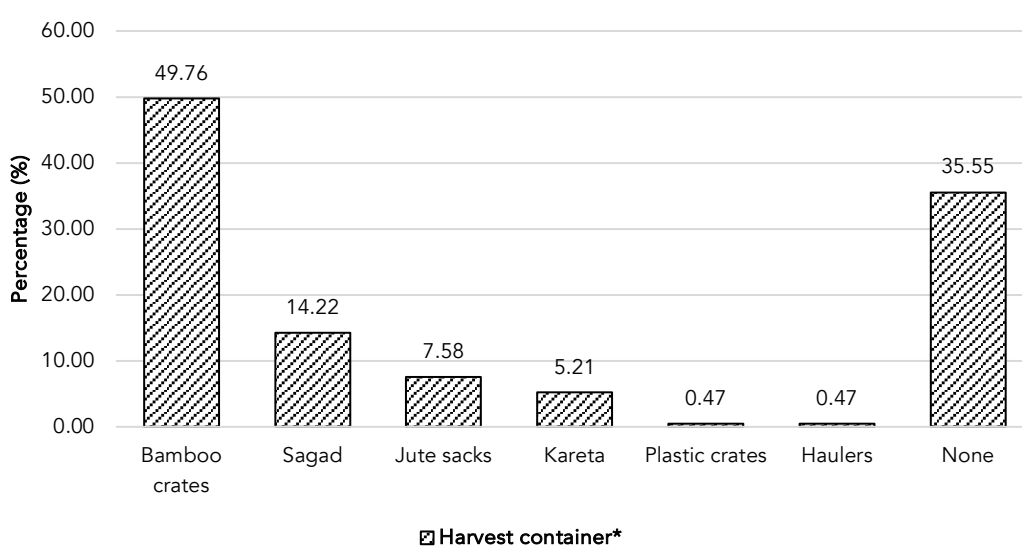


Figure 30. Problems reported with the harvesting method, Camarines Norte, Philippines, 2023.

Farmers utilize a variety of field containers in their harvest operations, as shown in Figure 31. These containers exhibit diversity not only in terms of the materials used but also in their rigidity. It is common for farmers to use bamboo crates, locally referred as *'kaing'* or *'tiklis'*, as the preferred container for freshly harvested *'Queen'* pineapples (Figure 32). Additionally, harvested fruits are also placed in other containers, such as jute sacks or bulk-loaded (without any packaging) in animal-drawn carts (Tag. *sagad* or *kareta*). Some farmers place the harvested fruit along field rows, awaiting subsequent hauling to the collection area.



\*with multiple responses

Figure 31. Field harvest containers used, Camarines Norte, Philippines, 2023.



Figure 32. Common field harvest containers for ‘Queen’ pineapple: (a) bamboo crates, (b) *kareta*, (c) *sagad*, and (d) directly in the field, Camarines Norte, Philippines, 2023.

The primary purpose of using field harvest containers is to protect pineapples from potential damage. As depicted in Figure 33, this method is effective and does not pose substantial problem or concern as reported by majority of the pineapple farmers (63.51%). However, some farmers have also encountered mechanical damage issues related to rough handling when placing harvested pineapples into field containers. Common issues stemming from the use of harvesting containers include bruising, cuts, and fruit punctures, which are typical causes of mechanical damage. Although pineapple fruits have a thick peel or shell, they are susceptible to mechanical damage like punctures caused by sharp edges or rough inside finish of the containers.

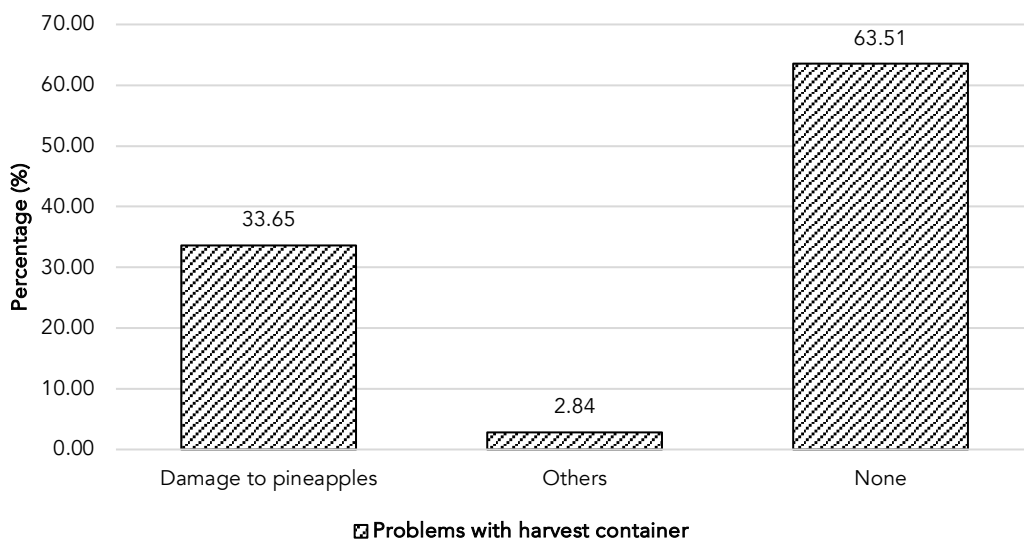


Figure 33. Problems reported on the use of harvest containers, Camarines Norte, Philippines, 2023.

In the study area, the timing of the actual harvest varies from farm to farm. However, it is a common practice for farmers to initiate their operations in the early hours of the morning (Figure 34). Given the considerable volume of pineapples to be harvested, many start their operations as early as 02:00 in the morning. A small percentage of farmers in the area start their harvest from afternoon to early evening and midnight.

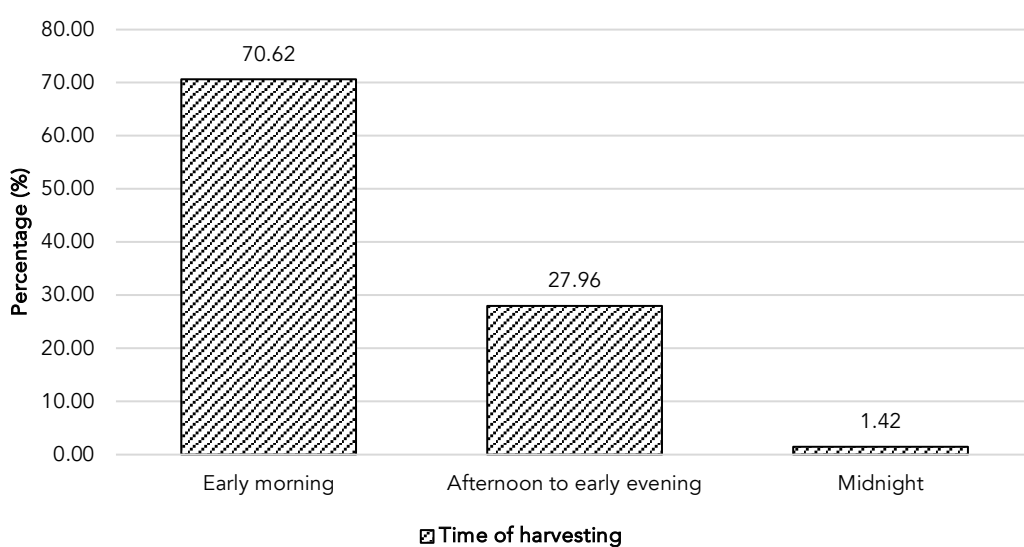


Figure 34. Time of harvest operations for 'Queen' pineapple, Camarines Norte, Philippines, 2023.

The primary reason behind the practice of early morning harvest is the need to immediately transport harvested pineapples to wholesale markets, particularly those intended for Metro Manila markets. Travel time can be quite lengthy, often spanning 12 hours or even more, depending on actual transport conditions. To prevent pineapples from being exposed to hot temperatures, especially during morning when the sun is intense, commencing at early hours of the day is prevalent. During peak harvest seasons when the volume of pineapples is even higher, operations may start even earlier, often beginning in the late evening, typically around 21:00, and continue through the early morning hours. This adjustment in timing ensures that pineapples reach the market in the best possible conditions and maintains their freshness.

The early morning harvest practice appears to be generally effective in the area, with the majority of farmers reporting no issues related to the timing of harvest (Figure 35). However, one recurring challenge is the exposure of both the harvesters and the harvested ‘Queen’ pineapples to high temperatures, especially when harvesting is carried out in the afternoons. Conversely, for early morning harvests, a common issue is the difficulty of harvesting when light conditions are not optimal.

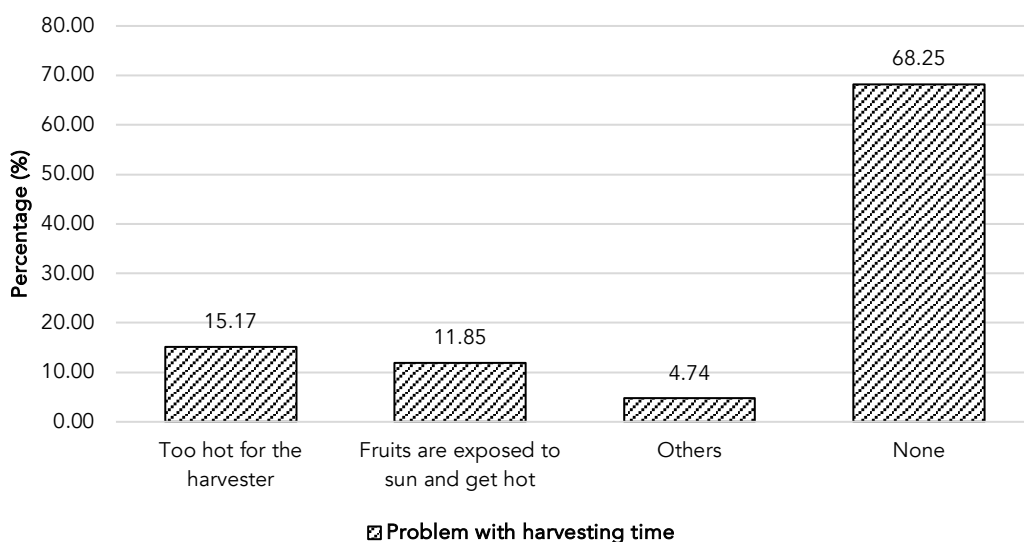


Figure 35. Problems encountered with the harvesting time for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

As harvesting is conducted during the cooler parts of the day, exposure to the sun or hot environment is avoided. Nevertheless, in situations where harvested

pineapples might be subjected to sunlight, a common practice is to provide field shade (Figure 36). Field covers, such as canvas tarpaulins and coconut leaves, are frequently used to mitigate the effects of sun exposure on freshly harvested fruits (Figure 37). This practice is prevalent in the region because temperature build up in the fruit will enhance ripening and other quality changes.

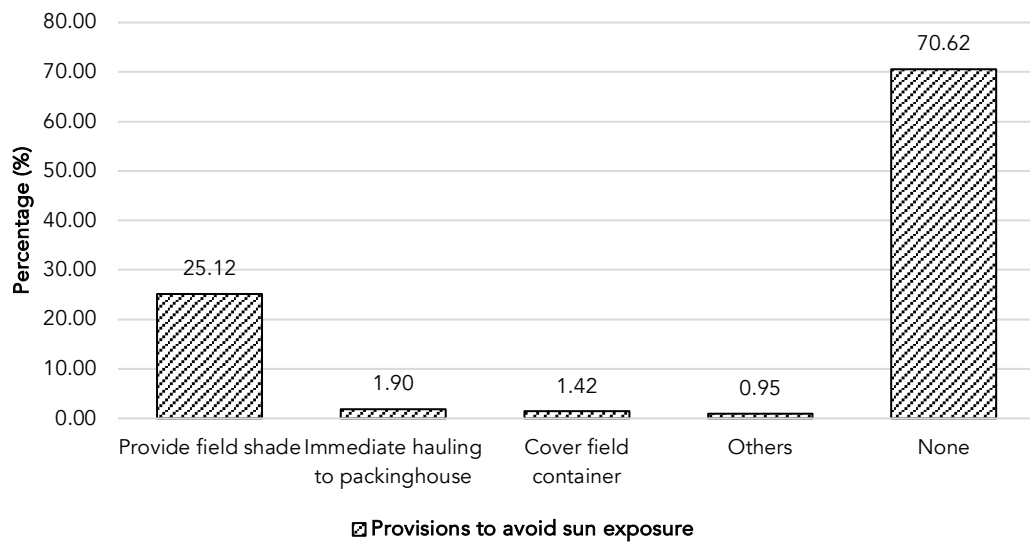


Figure 36. Provisions to avoid sun exposure of pineapples, Camarines Norte, Philippines, 2023.



Figure 37. Provision of field shade on harvested pineapples using coconut leaves, Camarines Norte, Philippines, 2023.

### *Yield and Preharvest Loss Estimates*

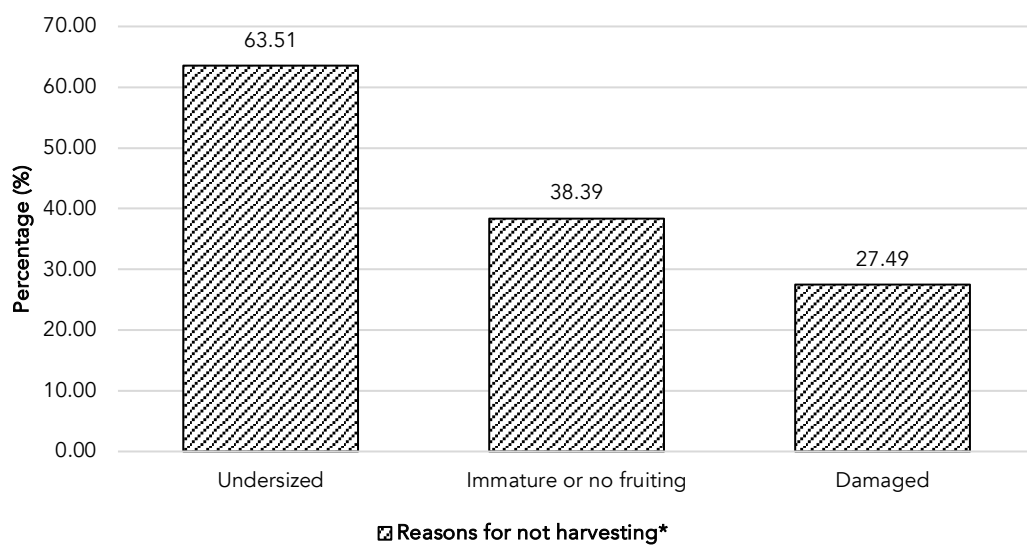
Table 19 provides a summary of the yield and value from producing ‘Queen’ pineapple in Camarines Norte. Over the course of a single cropping year, the average yield is approximately 14,800 pieces per hectare. This translates to an average production value of roughly PhP 85,000.00 per hectare (equivalent to US\$ 1,545.45 per hectare).

Table 19. Summary of ‘Queen’ pineapple yield, value, and pre-harvest losses reported at the farm-level, Camarines Norte, Philippines, 2023.

Variable	Unit	Mean	Std. Dev.	Min	Max
Farm Size	ha	1.104739	1.045285	0.25	7
Total Yield	pieces	11630.37	9572.321	800	92000
Total Value	PhP	66928.57	63579.99	2000	500000
Average Production Yield	pieces per ha	14817.6	11236.56	400	72000
Average Production Value	PhP per ha	85079.69	70461.47	1650	400000
Volume Not Harvested	pieces per ha	2123.077	3622.824	0	40000
<b>Preharvest Losses</b>	<b>percentage</b>	<b>14.92823</b>	<b>15.42599</b>	<b>0</b>	<b>83.00</b>

In a single plantation, it is a common occurrence for farmers to incur losses even before the actual harvest due to various factors. These factors encompass aspects such as crop physiology, environmental conditions, adverse weather events, pest and disease infestations, and cultural management practices. These factors collectively influence the growth and development of ‘Queen’ pineapples and are characterized as preharvest losses. These preharvest losses pertain to pineapples that are unsuitable for harvesting, excluding mature fruits. On average, from the reported figures, approximately 2,100 pineapples per plantation are not harvested. This translates to an estimated preharvest loss of 14.93% in the study area (Table 19).

As reported in Figure 38, reasons for not harvesting that contribute to preharvest losses are predominantly due to undersized fruits, accounting for 63.51% of reported losses. This is followed by immature fruits (Tag. *batibot*), or plants with no fruiting at 38.39%. Damaged fruits, primarily resulting from insect and pest infestations, also contribute to the unharvested fruit count (Figure 39). Notably, while these preharvest losses are quite significant, majority of farmers (65.40%) still perceive these types of losses not a major concern.



\*with multiple responses

Figure 38. Nature and causes of pre-harvest losses in 'Queen' pineapples, Camarines Norte, Philippines, 2023.



Undersized and immature fruits



Insect- and Pest-damaged Fruits

Figure 39. 'Queen' pineapple fruits considered as pre-harvest losses, Camarines, Norte, Philippines, 2023.

#### *Loss Estimates at Harvest*

The prevalent manual harvesting practice in the area contributes significantly to postharvest losses due to the rough handling of fruits. Mechanically damaged fruits typically exhibit fruit cracking, severe compression, and the crown being removed from the fruit due to the "twist-and-bend" method (Figure 40). These damaged fruits are considered non-marketable rejects that are discarded even before they reach the hauling stage. The estimated non-marketable rejects that are considered as outright losses amount to approximately 5.042% (Table 20).

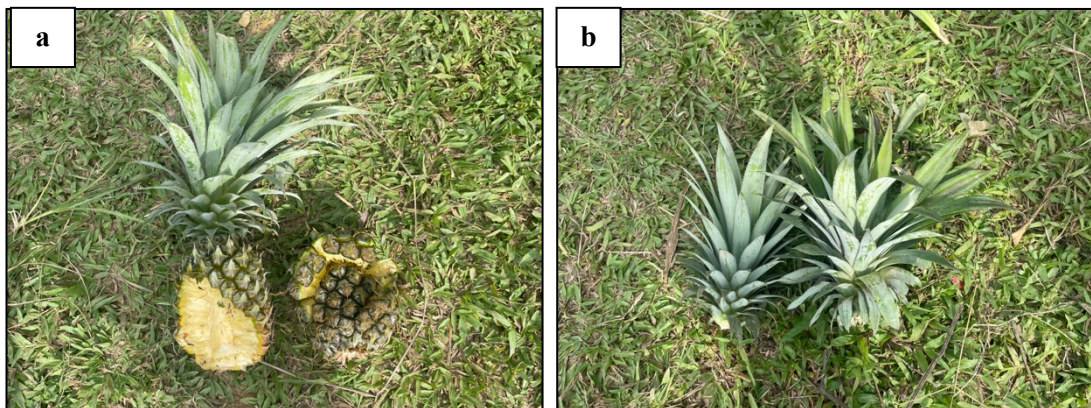


Figure 40. Nature of non-marketable rejects at harvest: (a) fruit cracking and severe compression, (b) detached crown, Camarines Norte, Philippines, 2023.

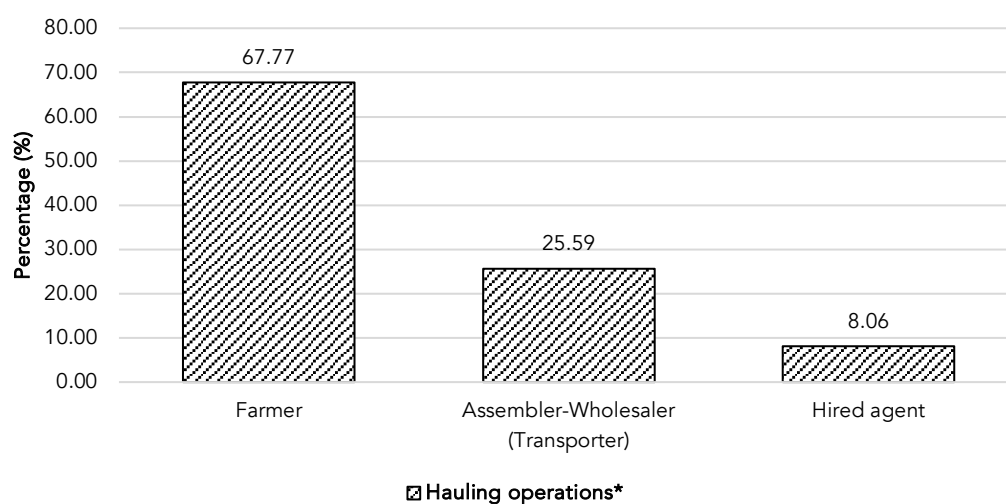
On the other hand, freshly harvested fruits that meet market standards, which include good quality fruits, slightly undersized, and those with minor deformities, slight compression, or abrasions, are hauled to the collection area. Consequently, marketable rejects often go unnoticed at the early stages of harvesting and are identified only during the sorting process. This underscores the need for improved harvesting methods and greater attention to careful field handling to minimize postharvest losses.

Table 20. Postharvest loss estimates during harvesting, Camarines Norte, Philippines, 2023.

Variable	Losses (%)	Std. Dev.	Min	Max
Non-marketable Rejects	5.04167	4.10005	1.00	10.00
Marketable Rejects	-	-	-	-
<b>Total Harvest Losses</b>	<b>5.04167</b>	<b>4.10005</b>	<b>1.00</b>	<b>10.00</b>

### 5.3.2.2 Hauling from Farm to Collection Area

Hauling is the practice of immediate transport of freshly harvested produce to a common assembly area or facility where subsequent packinghouse operations take place. In the context of ‘Queen’ pineapples, the standard practice involves promptly transporting the harvested fruits to a central collection area immediately after being picked. In Camarines Norte, this hauling operation is typically overseen by the farmers themselves, local assemblers (transporters), or hired agents of these traders (Figure 41).



\*with multiple responses

Figure 41. Management of hauling operations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

Freshly harvested pineapples are transported from the farm to the nearest roadsides, which serve as the primary collection points within the study area. As evident from the survey, 89.57% of farmers in Camarines Norte commonly utilize these roadsides as the primary collection areas (Figure 42). In cases where pineapples are destined for local retail markets, they may bypass the roadside collection and instead the fruits are directly loaded onto vehicles, commonly using haulers or tricycles.

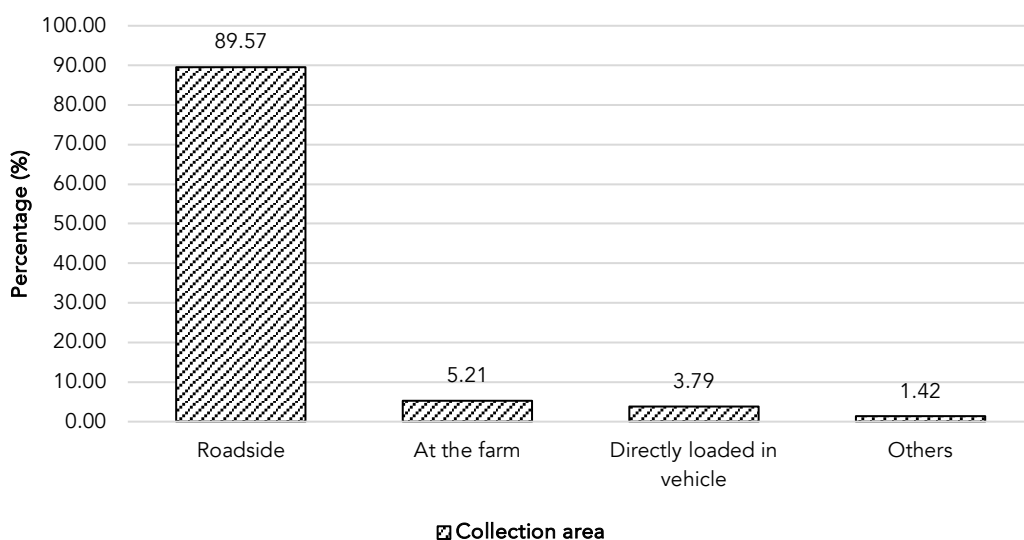


Figure 42. Common collection area for 'Queen' pineapple, Camarines Norte, Philippines, 2023.

The hauling distance from pineapple plantations to the common collection area exhibits considerable variation, with some farms located as close as 10 meters to the roadside, the farthest being beyond five kilometers. Notably, a significant portion, 36.97% of the surveyed farmers, have relatively shorter hauling distances of less than 500 meters (Table 21). However, the majority of farms are situated beyond 500 meters from the roadsides, rendering their hauling distances relatively longer. On average, the distance from the farms to the collection area spans approximately 1,100 meters. This wide range of hauling distance underscores the geographical and logistical challenges faced by pineapple farmers in the region.

Table 21. Summary statistics of hauling distance from farm to collection center, Camarines Norte, Philippines, 2023.

Distance from farm to collection area	Frequency	Percentage
Less than 500 meters	78	36.97
Between 501 to 1000 meters	49	23.22
1.0 km and beyond	49	23.22
No response or unknown	35	16.59
Mean	1122.67	
Std. Dev.	1067.999	
Min	10	
Max	5000	

For the hauling method of harvested ‘Queen’ pineapples, the predominant method involves the use of carabao-drawn carts, accounting for a substantial 93.14% of the reported practices (Figure 43). In cases where the pineapples are destined for nearby local markets, haulers such as tricycles are used. However, depending on the distance between the farm and roadsides, some farmers may resort to simply carrying the produce to the collection area, although this method is not commonly adopted and is practiced only by a few.

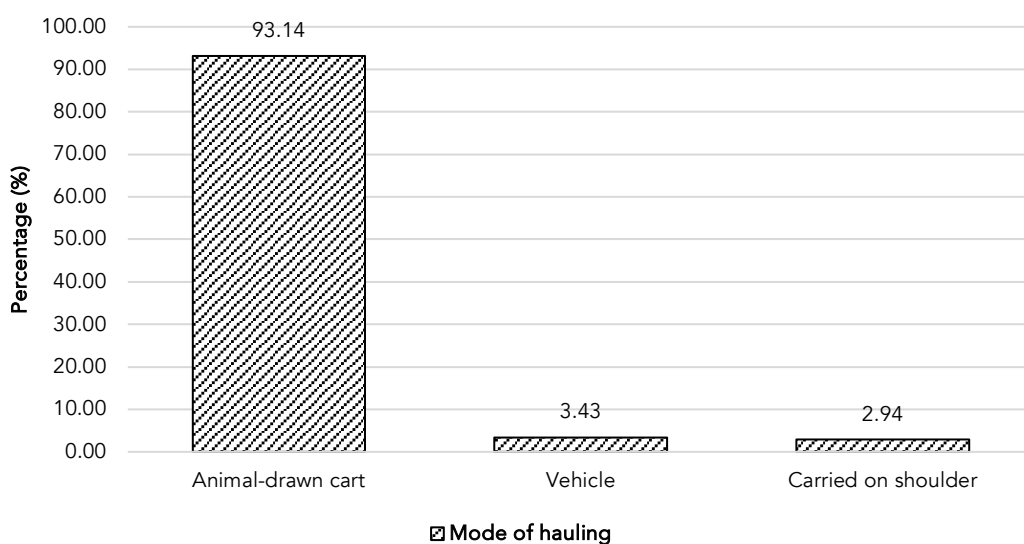


Figure 43. Mode of hauling for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

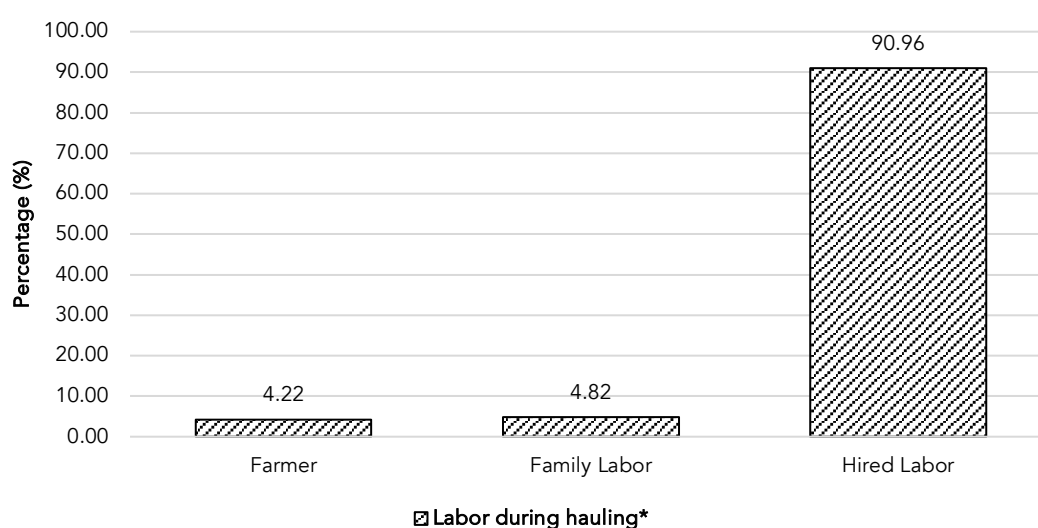
Two types of hauling containers are prevalent in the area (Figure 44). These containers locally known as *kareta*, which is an animal-drawn cart with wheels, and

*sagad* or *hilada*, a simple animal-drawn cart without wheels. These carts are constructed using wooden materials.



Figure 44. Hauling containers for harvested pineapples, (a) *kareta* and (b) *sagad* or *hilada*.

In general, majority of operations during hauling is carried out by hired laborers, as represented by 90.96% of the responses (Figure 45). The total number of hours dedicated in a single hauling is contingent on several factors, such as the distance covered, the total volume of pineapples being transported, and the number of haulers or laborers involved. Nevertheless, in a single hauling operation, the average time spent on hauling is around four hours, which is equivalent to 0.50 man-day based on a standard 8-hour working duration in the Philippines.



\*with responses ( $n=166$ )

Figure 45. Labor management during hauling, Camarines Norte, Philippines, 2023.

Haulers are typically hired as laborers by the assembler-wholesaler (transporter), and the number of haulers varies depending on the quantity of pineapples harvested in a day or the number of farms involved. On average, five to ten laborers are usually on-site, ensuring the efficient and timely transport of pineapples from the farm to the collection area (Figure 46). This flexible workforce can be adjusted to meet the demands of each day's harvest and the number of farms that need their services.

Overall hauling costs are typically calculated based on the total number of pineapples hauled, measured in pieces. The pricing structure for hauling costs is directly influenced by the distance between the farm and the roadside (Table 22). Ordinarily, the hauling cost is set at PhP 0.80 (US\$ 0.015) per piece when the distance exceeds one kilometer. However, for shorter distances, specifically if it is less than one kilometer, the hauling costs is reduced to PhP 0.50 (US\$0.009) per piece. This tiered pricing system ensures that the hauling expenses are appropriately adjusted based on the distance traveled.

Table 22. Summary of labor costs during hauling, Camarines Norte, Philippines, 2023.

Hauling Distance	Labor Cost (PhP per piece)	Std. Dev.	Min	Max
Less than 1km	0.4740385	0.1219489	0.2	0.6
Beyond 1km	0.8335714	0.3133181	0.1	1.5
All	0.674812	0.3294063	0.1	1.5



Figure 46. Hauling practices for 'Queen' pineapple, Camarines Norte, Philippines, 2023.

### *Loss Estimates during Hauling*

Loss estimates during hauling are minimal, with reported figures ranging from as low as ten to fewer than 300 pieces out of the total ‘Queen’ pineapples hauled. Approximately, losses during hauling are estimated to range from 0.028% to 4.286% (Table 23). Postharvest loss estimates during this operation primarily result from non-marketable rejects, averaging at 0.946%. A significant portion of the surveyed respondents (47.87%) are able to identify the nature and type of postharvest losses during hauling. These losses are predominantly attributed to mechanical damages such as severe compression (Tag. *pisa*), fruit cracking, and severe bruising (Tag. *lamog*, Bicol. *lanog*) due to rough handling. Furthermore, instances of fruits falling from the hauling containers (Tag. *nahulog*) also contribute to these losses.

Table 23. Postharvest loss estimates during hauling, Camarines Norte, Philippines, 2023.

Variable	Losses (%)	Std. Dev.	Min	Max
Non-marketable Rejects	0.94618	0.80698	0.2778	4.28571
Marketable Rejects	-	-	-	-
<b>Total Hauling Losses</b>	<b>0.94618</b>	<b>0.80698</b>	<b>0.2778</b>	<b>4.28571</b>

When it comes to challenges faced during hauling, majority of the respondents reported issues related to pineapple damage (Figure 47). Other problems encountered during hauling involve severe fruit compression resulting from the over-packing in bulk in animal-drawn carts and rough handling practices like throwing of pineapples when loading and unloading in carts (Figure 48).

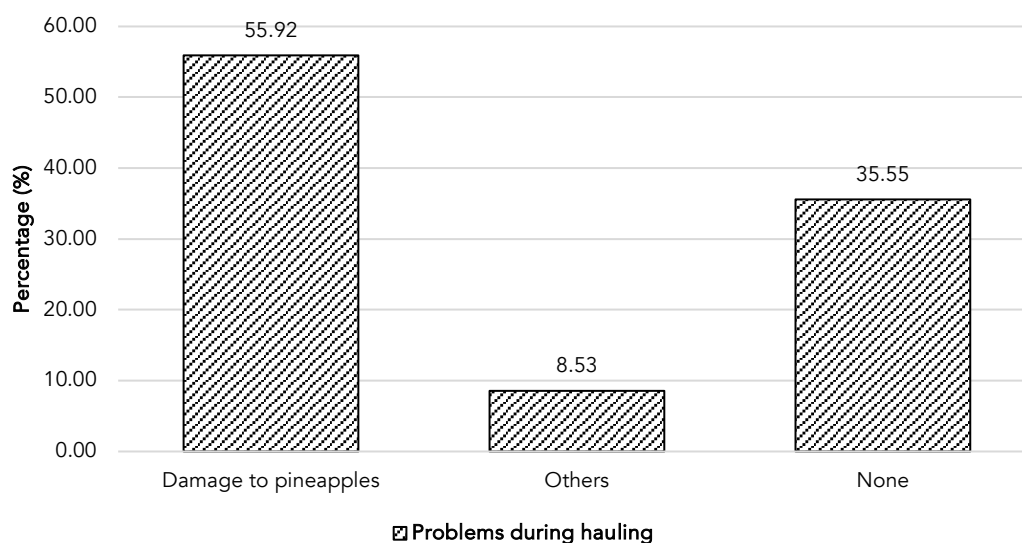


Figure 47. Problems encountered during hauling, Camarines Norte, Philippines, 2023.



Figure 48. Rough handling during hauling (e.g., throwing of pineapples).

Several contributing factors aggravate these losses. One key factor is the timing of harvesting and hauling, often taking place during the late hours of the night to early morning. This timing may affect the vision and strength of the laborers since working until late evening results in fatigue and workers do not pay attention to careful handling of the produce. Additionally, the poor road conditions from the farm to the roadside collection areas further compound the problems faced by farmers during hauling.

### 5.3.2.3 Packinghouse Operations

Today, consumers' decision-making process have evolved beyond merely assessing the fruit's physical appearance. In addition to the fruit's external attributes

like color, size, freedom from defects, consumers now also take into account intrinsic quality factors such as sweetness, aroma, flavor, nutritional benefits, and safety. Origin has also become a consideration in the purchasing behavior. Given the complex market and consumer demands, pineapples must be prepared for their target markets while maintaining the quality that was initially established after harvest. To meet quality and safety requirements, subsequent operations, termed as packinghouse operations or market preparations, are carried out.

In Camarines Norte, packinghouse operations are relatively minimal, encompassing essential tasks such as field sorting and grading, trimming, cleaning, and the subsequent loading onto transport vehicles (Figure 49). These operations are typically carried out by either the farmers themselves or laborers hired by the trader, who function as the assembler-wholesaler (transporter). These operations ensure that harvested pineapples are prepared for the market efficiently, maintaining their quality and safety.

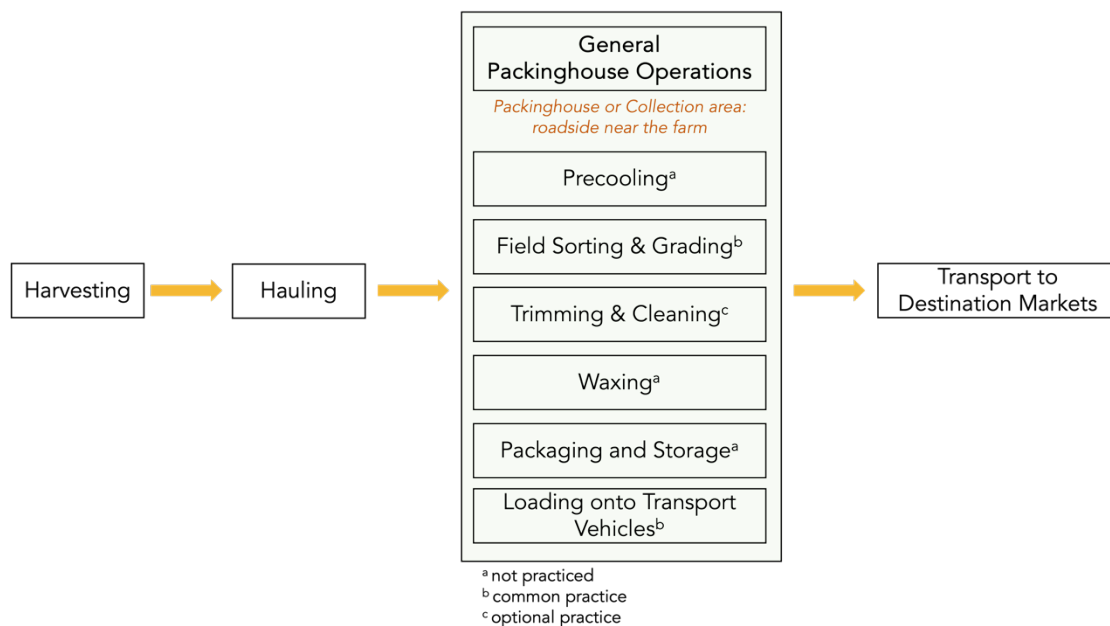


Figure 49. General packinghouse operations for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

### Field Sorting and Grading

Regardless of intended market destination, pineapples undergo sorting process based on size, shape, and overall external appearance. Initial sorting can be carried out in the field (Figure 50) or in a collection center. Pineapples are categorized as marketable (qualitative losses) and non-marketable (outright physical losses). The fruit specifications during sorting follows the criteria and standards set by individual markets and are widely adopted by the traders in the study area. Pineapples intended for wholesale markets must meet stringent requirements. These include freedom from insect damage and disease, at the right maturity, freedom from mechanical damage such as bruising, cuts, or punctures, intact crown, with the fruit generally exhibiting an overall good external appearance. Adhering to these quality standards ensures that pineapples are well-prepared to meet the expectations of diverse markets and consumers.



Figure 50. Field sorting of pineapples (Tag. *tamanyo*), Camarines Norte, Philippines, 2023.

When it comes to field containers used during sorting, majority of the surveyed respondents favored the use of bamboo crates (Tag. *tiklis*) (Figures 51 & 52). However, other containers like jute sacks, plastic crates, and plastic pails are seldom used as containers during sorting. It is worth noting that a significant proportion of respondents indicated that no specific field containers are used during sorting in the area.

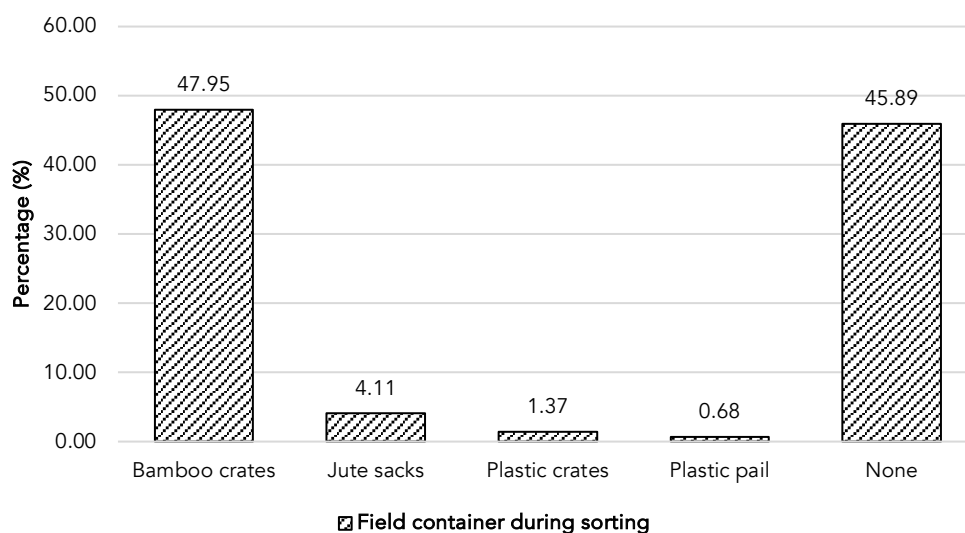


Figure 51. Types of field containers used during sorting, Camarines Norte, Philippines, 2023.

Furthermore, sorting aids, particularly gloves, were found to be a common practice in the region (Figure 52). Given the rough texture of ‘Queen’ pineapples and the presence of spines on the leaves, gloves serve a dual purpose: they protect the sorters and make it easier to handle the pineapples.



Figure 52. Use of *tiklis* and gloves during field sorting of ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

In Camarines Norte, the use of field containers during sorting appears to be generally effective since majority of the surveyed respondents reported no problems with their use (Figure 53). Nevertheless, it should be noted that a significant proportion of respondents did mention incidents of pineapple damage attributed to the containers used. These mechanical damages primarily in the form of bruising (Tag. *lanog*) further contribute to losses incurred during sorting.

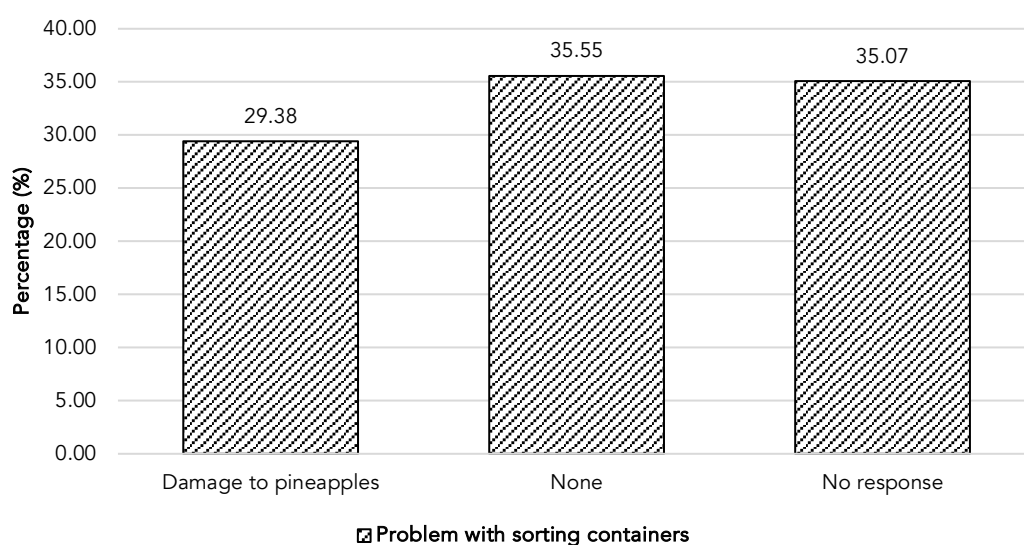


Figure 53. Problems with field containers used for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

In terms of labor management during sorting, a variety of labor sources are commonly observed. These include farmers themselves, family labor, or hired laborers. However, the prevailing labor arrangement during sorting involves the use of hired sorters, typically recruited by assembler-wholesalers (transporter). These sorters are compensated based on the volume of ‘Queen’ pineapples they sort or classify. In general, it is typical to have about five hired laborers engaged in sorting, and they usually work for approximately 0.50 man-days, which is roughly equivalent to four hours of sorting. On average, labor costs are estimated at PhP 0.35 per piece sorted, translated to approximately US\$ 0.006 (Table 24).

Table 24. Summary of labor management during field sorting, Camarines Norte, Philippines, 2023.

Variable	Mean	Std. Dev.	Min	Max
Number of Laborers	4.911504	3.200328	1	20
Working Days	1	0	1	1
Total Man-days	0.4986264	0.23236	0.125	1.5
Labor Cost (PhP per piece sorted)	0.3467742	0.2085408	0.1	1

In some instances, labor costs encompassing activities from hauling, sorting, piling, and loading onto transport vehicles are paid lump sum. This lump sum payment is often calculated based on the total volume of pineapples handled. Typically, the remuneration allocated to hired sorters fall within a range of 10% to 30% of the total prices paid by traders to the farmers.

#### Size Classification

The Department of Agriculture has established the PNS for pineapples (PNS/BAFPS 09:2004) (Table 25). These standards, particularly those for the ‘Queen’ pineapple are highly recommended by the government for industry practice. However, despite the availability of these standards, adoption is not mandatory. Consequently, there is no uniform sorting and grading practices within Camarines Norte.

Table 25. Size classification of ‘Queen’ pineapple, Philippine National Standards.

Size	Local Term	Weight (in kilograms)
Extra Large (XL)	Extra or Jumbo	1.30 and above
Large (L)	<i>Primera</i>	1.00 to 1.29
Medium (M)	<i>Segunda</i>	0.75 to 0.99
Small (S)	<i>Tercera</i>	0.50 to 0.74
Extra Small (XS)	Butterball or <i>buruot</i>	less than 0.50

Note: Whole fruit crown

Size classification in the study area vary among different traders, with no uniform sizing or classification protocols being consistently practiced. In the case of “all-in” pricing system (referred to as ‘*arasar*’ or ‘*syamber*’), harvested pineapples are not sorted based on size. Under this system, a single farmgate price is set by the traders, irrespective of the pineapple’s size. Conversely, in the “ladderized” pricing system (known as ‘*klase-klase*’ or ‘*tamanyuhan*’), there are two general categories of the harvested produce: ‘good’ and ‘butterball’ (Figure 54). This system underscores the

importance of size differentiation (Tag. *pagtatamanyo*), which can be beneficial for both traders and farmers (for pricing system details, refer to section 5.5).



Figure 54. General classification for ‘Queen’ pineapple: (L) butterball and (R) good.

Pineapples classified as ‘good’ are those that conform to regular size set by traders themselves ranging from the largest (jumbo or extra-large) until 5<sup>th</sup> size (*panlima*) (Table 26). However, even though there are existing size categories followed by the industry in the area, there are still instances that traders follow different sorting criteria for ‘good’ pineapples. Those that do not conform to their regular sizing standards fall under ‘butterball’ or *buraot* category. Butterballs are undersized pineapples usually weighing 200 grams and below. While this prevailing sizing is not uniform and may vary per trader, generally, sorting classification is decided by the traders, specifically the assembler-wholesalers (transporters).

Table 26. General size classification of ‘Queen’ pineapples set by traders, Camarines Norte, Philippines, 2023.

Category	Local Term	Description
A. Good		
First size	<i>Primera</i>	Extra-large, usually weighs more than 1000 grams
Second size	<i>Segunda</i>	Large, 800 to 1000 grams
Third size	<i>Tercera</i>	Medium, 600 to 800 grams
Fourth size	<i>Pang-apat</i>	Small, 400 to 600 grams
Fifth size	<i>Panlima</i>	Extra-small, 200 to 400 grams
B. Butterball	<i>Pang-anim</i> or <i>Buraot</i>	Undersized, usually weighs below 200 grams

In the field, the classification of ‘good’ pineapples is typically influenced by two key factors: (a) prevailing farmgate prices offered by traders to the farmers, which serve as a crucial benchmark for quality assessment, and (b) farm scouting and preliminary estimates provided by hired agents prior to harvesting.

In the context of prevailing farmgate prices, it is important to note that the pricing dynamics can influence the sizing classification of ‘good’ pineapples. For example, if the prices offered by traders are generally high for well-sorted ‘good’ pineapples (e.g., PhP 10.00 or US\$ 0.18 per piece), traders tend to adopt a stringent sizing classification, typically focusing on up to four categories – *primera*, *segunda*, *tercera*, and *pang-apat*. The 5th category, *panlima*, may be designated as ‘butterball.’ Conversely, when farmgate prices offered are lower (e.g., PhP 7.00 or US\$ 0.13 per piece), traders are more likely to adhere to the conventional 5-size classification, and in some cases, may even implement a more stringent classification system (e.g., up to 6th size or *pang-anim* as ‘good’)

Another factor that influences a trader’s decision regarding the classification of ‘good’ and ‘butterball’ pineapples is the input from their hired agents. These agents are typically engaged by traders to assess pineapple plantations that are nearing harvest readiness. Agents typically employ a combination of field observations and surveys to estimate the proportion of ‘good’ and ‘butterball’ pineapples in a particular farm. This scouting process involves a thorough examination of the pineapple plantation.

Hired agents relay their pre-harvest estimates on the expected proportion of ‘good’ and ‘butterball’ pineapples to the traders a few days prior to actual harvesting. These estimates serve as a guide to the traders on how to classify the pineapples they will procure. The accuracy of these estimates helps traders make informed decision regarding the categories of pineapples they will purchase. If there is an expectation of a higher volume of ‘good’ pineapples, the size classification may be restricted to the 3rd and 4th sizes. Beyond these sizes, the fruits are automatically categorized as ‘butterball.’ This strategy allows traders to include some ‘good’ pineapples in the ‘butterball’ category, effectively reducing the total amount paid to farmers. However,

when these pineapples reach wholesale markets, the 4th and 5th sizes can often be upgraded back to regular sizes, fetching normal market prices of the ‘good’ category.

On the other hand, if there is an expectation of a greater quantity of ‘butterball’ pineapples during harvest, a more rigorous classification system may be implemented. This might involve further categorizing some ‘butterball’ into two or three distinct subcategories, such as *pang-anim* (6th size or butterball 1) and *pampito* (7th size or butterball 2), with different pricing tiers. This ladderized pricing for ‘butterball’ allows trader to even lower the total payments to farmers by reducing the prices one step below the standard ‘butterball’ pricing.

The aforementioned categories and pricing systems indicate the flexible and dynamic nature of pineapple classification in response to market conditions. It is evident that the consistent implementation of size classification set in the Philippine National Standards can be challenging.

#### *Loss Estimates during Sorting*

When it comes to distinguishing between marketable and non-marketable rejections after field sorting, surveyed farmers provided insights into the types and characteristics of losses incurred during sorting, as outlined in Table 27. According to farmers, a significant portion of marketable rejections primarily consists of undersized pineapples (Table 27). Additionally, farmers reported other reasons of rejections such as ripe pineapples, minor deformities, and slight mechanical damage. It is noteworthy that while these pineapples are categorized as marketable, they are priced lower due to their quality defects.

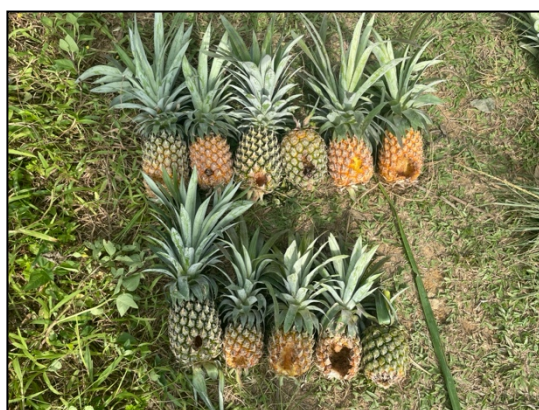
Table 27. Nature of losses after field sorting, Camarines Norte, Philippines, 2023.

Nature of Rejects	Frequency ( <i>n</i> =121)	Percentage
Marketable Rejects		
Ripe	3	2.48
Slight deformation	1	0.83
Slight mechanical damage	1	0.83
Undersized	35	28.93
Slight insect damage	1	0.83
<b>Total</b>	<b>41</b>	<b>33.88</b>

Table 27. *continued...*

Nature of Rejects	Frequency ( <i>n</i> =121)	Percentage
Non-marketable Rejects		
Overripe	11	9.09
Severe insect/pest damage	22	18.18
Severe deformation	14	11.57
Decay	2	1.65
Mechanical damage	31	25.62
<b>Total</b>	<b>80</b>	<b>66.12</b>

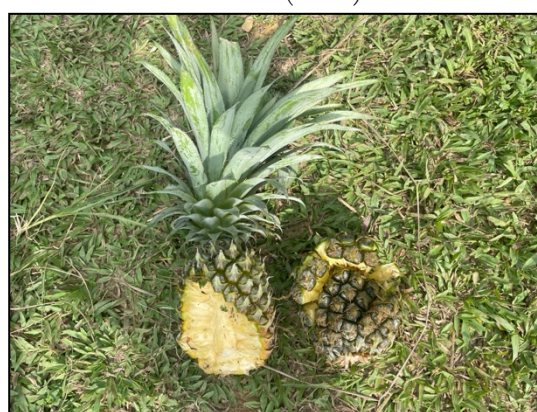
Regarding non-marketable rejects, mechanical damage emerged as a significant contributor to these rejections, based on the accounts of the majority of the farmers. In addition to mechanical damage, non-marketable rejections encompass severe insect damage, pronounced deformation, overripe fruit, and pineapples that exhibit decay.



Insect and pest damage (rats, birds)

Immature (*batibot*)

Overripe

Mechanical damage (*pisa, lanog*)

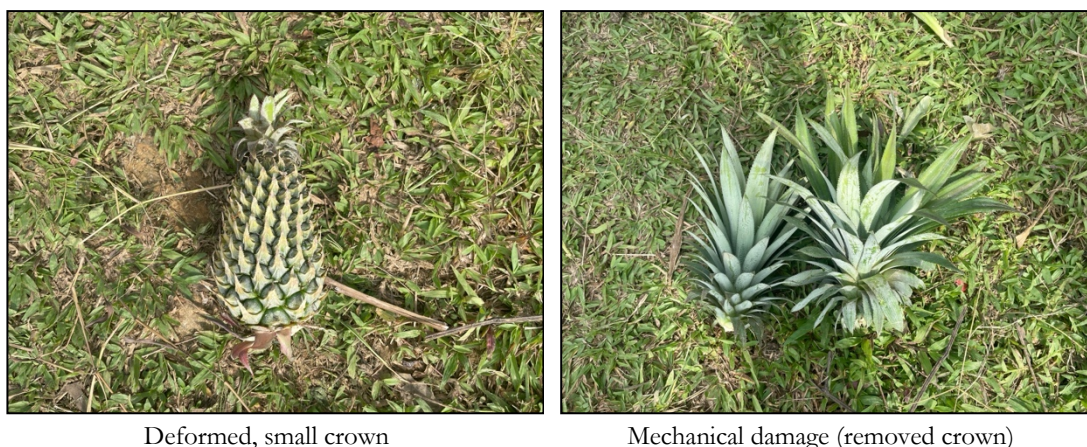


Figure 55. Type of losses (non-marketable rejects) after field sorting and grading.

Mechanical damage to fruits is a contributor to non-marketable rejections primarily attributed to rough handling during field sorting typically exemplified by the careless tossing of fruits from one hired laborer to another during sorting or *pagtatamanyo*. Pineapples are accidentally dropped resulting to pineapples being damaged. Both farmers and traders describe the damage as *nalalanog* (in Bicol) or *nalalamog* (in Tagalog), indicative of severe bruising, making the pineapples unsuitable for market. The detrimental effects of these rough handling practices can become apparent at the wholesale and retail levels, especially when the pineapples are typically at the eating ripe stage. Recognizing and mitigating the impacts of rough handling on pineapples is crucial in ensuring the quality and marketability of the produce.

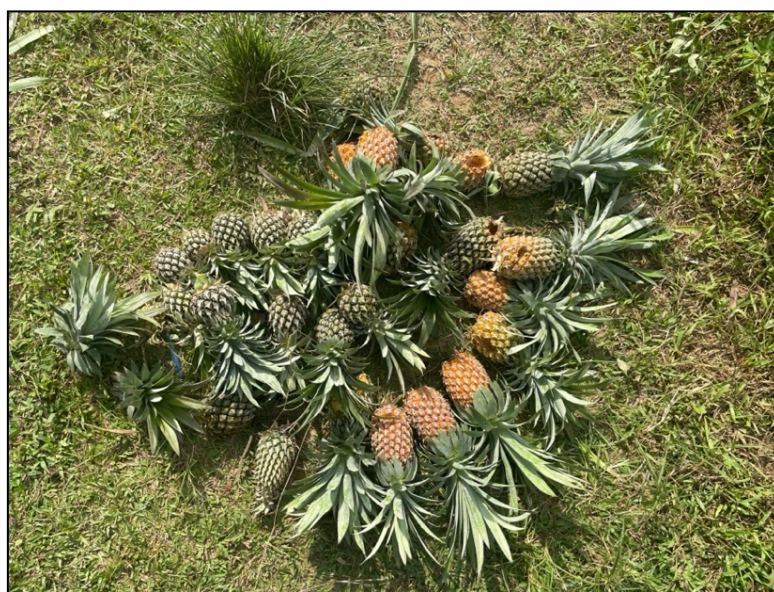


Figure 56. Non-marketable rejects after sorting, Camarines Norte, Philippines, 2023.

From the documented cases of marketable and non-marketable rejections, the overall postharvest loss estimates subsequent to field sorting is summarized in Table 28. The aggregate postharvest loss estimate during this phase is notably substantial, amounting to 36.262%. Within this estimate, marketable rejections account for approximately 32.853%, while non-marketable rejections constitute an average of 3.409%.

Table 28. Postharvest loss estimates during sorting, Camarines Norte, Philippines, 2023.

Variable	Losses (%)	Std. Dev.	Min	Max
Non-marketable Rejects	3.40862	7.33439	0.2	50.00
Marketable Rejects (butterballs)	32.8534	19.13192	0.68966	88.88889
<b>Total Sorting Losses</b>	<b>36.26202</b>	<b>26.46631</b>	<b>0.2</b>	<b>88.89</b>

In the context of assessing losses, it is important to recognize that butterballs or *buraot* can be classified as postharvest losses at the farm level. This classification is justified as there is already a noticeable decline in both quality and quantity, particularly concerning the saleable weight of the pineapples. While these butterballs are still technically considered marketable, their farmgate price is already reduced due to this condition. Given this situation and the extent of rejection criteria, it is appropriate to categorize butterballs as part of the marketable rejects, translating to certain economic losses for farmers.

However, due to the enduring traditional practices in the region and the significant proportion of butterballs encountered during harvesting and sorting, it has become a customary belief among farmers and traders not to view them as losses (Figure 57). Nonetheless, in practical terms at the farm-level, if stricter standards were to be enforced, significant postharvest losses, both in terms of quality and quantity, can be attributed to the presence of undersized pineapples categorized as butterballs or *buraot*. Recognizing these losses is pivotal in improving the overall handling practices, particularly in reducing postharvest losses, and ensuring the quality of harvested pineapples.

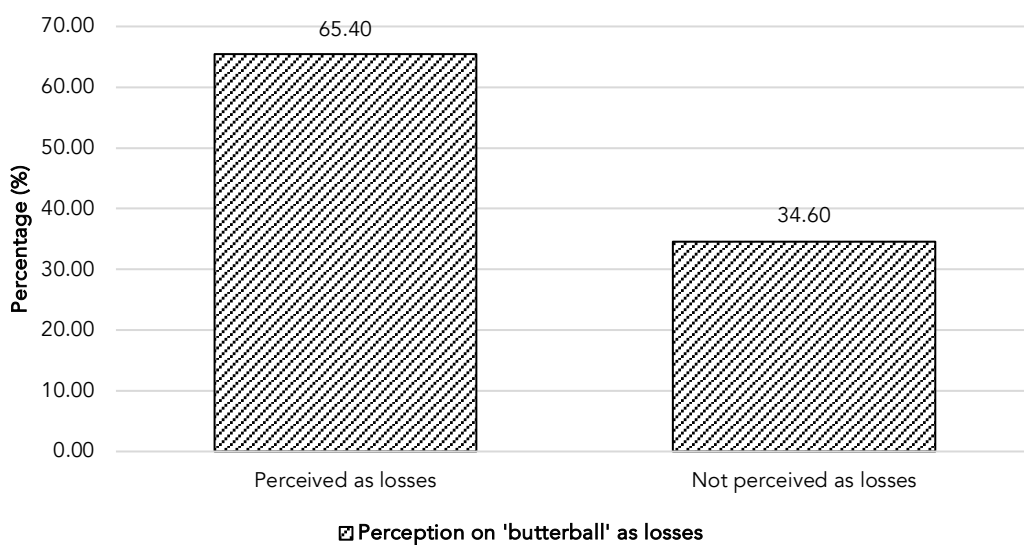
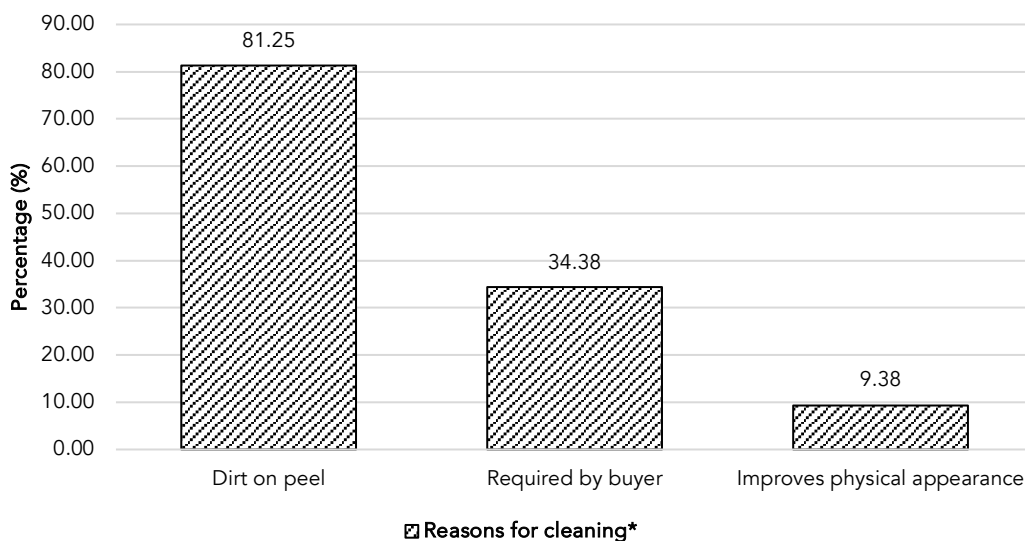


Figure 57. Farmer's perception on butterball or *buraot* as postharvest losses, Camarines Norte, Philippines, 2023.

### Trimming and Cleaning

Other packinghouse operations in 'Queen' pineapples include individual fruit cleaning and trimming of stem. Cleaning generally entails the removal of dirt and debris from the peel either dry brushing or washing in water. Typically, the domestic market does not require cleaning. However, in Camarines Norte, this operation is only carried out when required by the target market, as indicated by a minority (15.17%) of the surveyed respondents. Usually, this task is performed immediately after harvest at the collection areas.

The main reasons for cleaning include the presence of dirt on the peel (81.25%), particularly when harvesting is done rainy weather. Furthermore, there are instances where traders require cleaned pineapples comprising 34.38% of the responses (Figure 58). Another reason for cleaning is to enhance the overall visual appeal of the harvested pineapples. The cleaning method typically involves washing the fruits in water to eliminate dust and dirt from the peel's surface. Subsequently, fruits are air-dried before packing or loading onto transport vehicles.

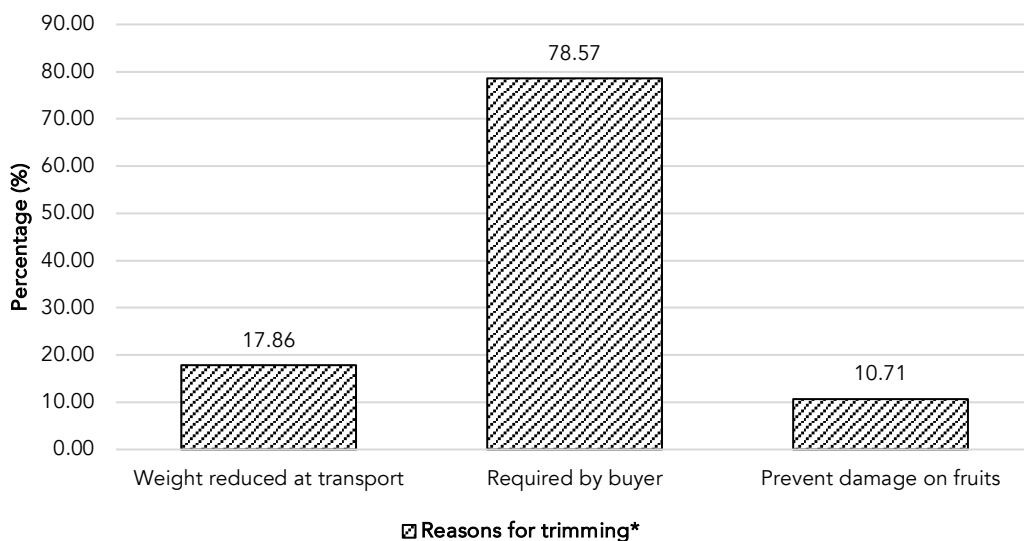


\*with multiple responses

Figure 58. Reasons for performing cleaning on 'Queen' pineapples ( $n=32$ ), Camarines Norte, Philippines, 2023.

The trimming operation entails removing the stem from the base of the pineapple fruit. Typically, during harvest operations, stems are already removed since the wholesale markets to which they are destined require pineapples to be already trimmed. This operation, however, is carried out only by a minority of surveyed respondents (13.27%), especially when the pineapples are intended for nearby local markets, such as public markets in the adjacent municipality of Daet.

Commonly used trimming tools include knives and the method involves cutting away the long stem, leaving about five to seven centimeters of the stalk size for bundling the fruits for local retailing. The primary reason for this operation is that some traders explicitly demand trimmed pineapples (Figure 59). Additionally, other reasons for this operation include the reduction of weight for transport purposes and the prevention of fruit damage. Long stems may inflict damage through punctures on the fruit during packing in containers or during piling and bulk loading in the transport vehicle.



\*with multiple responses

Figure 59. Reasons for performing trimming on ‘Queen’ pineapples ( $n=28$ ), Camarines Norte, Philippines, 2023.

#### Waxing, Packaging, Precooling, and Temporary Storage

Following the cleaning and drying process, pineapples may undergo waxing, a postharvest operation that can significantly extend their shelf life. While this technique has the advantage of enhancing the longevity of pineapple fruits, it is not yet widely practiced in Camarines Norte. The primary reason for the limited use of fruit coatings or wax on ‘Queen’ pineapples is the lack of awareness among farmers regarding this postharvest technique. The advantages of waxing include prevention of internal browning during cold storage, decreased moisture loss, and a glossy external appearance (DOST-PCAARRD, 2014; Joy & Rashida, 2016). Tiny scratches on the peel are also sealed thus preventing the entry of microorganisms that lead to decay. Given that pineapples are inherently perishable, and that significant losses due to rapid ripening and decay are incurred, it is worth exploring the use of waxing in the region to maintain the quality of pineapples.

In the Philippines, natural or synthetic food-grade waxes or fruit coatings are commercially available and can be applied using methods such as brushing, spraying, or dipping the fruits in coating solutions (DOST-PCAARRD, 2014). The method of application should be considered, ensuring that wax is only applied on the fruit surface

and not on the crown, as some waxes can cause injury to the crown (Joy & Rashida, 2016).

Packaging is an activity in a packinghouse or collection center, aimed primarily at protecting the pineapples, especially during transport, wholesale, and retail distribution. Various types of packaging material are used particularly if the produce is intended for the domestic market. However, in the study area of Camarines Norte, packaging is not practiced. Pineapples are typically loaded directly into transport vehicles without any protective packaging, called bulk loading. This is a common practice in pineapples intended for the wholesale markets in Metro Manila and other provinces. For local retail markets within the area, 'Queen' pineapples are usually bundled consisting of six or ten fruits in a bundle and tied with plastic straw for subsequent display upon reaching retail fruit stalls or stands (Figure 60).



Figure 60. Bundle packs by ten for 'Queen' pineapple, Camarines Norte, Philippines, 2023.

Packaging is primarily practiced for export markets using corrugated fiberboard carton boxes. The typical packing method involves fruits laid in a flat manner with an alternate crown-to-base positioning (DOST-PCAARRD, 2014). In the case of multinational companies like DOLE and Del Monte in Mindanao, pineapples are packed horizontally in molded trays at the bottom of the carton. The use of rigid containers with proper ventilation is essential to prevent mechanical damage, particularly during stacking and piling (Joy & Rashida, 2016). The use of such rigid

containers further mitigates the risk of fruit compression, which can lead to significant losses upon arrival at destination markets.

To maximize the postharvest life of 'Queen' pineapples, it is essential to cool them promptly after harvest and maintain this low temperature during transport to destination markets. Elevated temperatures can significantly reduce shelf-life, often to just a few days when stored at ambient temperatures.

Precooling is another important packinghouse operation. This involves rapid removal of field heat from the commodity to reduce fruit metabolism. Precooling is done also prior to cold storage or transport to reduce the heat load of the refrigeration system. Common methods for precooling freshly harvested produce include room cooling, forced-air cooling, water or hydrocooling, ice cooling, and vacuum cooling (Bautista & Esguerra, 2007).

Unfortunately, in the study area, none of these precooling techniques are employed since the fruits are intended mainly for the local market. Precooling is often done in pineapples for export. Moreover, temporary holding or storage before market transport is not practiced. Pineapples are recommended to be stored at temperature conditions between 7°C to 12°C, provided that fruits are already at the color break stage, equivalent to PCI 2 or PCI 3 (Paull & Chen, 2003). The lack of awareness about these techniques and the absence of available storage and cooling facilities contribute to why farmers and traders do not engage in these operations.

Given the limitations of facilities and the inability to regulate or control temperature on the farm, the most viable practice is to immediately transport harvested fruits from the farm to collection area. There, fruits are sorted, classified, and loaded onto transport vehicles, and dispatched to destination markets on the same day of harvest such that the fruits arrive the market in its fresh condition.

### *Willingness to Adopt Postharvest Technologies*

Although postharvest operations like waxing, packaging, precooling, and temporary storage are vital for preserving the freshness of ‘Queen’ pineapples and extending their postharvest life, farmers in the area face significant challenges in adopting these practices. The scarcity of resources, lack of awareness on these technologies, and the demands of the domestic market are the main reasons for the non-adoption of these operations.

In the study area, when asked about the potential availability and introduction of new technologies or improvements for these postharvest operations, a substantial majority expressed their willingness to adopt these innovations (Table 29). This willingness underscores the eagerness of local farmers to improve their existing practices and enhance their access to postharvest technologies that can benefit both producers and consumers.

Table 29. Willingness to adopt postharvest (PH) technologies, Camarines Norte, Philippines, 2023.

<b>Willingness to adopt PH technology</b>	<b>Frequency</b>	<b>Percentage</b>
Waxing		
Yes	128	60.66
No	41	19.43
No Response	42	19.91
Packaging		
Yes	92	43.60
No	46	21.80
No Response	73	34.60
Precooling		
Yes	128	60.66
No	39	18.48
No Response	44	20.85
Storage		
Yes	89	42.18
No	42	19.91
No Response	80	37.91

If a cost-effective and readily available waxing material is developed and introduced, farmers generally expressed their willingness to adopt this technology. They recognize that waxing plays a crucial role in maintaining the freshness of pineapples and extending their shelf life. Moreover, the introduction of a new waxing

material is viewed as an opportunity for farmers to acquire additional knowledge and skills. However, for some, the prospect of added labor in the waxing process may deter those who are less willing to try this technique.

Similarly, farmers are receptive to adopt packaging, particularly if appropriate packaging materials for pineapples are developed. The key drivers for their willingness include the potential for better selling prices for pineapples and the capacity to preserve pineapple quality during transportation. It is important to note that some farmers expect traders, especially the local assembler-wholesaler (transporter), to handle this operation as it may involve additional costs and labor.

In the case of precooling, farmers are generally receptive in trying this technique due to the desire to maintain quality, extend storage life, and prevent rapid decay of pineapples. Their willingness to adopt these techniques is contingent on their effectiveness. However, some farmers view precooling as an additional, possibly unnecessary step in their operations.

Regarding storage techniques, specifically on the development of suitable storage protocols and temporary holding facilities, farmers' willingness to adopt depends on the effectiveness of these operations in preserving the fruit's quality and extending storage life. Effective storage techniques are seen as an opportunity for farmers to acquire valuable knowledge. Nonetheless, some farmers express reluctance to engage in this operation, believing that pineapples are not suited for cold storage and that it might entail extra labor in their operations.

In summary, farmers in the study area demonstrate a generally positive disposition towards adopting various postharvest technologies for 'Queen' pineapples, with their willingness hinging on the perceived benefits and effectiveness of these techniques. This reveals the nuances and trade-offs that farmers consider in integrating these new postharvest technologies into their existing operations, indicating a willingness to embrace innovation while weighing the practical challenges involved.

### 5.3.2.4 Loading onto Transport Vehicles

In Camarines Norte, a diverse range of transport vehicles is used in operations, including six- or 10-wheeler trucks, elf-type trucks (forward), haulers (tricycles), and container vans (Figure 61). The predominant choice for loading and transportation operations is the six- or 10-wheeler trucks, accounting for the majority of respondents (52.04%). These transport vehicles are typically provided by assembler-wholesalers (transporters). In the region, the selection of transport vehicles is influenced by factors such as market destinations and distance, which in turn affect transport costs, creating variations in the overall cost structure.

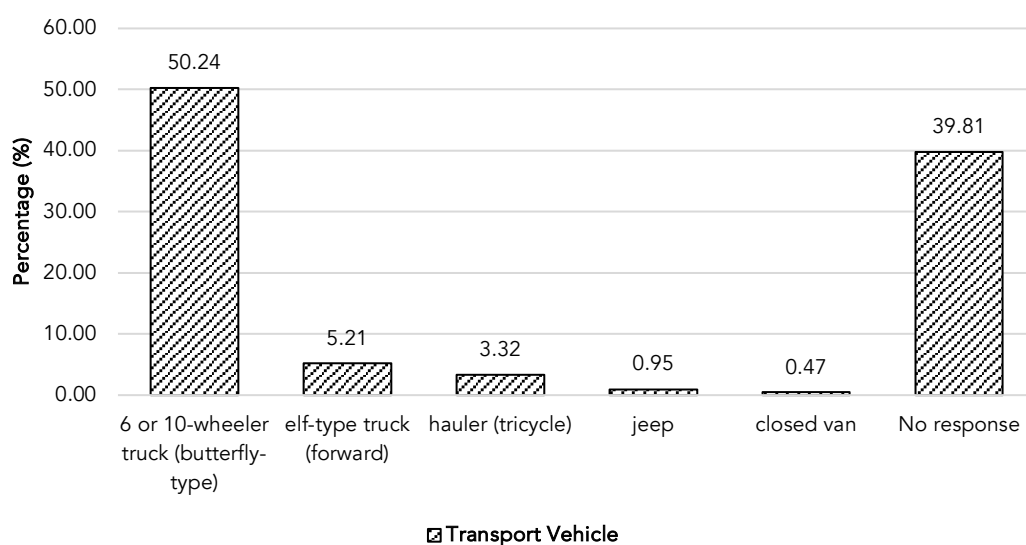


Figure 61. Types of transport vehicles for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

Each of these vehicle types is associated with distinct loading capacities, as shown in Table 30. Six- or 10-wheeler trucks, for instance, has an average loading capacity of 25,000 pieces of ‘Queen’ pineapples accommodated in a single load. In certain cases, the full-load capacity can even extend to 30,000 pieces. This high capacity primarily serves the purpose of long-distance transportation, especially when heading to major wholesale markets in Metro Manila, such as Balintawak and Pasig, where substantial quantities of ‘Queen’ pineapples are traded.

Table 30. Loading capacity of different transport vehicles for ‘Queen’ pineapple, Camarines Norte, Philippines, 2023.

Transport Vehicle	Mean	Std. Dev.	Min	Max
6W- or 10W-truck	23488.37	8850.05	10000	60000
Elf-type truck	17300	7071.853	8000	30000
Jeepney	4250	353.5534	4000	4500
Hauler (Tricycle)	500	216.0247	300	800

On the other hand, elf-type or forward-type trucks have lower loading capacities, typically around 17,000 pineapples per single loading. Jeepneys have an average loading capacity of approximately 4,000 pieces of pineapples. These vehicles with smaller volume capacities are typically utilized for transporting pineapples to nearby wholesale and retail markets within the Bicol region, such as Naga City, Camarines Sur, Albay, and Sorsogon. Haulers, such as tricycles, have a limited loading capacity of 500 pieces, making them suitable for shorter transport routes, particularly when fruits are directly transported to local retail markets such as Daet public market.

After the pineapples have been sorted at the collection area, loading and stacking them into the transport vehicles follow. This is a routine operation typically involving the same team of laborers employed by the assembler-wholesaler (transporter), who may have also participated in the earlier packinghouse operations. During loading, pineapples are carefully placed into bamboo baskets, which are then manually loaded onto the transport vehicle (Figure 62). The six- or 10-wheeler trucks are strategically positioned near the main roads, waiting until they are fully loaded with pineapples (Figure 63).



Figure 62. Manual loading of bamboo baskets in transport vehicle, Camarines Norte, Philippines, 2023.



Figure 63. Typical transport vehicle (10-wheeler truck) for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

For the stacking and loading practice (Tag. *kamada*), pineapples are arranged from the bottom and continues until the pile reaches the roof of the vehicle. Notably, no pallets, whether wooden or plastic, are used in the transport vehicle. Neither dividers nor liners between the piles and stacks of pineapples are used. However, slatted bamboo are strategically positioned on both sides of the transport vehicle (Figure 64) to secure the piled pineapples.



Figure 64. Slatted bamboo used as protective barriers within the transport vehicle, Camarines Norte, Philippines, 2023.



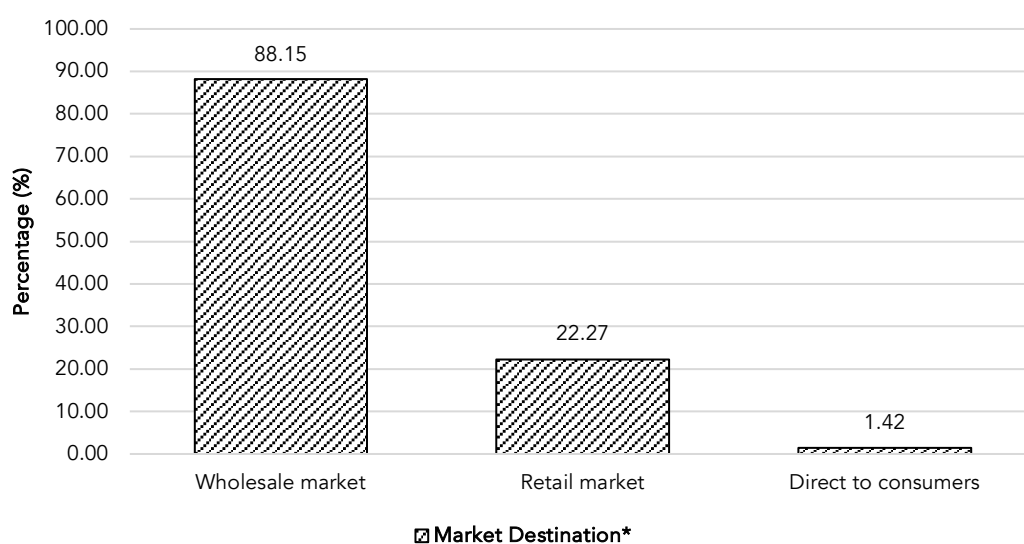
Figure 65. Loading practices of ‘Queen’ pineapples in winged trucks, Camarines Norte, Philippines, 2023.

While the prevailing practice in the area involves stacking pineapples in a consistent manner, it was observed that some traders have adopted a slightly different method locally referred to as ‘*balinsutan*.’ It involves an alternative stacking following a base-to-base and crown-to-crown pattern. Additionally, some traders spray the stacked pineapples with ethephon (Brand name: Ethrel®). This treatment aims to induce peel coloration upon reaching the destination market, typically up to 50% of the fruit portion starting from the base. This is commonly practiced by traders since

consumers in Metro Manila are used in buying pineapples that exhibit advanced peel coloration thinking that they are sweeter. However, in the case of ‘Queen’ pineapple, once peel coloration is induced, it rapidly ripens and become overripe within one or two days. Moreover, if there are pineapples that are still immature, uneven peel coloration occurs and the desired sweetness and flavor is lacking. Thus, while this practice may have its advantages, it is essential to consider the implications of such practices on the quality and market value of ‘Queen’ pineapples.

### 5.3.2.5 Transport to Destination Markets

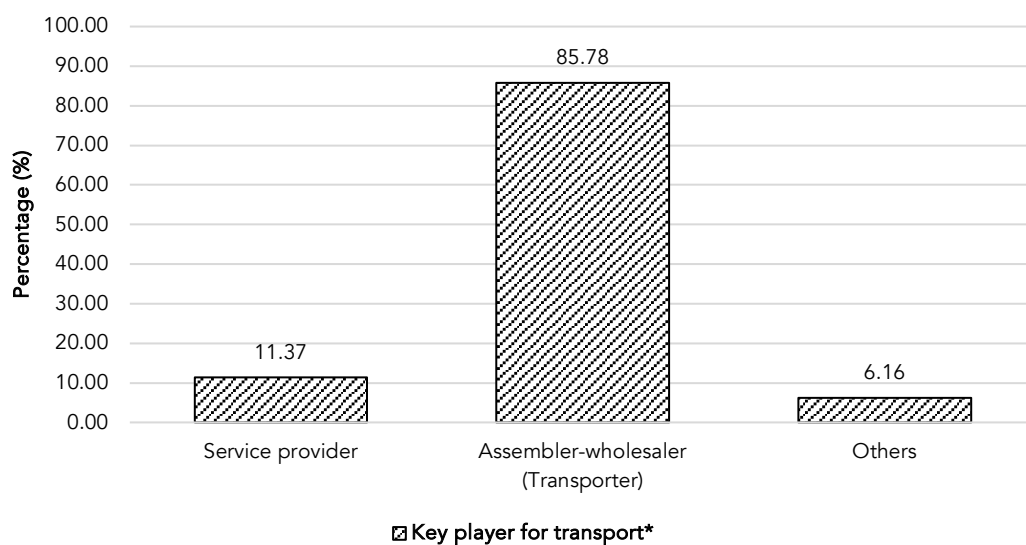
Following the completion of essential packinghouse operations to prepare ‘Queen’ pineapples for the market, the next step is their prompt transport to the destination markets. In the case of ‘Queen’ pineapples, majority (94.79%) of the surveyed farmers are well-informed about the destination markets for their harvested produce. Wholesale markets emerge as the most prevalent destination market, accounting for 88.15% of the responses (Figure 66). On the other hand, some farmers and traders opt to directly deliver their harvested produce to retail markets, while others engage in direct selling to consumers.



\*with multiple responses

Figure 66. Market destinations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

Transport practices in Camarines Norte are typically overseen by the assembler-wholesaler (transporter) (Figure 67). Additionally, transport service providers, often referred to as ‘*biyaheros*,’ play a role in providing transport vehicles. It is noteworthy that some farmers take on the responsibility of managing the transport to destination markets, particularly for shorter-distance journeys to retail markets.



\*with multiple responses

Figure 67. Key player for transport operations for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

The timing of transport in the area can vary, but it is customary to promptly deliver the produce to destination markets right after achieving full loading. All operations, from harvesting to transport, are efficiently completed within the day. Transport typically occurs during the cooler time of the day, commencing from late afternoon and often reaching major wholesale markets in the early morning. Notably, the practice involves full-load single commodity transport, and mixed-commodity transport is not common.

Common problems encountered during transport are shown in Figure 68. A significant number of the surveyed farmers have identified the ripening of ‘Queen’ pineapples as a prevalent issue during transport, with problems occurring upon reaching market destinations, particularly wholesale markets. Other reported challenges

associated with this practice include issues related to poor road conditions, transport delays, and other factors.

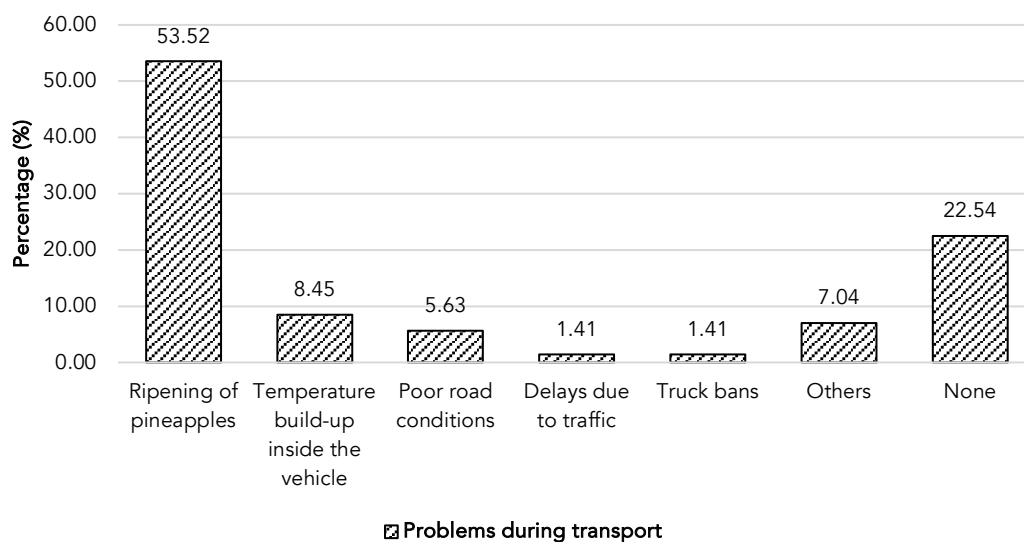


Figure 68. Common problems encountered during transport, Camarines Norte, Philippines, ( $n=71$ ), 2023.

For long-distance journeys, such as transporting goods to major wholesale markets in Metro Manila, the transport duration can extend up to 12 hours or more, contingent upon the prevailing transport conditions. Given these long travel times, it becomes crucial for transport to be properly ventilated. There is a general knowledge among farmers and traders that transport vehicles lack adequate ventilation. The absence of proper ventilation results in temperature build-up within the piles of pineapples accelerating ripening, and in some cases, premature decay upon reaching the wholesale markets. This issue is a recurrent concern reported in the study area, emphasizing the importance of addressing these challenges in the transport practice to maintain the quality of the produce.

In cases where transport is delayed, often caused by adverse weather conditions, the practice of some traders is to temporarily keep the pineapples along roadsides and covering them with canvas tarpaulins until transport becomes feasible. These transport delays typically range from one to two days, and during this period, the pineapples are susceptible to ripening and decay. Additionally, temperature builds up in the canvas-covered piles of pineapples, which accelerates the ripening of the fruit. In situations

where the environment is humid, fruits are also susceptible to decay. Along with the absence of adequate temporary holding or storage facility, such scenarios often result in losses when the produce reaches its destination market.

#### *Loss Estimates during Transport*

Regarding postharvest losses incurred during transport, surveyed farmers were able to discern between marketable and non-marketable rejections, specifying their types and characteristics. The occurrence of marketable rejections is relatively low and primarily consists of fruits that are ripe, deformed, mechanically-damaged, or compressed (Table 31). However, majority of losses during transport can be attributed to non-marketable rejections due to overripening. The reported incidence for marketable and non-marketable fruit rejections shed light on the postharvest losses occurring subsequent to transport. Understanding the types and causes of these losses is pivotal for devising strategies to mitigate these problems and enhance quality and marketability of ‘Queen’ pineapples.

Table 31. Nature of losses after transport, Camarines Norte, Philippines, 2023.

Nature of Rejects	Frequency ( <i>n</i> =42)	Percentage
Marketable Rejects		
Ripe	2	4.76
Deformed	1	2.38
Mechanical damage	1	2.38
Compressed	1	2.38
<b>Total</b>	<b>5</b>	<b>11.90</b>
Non-marketable Rejects		
Overripe	29	69.05
Severe insect damage	2	4.76
Decay	6	14.29
Severe compression	3	7.14
<b>Total</b>	<b>40</b>	<b>95.24</b>

The aggregate postharvest loss estimate for this operation stands at 5.563% (Table 32). Further breaking down this estimate, marketable rejections contribute to 2.250% of the total losses, while non-marketable rejects account for a slightly higher proportion at 3.313%. This information is essential in pinpointing the areas where interventions and improvements are most needed to minimize losses and enhance the overall efficiency of the ‘Queen’ pineapple value chain.

Table 32. Postharvest loss estimates during transport, Camarines Norte, Philippines, 2023.

Variable	Losses (%)	Std. Dev.	Min	Max
Non-marketable Rejects	3.3125	6.61102	1.00	30.00
Marketable Rejects	2.250	2.50	1.00	6.00
<b>Total Transport Losses</b>	<b>5.5625</b>	<b>7.55991</b>	<b>1.00</b>	<b>36.00</b>

### 5.3.2.6 Wholesale and Retail Practices

‘Queen’ pineapples produced in Camarines Norte are distributed to different points in the country, reaching their intended markets. Typically, wholesale practices are conducted in major wholesale markets, while retail practices take place in various local markets, whether they are nearby or more distant. Most farmers in Camarines Norte, due to their limited resources, are not actively involved in these practices beyond their primary roles of production, field-level postharvest operations, and selling to assembler-wholesalers (transporters).

However, there are exceptions where farmers engage in direct selling in retail markets, particularly within the locality. Instead of transporting produce to distant wholesale markets and selling to traders, a proportion of surveyed farmers opt for direct retailing in local public markets or ‘*tiangge*’ areas. Farmers choose to sell directly to the local markets because of the lower farmgate prices offered by traders. This enables them to have more control over pricing, ensuring that they receive fair returns for their produce. Table 33 presents the sorting classification and retail pricing typically observed in these farmer-retailer transactions.

Table 33. Sorting and retail practices by farmer-retailers, Camarines Norte, Philippines, 2023.

Sorting Classification	Weight Range (in grams)	Retail Price (per piece)
Good		
Jumbo or Extra	more than 1000	PhP 12.00 (US\$ 0.22)
<i>Primera</i>	750 to 1000	PhP 10.00 (US\$ 0.18)
<i>Segunda</i>	500 to 750	PhP 8.00 (US\$ 0.15)
<i>Tercera</i>	250 to 500	PhP 6.00 (US\$ 0.11)
Butterball ( <i>buraot</i> )	less than 250	PhP 4.00 (US\$ 0.07)

## 5.4 System of Actors

The successful operations within the ‘Queen’ pineapple value chain hinges on the active participation of several key players. These main actors encompass farmers, assembler-wholesalers (transporters), agents, market wholesalers and retailers, and processors (Figure 69). Additional actors include family laborers and hired workers in the field, who execute specific tasks at various stages of the chain.

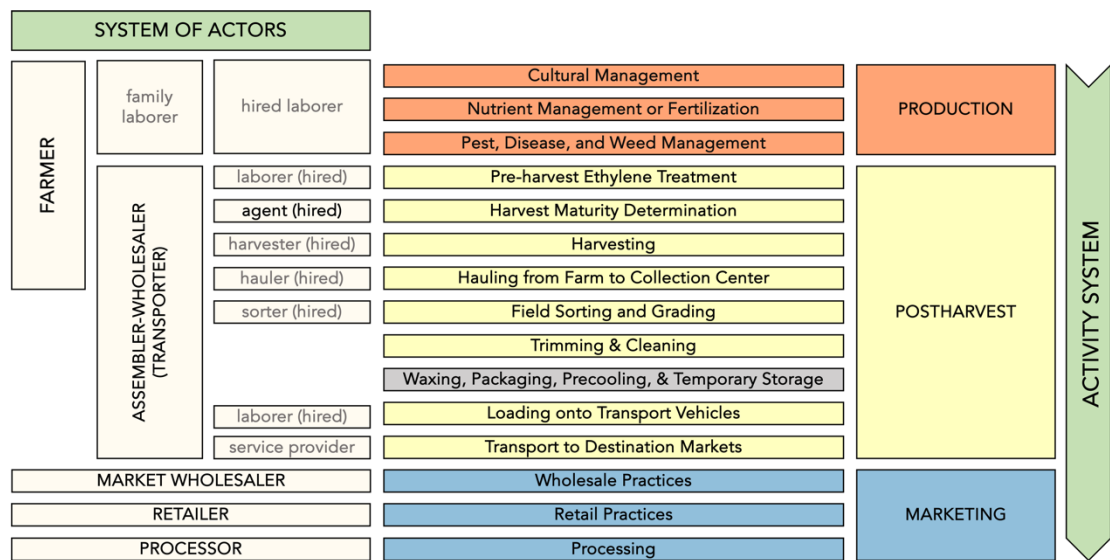


Figure 69. System of actors within the activity system in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.

Each of these participants undertakes specific functions spanning production, postharvest handling, marketing, and processing activities. The smooth flow of activities in the chain significantly relies on the collaborative efforts among these primary actors in efficiently delivering and ensuring safe and quality ‘Queen’ pineapples to end consumers.

Farmers and assembler-wholesalers (transporters) are the primarily responsible for most of the activities in the value chain encompassing both production and postharvest aspects. Farmers shoulder a substantial portion of the value chain’s activities, encompassing all production-related activities to harvest operations and hauling to collection areas. Family and hired laborers assist the farmers in production-related tasks. Simultaneously, assembler-wholesalers, serving as transporters, manage

packinghouse operations and transportation logistics, ensuring that freshly harvested ‘Queen’ pineapples reach their destination markets. Notably, some tasks such as determining harvest maturity and hauling activities, are jointly undertaken by both farmers and assembler-wholesalers. Hired agents play a pivotal role, particularly in assessing harvest maturity.

The workforce required in managing field operations includes a combination of family and hired laborers, who collaborate with farmers to carry out production-related tasks. In contrast, postharvest handling operations primarily rely on hired laborers provided by the assembler-wholesalers (transporters), covering activities such as hauling, sorting, loading and transportation services.

Market wholesalers and retailers predominantly focus on marketing-related activities, while processors specialize in transforming freshly harvested ‘Queen’ pineapples into various processed product forms. This intricate interplay among key players ensures the efficient functioning of the ‘Queen’ pineapple value chain, from cultivation to consumers’ tables.

In most cases, following the harvest of ‘Queen’ pineapples, the majority of farmers typically choose between two primary avenues for selling their produce (Figure 70). They either opt to sell pineapples to assembler-wholesaler (transporter) who then facilitate the distribution to destination markets, often wholesale markets. Alternatively, some farmers prefer to directly sell their produce to retailers. The choice on the type of buyer, particularly traders, hinges on several factors such as accessibility and availability, operational costs, and credit ties.

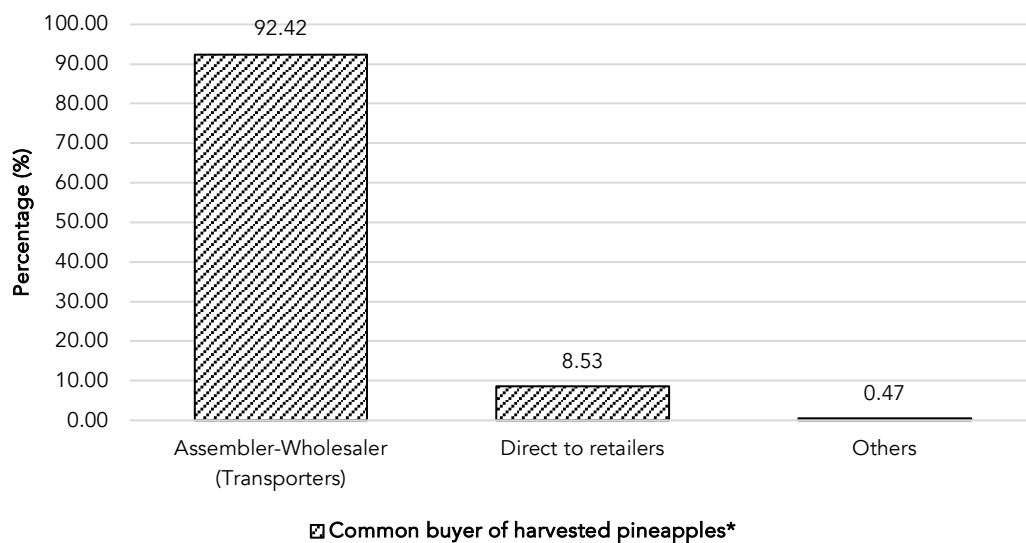


Figure 70. Common types of traders after harvesting pineapples, Camarines Norte, Philippines, 2023.

The availability and accessibility of traders in the area play a significant role in farmers' decisions. Since there are few traders, farmers have limited options when it comes to choosing where to sell their pineapples, especially in bulk. Regarding operational costs, engaging in marketing and trading operations can be financially burdensome to some farmers. Expenses like renting transport vehicles and associated costs during transportation to destination markets accordingly will reduce their profits. This makes the option of selling to traders who handle these costs more appealing. Lastly, in some cases where farmers might have financial ties or credit arrangements with specific traders, they may be obligated to sell their produce to these traders. This scenario often arises when traders provide cash advances to farmers, with the condition that farmers will exclusively sell their produce to them.

### 5.5 Pricing System

In Camarines Norte, there two distinct pricing systems for 'Queen' pineapples: (1) all-in pricing (referred to as '*arasar*' or '*syomber*') and (2) ladderized pricing (known as '*klase klase*' or '*tamanyuhan*'). Notably, the ladderized pricing system is the more commonly adopted, accounting for 73.46% of the surveyed farmers, while the remaining farmers opt for the all-in pricing system as indicated in Figure 71.

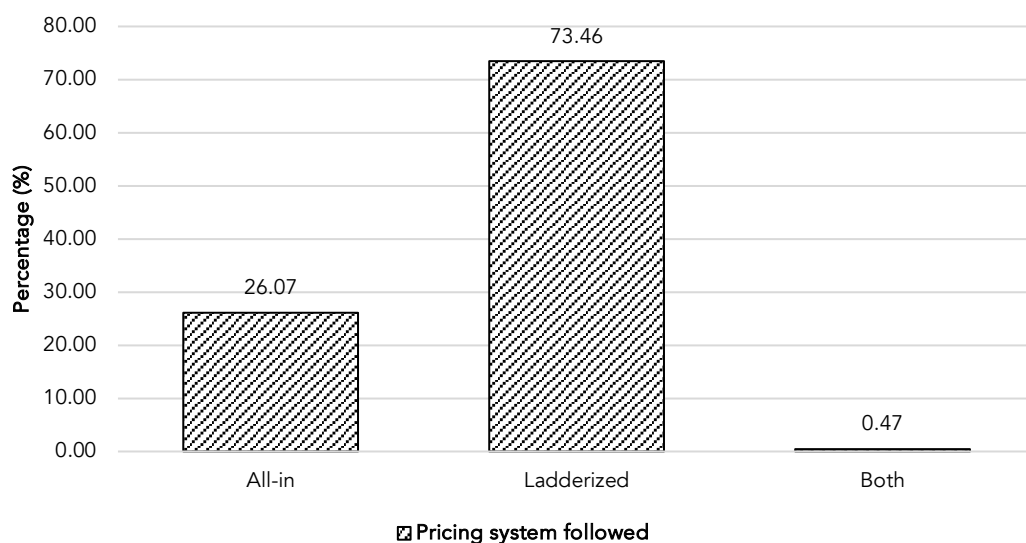


Figure 71. Pricing system followed by farmers in Camarines Norte, Philippines, 2023.

#### 5.5.1 All-in Pricing System (*Arasar* or *Symer*)

The all-in pricing system, as the name suggests, offers a single uniform price for all harvested produce, eliminating the need for sorting and price differentiation. In this system, there is only one farmgate price for both ‘good’ and ‘butterball’ pineapples.

The adoption of the all-in pricing system can be attributed to several key advantages. Firstly, it simplifies transactions between farmers and traders, avoiding the negotiation process. Secondly, it reduces the labor-intensive nature of sorting, thus minimizing the need for meticulous categorization. Lastly, in some cases, it can provide a competitive advantage to farmers, particularly when a higher proportion of ‘butterball’ pineapples is expected in the harvest.

However, it is important to note that the farmgate prices paid by traders under the all-in pricing system exhibit significant variability. The all-in price per pineapple can range from as low as PhP 2.50 (US\$ 0.05) to as high as PhP 12.00 (US\$ 0.22). On average, the prevailing all-in price for ‘Queen’ pineapples stands at PhP 5.50 per piece (US\$ 0.10). This variation in pricing emphasizes the importance of understanding market dynamics and trends when participating in the all-in pricing system. Farmers and traders should remain vigilant and informed to make the most of this pricing approach in the pineapple industry.

### 5.5.2 Ladderized Pricing System (*Klase-klase* or *Tamanyuhan*)

The predominant pricing system in Camarines Norte is the ladderized pricing system, characterized by tiered pricing based on the sorted categories of pineapples. This system typically offers two distinct price levels, with ‘good’ pineapples commanding a higher price than ‘butterball’ pineapples. Compared to the all-in pricing system, the ladderized pricing system generally provides higher farmgate prices, making it a preferred choice among farmers seeking greater profitability. Most farmers perceive this system as more favorable for them. Furthermore, the majority of traders in the region adhere to the ladderized pricing model, offering the all-in pricing option only in specific circumstances.

However, a notable drawback of the ladderized pricing system is the considerable variability in sorting classification, leading to non-uniform sorting practice in the area. While many adhere to the standard 5-size classification for ‘good’ pineapples, variations are common. As indicated in Table 34, traders often employ diverse sorting classifications, ranging from less stringent, with fewer than the regular 5-size categories, to more rigorous standards, including six or more size categories, depending on the trader’s requirements. The variability in sorting standards is a challenge that farmers face in the region, as it can sometimes lead to misclassification of ‘good’ and ‘butterball’ pineapples (for detailed sorting practices, refer to section 5.3.2.3).

Table 34. Different sorting classification in ladderized pricing system, Camarines Norte, Philippines, 2023.

Sorting Classification	Frequency	Percentage from all responses ( <i>n</i> =211)	Percentage from ladderized pricing ( <i>n</i> =156)
Good only	43	20.38	27.56
Extra, 1st to 5th size	3	1.42	1.92
Extra, 1st to 4th size	2	0.95	1.28
Extra, 1st to 3rd size	2	0.95	1.28
1st to 6th size	4	1.90	2.56
1st to 5th size	74	35.07	47.44
1st to 4th size	16	7.58	10.26
1st to 3rd size	11	5.21	7.05
1st to 2nd size	1	0.47	0.64

The price fluctuations within this pricing system are evident, with ‘good’ pineapples ranging from as low as PhP 4.00 (US\$ 0.07) to as high as PhP 18.00 (US\$ 0.33) per piece. ‘Butterball’ pineapples also exhibit variability, with farmgate prices ranging from as low as PhP 1.00 (US\$ 0.02) up to PhP 6.00 (US\$ 0.11) per piece. On average, ‘good’ pineapples are priced between PhP 10.00 to 11.00 (US\$ 0.18 to 0.20) per piece, while ‘butterball’ pineapples typically range from PhP 2.00 to 3.00 per piece (US\$ 0.04 to 0.05).

Table 35. Pricing system for ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

Category	Farmgate Price		Wholesale Price	Retail Price
	All-in Pricing	Ladderized Pricing		
Good				
First size			40.00 (0.73)	60.00 (1.09)
Second size	5.50	10.00 to 11.00	35.00 (0.64)	-
Third size	(0.10)	(0.18 to 0.20)	30.00 (0.55)	-
Fourth size			25.00 (0.45)	-
Fifth size			20.00 (0.36)	-
Butterball	5.50 (0.10)	2.00 to 3.00 (0.04 to 0.05)	5.00 (0.09)	10.00 (0.18)

Price indicated is PhP per piece. Values in parenthesis indicate price in US\$.

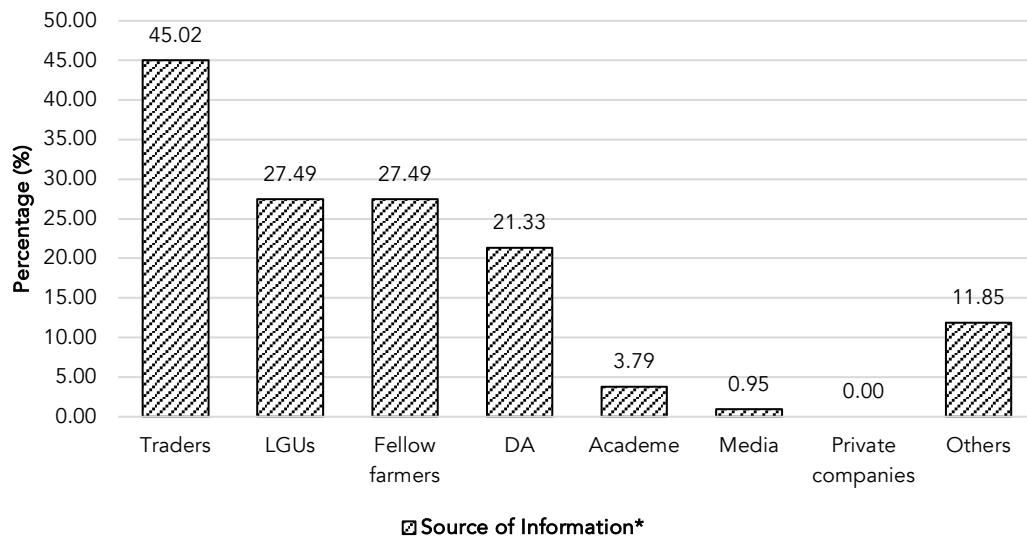
In conclusion, the ladderized pricing system in Camarines Norte offers a tiered pricing structure that can provide better returns to farmers compared to the all-in pricing model. However, the system’s flexibility and variable sorting standards pose challenges in achieving uniformity. It is crucial for both farmers and traders to engage in this pricing system with an understanding of the associated fluctuations and standards, ensuring fair and profitable transactions within the pineapple industry.

## 5.6 Relational Flows

In the context of a value chain, a relational flow pertains to the communication, collaboration, and interaction between the various participants or actors involved in the chain. Mapping these flows helps determine each key player’s behavior and roles in the overall success of the chain (Kaplinsky & Morris, 2001). In the ‘Queen’ pineapple value chain, which encompasses the process of bringing pineapples from production to the end consumer, relational flows play a critical role in ensuring the smooth and efficient functioning of the chain.

### 5.6.1 Information Flow

Participants in the value chain, such as farmers, assembler-wholesalers (transporters), processors, wholesalers, and retailers, need to exchange information regarding crop status, demand forecasts, quality standards, pricing, and logistical details. Effective communication helps in coordinating activities and making informed decisions. Within the ‘Queen’ pineapple value chain, a diverse range of information sources influences the surveyed farmers (Figure 72). Among these sources, traders play a pivotal role, being the primary source of information, accounting for 45.02% of responses. Local government units and fellow farmers also hold significant importance, with both representing major sources of information at 27.49% each. The national agriculture department is another noteworthy source of guidance.



\*with multiple responses

Figure 72. Sources of technology and information of ‘Queen’ pineapple farmers, Camarines Norte, Philippines, 2023.

Additionally, the academe and media contribute to information related to pineapple farming, offering valuable insights and technology updates. Some farmers also rely on their personal experiences and expertise for informed decisions and practices within the value chain. The availability of information and their sources underscore the multidimensional nature of knowledge acquisition within the ‘Queen’ pineapple value chain, where diverse channels of information collectively contribute to informed decision-making among farmers.

Regarding pricing information, especially concerning prevailing market prices and the rates paid by traders in destination markets, there is a significant information gap among the surveyed farmers. The majority of these farmers have limited to no knowledge of current market prices, with only a small fraction (12.80%) having an awareness of market rates. Notably, most farmers typically sell their pineapples to traders based on agreed-upon farmgate prices, which are normally determined by the traders themselves. These farmgate prices exhibit variability and are contingent on the trader's discretion.

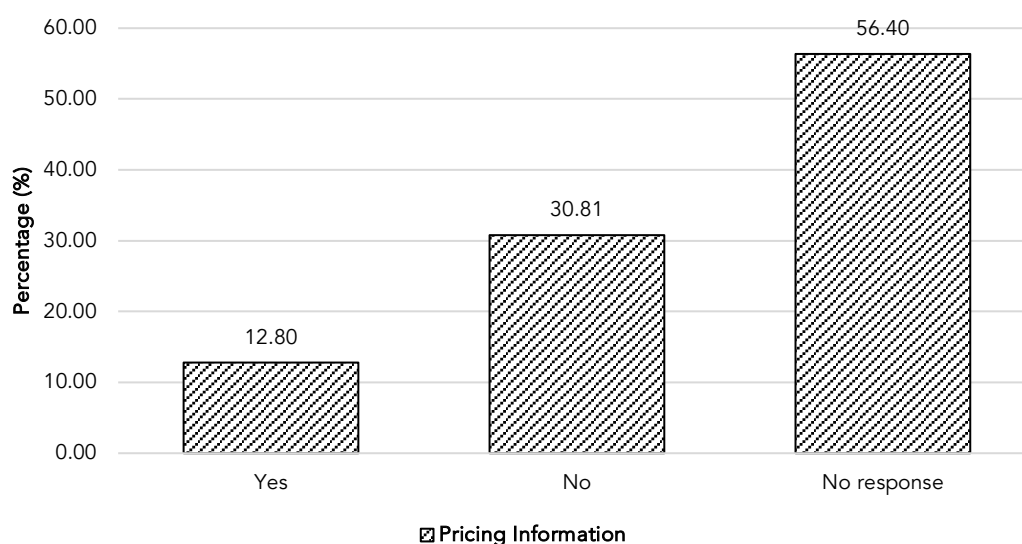
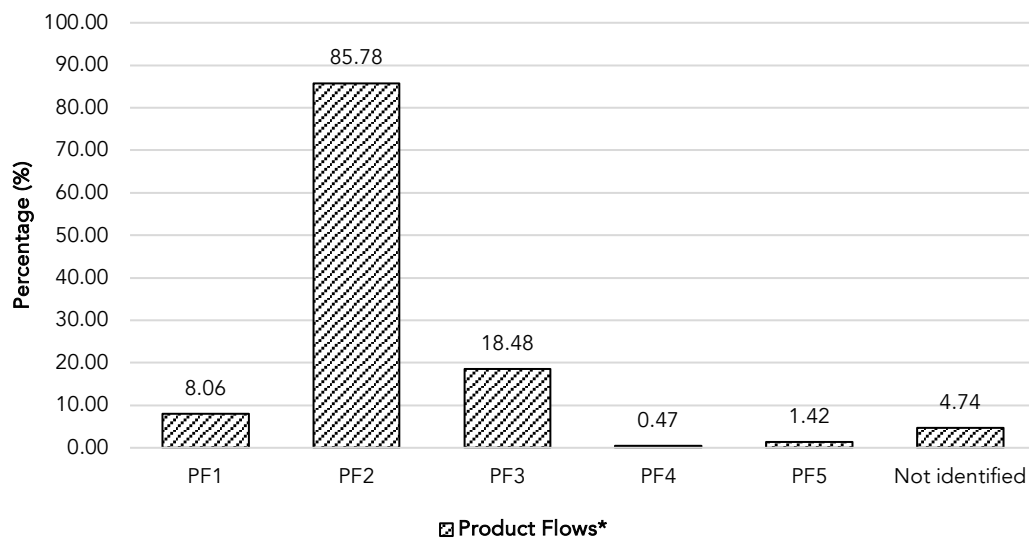


Figure 73. Price information of 'Queen' pineapple farmers, Camarines Norte, Philippines, 2023.

In the absence of price monitoring and with the prevalence of this pricing system, farmers find themselves with limited room for negotiation, often accepting the offered prices without much leverage. Furthermore, farmers are generally unaware of the final prices paid in the destination markets. This lack of market knowledge and the scarcity of price information sharing represent a notable challenge encountered by farmers in Camarines Norte. Addressing this information gap and empowering farmers with better market information could enhance their ability to negotiate fair prices and make more informed decisions within the 'Queen' pineapple value chain.

### 5.6.2 Product Flow

Within the ‘Queen’ pineapple value chain, five distinct product flows (PF) exist, each following diverse routes and engaging specific key actors. These PFs indicate the diversity of the production-distribution continuum of ‘Queen’ pineapple value chain. The flows can exhibit varying lengths, ranging from short and direct to more extensive routes, and may involve a multitude of actors or operate with minimal intermediaries.



\*with multiple responses

Figure 74. Different product flows in the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.

#### Product Flow 1

The initial product flow, denoted as PF1, is characterized by its emphasis on direct retailing within local markets situated within the province. This distribution channel is short and direct, involving minimal intermediary steps. The primary actors in this product flow are the farmers and retailers.

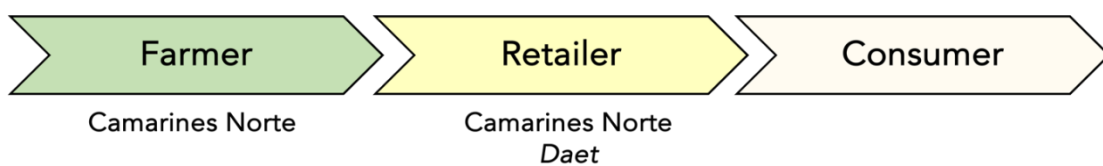


Figure 75. Product Flow 1

In PF1, the distribution of ‘Queen’ pineapples commences at the farms, where they are immediately loaded onto haulers and promptly transported to nearby markets within the same province. Notably, this product flow frequently centers on Daet public markets as the prime destination for direct retail sales. In PF1, the all-in pricing system prevails eliminating sorting in packinghouses. PF1 is the preferred route when dealing with smaller volumes of ‘Queen’ pineapples, typically less than 1000 pieces.

### Product Flow 2

The second product flow, denoted as PF2, stands out as the most extensive in terms of geographical coverage and the involvement of numerous key players. This particular product flow serves as the primary distribution route in Camarines Norte. PF2 is a vital component of the ‘Queen’ pineapple value chain, enabling the efficient distribution of these pineapples to a broader consumer base.

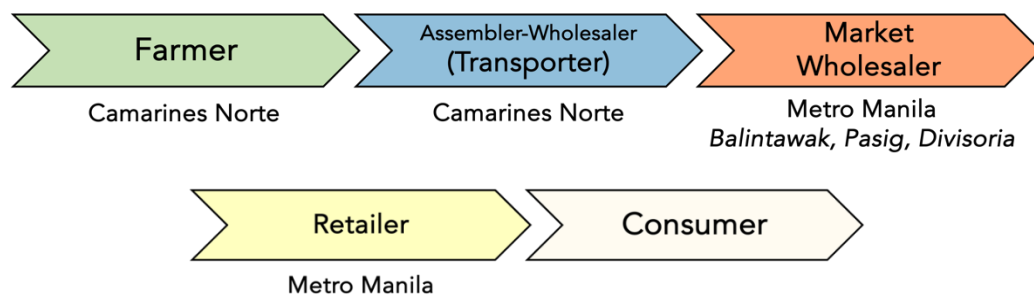


Figure 76. Product Flow 2

‘Queen’ pineapples originating in Camarines Norte are predominantly directed towards major wholesale markets, specifically in Metro Manila, which includes Balintawak, Pasig, and Divisoria markets. These markets serve as active hubs where substantial volumes of fresh produce, including fruits and vegetables, are traded and distributed throughout the entire country.

The operational process in Camarines Norte for PF2 commences with the handling of freshly harvested pineapples, ensuring their quality is maintained. Once prepared for the market, pineapples are loaded onto transport vehicles, embarking on a long-distance journey spanning more than 350 kilometers. Upon reaching the wholesale markets in Metro Manila, the prevalent trading practice is wholesale in nature. Here,

fruit stalls or stand owners procure large volumes of ‘Queen’ pineapples directly from the assembler-wholesaler (transporter). These pineapples are then resold to retailers or consumers in retail or smaller quantities.

### Product Flow 3

The third product flow, known as PF3, represents a more regionally focused distribution route that extends to neighboring provinces within Bicol region. It becomes the preferred choice for both farmers and assembler-wholesaler (transporter) if ‘Queen’ pineapples are not destined for major wholesale markets in Metro Manila, often due to the challenges of long-distance transportation. PF3 offers an alternative route that caters to the specific needs of regional markets, ensuring that ‘Queen’ pineapples are made available to a broader consumer base beyond the major metropolitan areas.

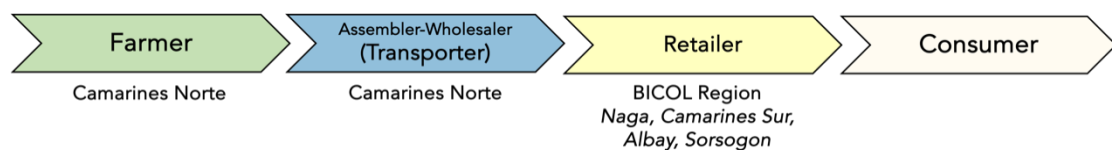


Figure 77. Product Flow 3

Just like in PF2, the process in PF3 begins with the careful preparation and loading of freshly harvested pineapples onto transport vehicles. However, in this case, the transport vehicles have smaller loading capacities compared to those used for major wholesale markets. In terms of distribution, pineapples are delivered in retail quantities to nearby cities and provinces, such as Naga, Camarines Sur, Albay, and Sorsogon. Here, market retailers and smaller-volume buyers play a key role in the procurement of ‘Queen’ pineapples, facilitating a more localized and accessible supply for consumers in the region.

### Product Flow 4

The fourth product flow, designated as PF4, represents a unique approach, particularly in terms of the final product forms provided to consumers. Starting at the plantations, ‘Queen’ pineapples undergo specialized preparation for raw material handling, primarily intended for local processors within the province.

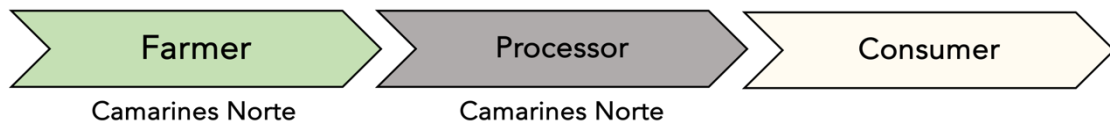


Figure 78. Product Flow 4

In this case, local processors often establish direct procurement relationships with the farmers, securing freshly harvested pineapples and subsequently transporting them to their processing facilities for conversion into various product forms. These include pineapple juice, dried pineapples, and even piña fiber used in textiles and clothing, among other products. PF4 exemplifies the versatility of ‘Queen’ pineapples as a valuable resource for various local processing endeavors, expanding the array of consumer goods derived from this fruit.

#### Product Flow 5

The fifth product flow, referred to as PF5, bears similarities to PF3 concerning the key actors involved and the distribution operations for ‘Queen’ pineapples. However, PF5 distinguishes itself by extending its reach to retail markets beyond the normal destinations in Metro Manila and within the region.

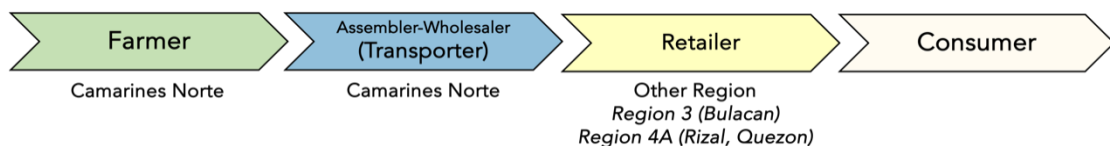


Figure 79. Product Flow 5

In PF5, ‘Queen’ pineapples originating from Camarines Norte are transported by the assembler-wholesaler (transporter) to provinces located outside the region. Notably, some traders opt to sell pineapples to retail markets in Region 3 specifically in Bulacan province, and in Rizal and Quezon provinces in Region 4A. This expanded reach underscores the adaptability of the ‘Queen’ pineapple value chain, offering a broader consumer base access to this fruit, while also opening up new avenues for local farmers and traders to explore diverse market opportunities.

### 5.6.3 Horizontal and Vertical Relationships

In the ‘Queen’ pineapple value chain, main actors establish both horizontal and vertical relationships to optimize the production, postharvest handling, distribution, and consumption of pineapples. These relationships are crucial for the smooth functioning of the value chain and for meeting the demands of the market. Table 36 presents the existing relationships of key players and the associated strengths in the value chain.

Table 36. Horizontal and vertical relationships of primary actors in the ‘Queen’ pineapple’ value chain, Camarines Norte, Philippines, 2023.

Relationship	Description	Strength
<i>Horizontal Relationship</i>		
Peer-to-peer Connections	From farmer to farmer, sharing of common resources is limited. A common shared resource is extra labor. However, most farmers still employ and pay additional laborers for production-related activities. Knowledge sharing on practices is evident.	moderate
Competition	Competition among farmers in terms of selling in local markets is non-existent. Supply is generally year-round ensuring that farmers are able to sell their produce to traders.	weak
Cooperation	Cooperation among farmers in terms of farming calendar or programming is weak. While supply is generally available year-round, oversupply in certain months may exist making marketing more difficult. Further, while farming organizations are active, however, there is limited sharing of operational costs such as tools and equipment procurement, and transportation resources to reduce their total costs.	moderate
Information Sharing	Sharing of information in terms of practices in production, postharvest handling, and marketing among farmers is evident in the area. Farmers also share the same information about local traders and their availability.	strong
<i>Vertical Relationship</i>		
Farmer-to-trader Connections	In general, farmers depend on traders for their production costs and other financial needs while traders depend on their production. Credit ties are also present in some cases resulting in farmer-trader agreements.	strong
Integration and Collaboration	The problem of permanent traders is prevalent in the area. Some farmers are often left with difficulty in looking for traders due to their limited procurement capacity especially when there is overproduction.	moderate

Table 36. *continued...*

Relationship	Description	Strength
Quality Assurance	Guidelines and standards on some operations, especially in sorting, shows non-uniformity in practice. While farmers meet most of the requirements, the lack of standard practice, monitoring, and policy guidelines remain a challenge.	weak
Information Sharing	Price information is limited to almost non-existent. However, farmers rely on these traders in terms of available technologies related to pineapple farming.	moderate

Vertical relationships are typically more hierarchical, with each stage of the chain being economically dependent on the previous one. Farmers depend on traders for their production costs and other financial needs, and traders rely on these farmers for their products. Therefore, trust and mutual benefit are critical in vertical relationships. Horizontal relationships, in contrast, are usually more peer-oriented and involve collaboration with other actors at the same stage in the value chain. These relationships can enhance resource sharing, learning, and the development of economies of scale.

Overall, both horizontal and vertical relationships are essential in the ‘Queen’ pineapple value chain. Horizontal relationships foster collaboration and knowledge sharing among actors, while vertical relationships ensure the efficient flow of pineapples from the farm to the consumer, emphasizing coordination, trust, and quality control.

### 5.7 Value Chain Map

Mapping the pineapple value chain with a focus on loss identification is crucial for improving efficiency, reducing loss and waste, and ensuring produce quality. It benefits the industry economically, environmentally, and in terms of sustainability, helping to meet the challenges of a complex and interconnected supply chain. Figure 80 presents the ‘Queen’ pineapple value chain map starting from production areas in Camarines Norte until distribution to wholesale and retail markets.

From the map, losses occur pre- and postharvest. With majority of the losses occurring during postharvest handling of ‘Queen’ pineapples, this knowledge becomes

vital for implementing strategies to reduce food loss and waste, which is not only economically wasteful but also has environmental implications.

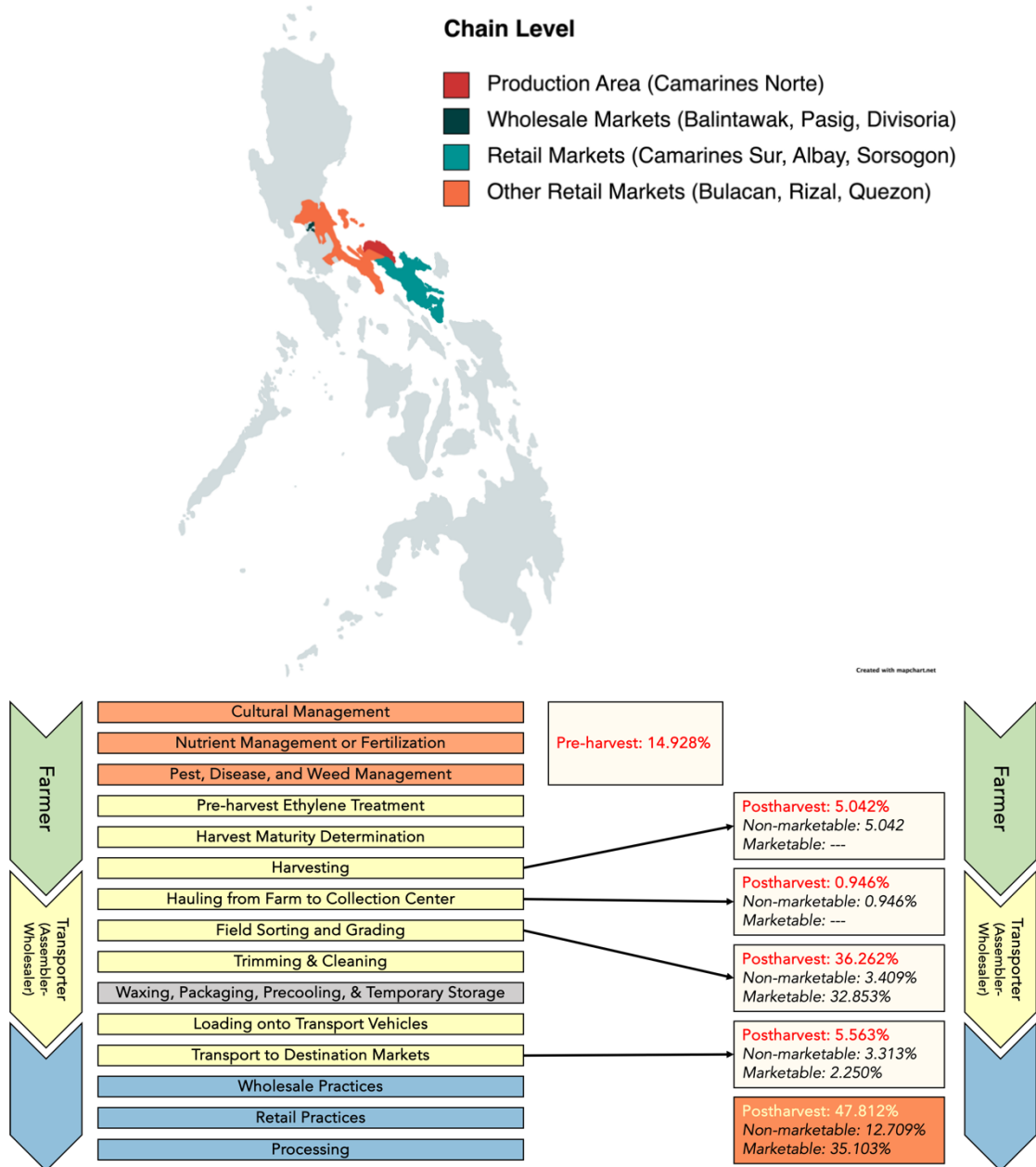


Figure 80. ‘Queen’ pineapple value chain map, Camarines Norte, Philippines, 2023.

Produce quality are compromised during certain postharvest operations including harvesting, hauling from farm to collection areas, field sorting, and transport to destination markets. With quantified total postharvest loss estimates at 47.812% (Figure 80), economic impacts of these losses are translated to profit losses of the

stakeholders involved, especially farmers and traders. Informed decisions in infrastructure investments, postharvest technology interventions, and innovations in handling practices can improve efficiency and reduce losses, ultimately leading to cost savings and added income of these actors.

The identified points in the value chain where losses occur allows for better risk management. Understanding the vulnerabilities and potential causes of losses enables stakeholders to develop risk mitigation strategies. This could involve improving handling practices, provision of facilities, adopting a standard sorting system acceptable to all players, or implementing pest and disease control measures.

Ultimately, the ‘Queen’ pineapple value chain map helps build resilience within the handling chain. Knowing where losses occur and how can these stakeholders prepare for and respond to disruptions, whether they are due to natural disasters, handling chain interruptions, or other unforeseen events.

## 5.8 Loss Estimates along the Value Chain

Within the activity system, farmers can effectively estimate losses incurred during various stages. These losses encompass both preharvest and postharvest categories and may include marketable and non-marketable rejects. The following table provides a summary of estimated losses within the ‘Queen’ pineapple value chain.

Table 37. Summary of loss estimates along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.

Chain Level	Loss Estimates (%)		Total (%)	Cumulative Total (%)
	Non-marketable Rejects	Marketable Rejects		
Preharvest	-	-	14.928	14.928
Postharvest				
Harvest	5.042	-	5.042	5.042
Hauling	0.946	-	0.946	5.988
Sorting	3.409	32.853	36.262	42.250
Transport	3.313	2.250	5.563	47.812
<b>Total</b>	12.709	35.103	47.812	

Notably, a substantial preharvest loss of 14.928% is incurred, emphasizing the need for loss mitigation measures throughout the value chain. ‘Queen’ pineapples are

renowned for their good-eating quality, and preserving this quality until they reach consumers is of paramount importance. However, losses do occur along the value chain, with both marketable and non-marketable rejects contributing to these losses. These losses accumulate from harvest to transportation to destination markets, with non-marketable rejections accounting for 12.709% and marketable rejects at 35.103%. The total pre-harvest loss estimates amount to 14.928%, while postharvest losses comprise 47.812% in total.

It is essential to recognize that these figures represent not only physical losses but, more significantly, economic losses in terms of potential profits for all stakeholders involved in the value chain. While these estimates provide a clear picture of the losses occurring throughout the handling process, it is imperative to conduct actual loss assessment measures to validate these estimates. Such assessments are crucial for accurately quantifying losses and implementing tailored solutions to minimize these losses effectively.

In conclusion, understanding and quantifying losses within the ‘Queen’ pineapple value chain are essential steps in ensuring the economic viability and sustainability of this industry. These findings highlight the urgency of addressing losses at every stage and the need for precise loss assessment to develop strategies that can mitigate economic and physical losses, ultimately benefiting all stakeholders in the pineapple production and distribution chain.

### **5.9 Critical Loss Points along the Value Chain**

A thorough analysis of the ‘Queen’ pineapple value chain has allowed us to assess the practices and activities at each stage, shedding light on the types and causes of losses incurred. This evaluation also extended to estimating the extent of these losses, paving the way for the identification of critical loss points within the chain. These critical loss points are strategic areas where interventions can be introduced to minimize losses, enhance overall efficiency, and streamline the ‘Queen’ pineapple value chain.

Within the activity system of key players in the value chain, several critical points have been pinpointed (Table 38). Notably, poor cultural management practices

and challenges related to insect and pest infestations contribute to pre-harvest losses in ‘Queen’ pineapple plantations. While these losses are inherently pre-harvest in nature, there is room for technical improvements in these activities to reduce pre-harvest losses in the field.

Table 38. Identified critical loss points along the ‘Queen’ pineapple value chain, Camarines Norte, Philippines, 2023.

Chain Level and Activities <sup>1</sup>	Type and Nature of Losses	Cause of Losses	Extent of Losses	Critical Loss Point
(F) Cultural Practices, Pest, Disease, Weed Management	<i>Pre-harvest:</i> undersized and immature fruits, infested fruits	- poor management practices - insect and pest infestations	14.93%	Yes
(I) Pre-harvest Ethylene Treatment	<i>Marketable rejects:</i> fruits exhibiting sourness or not enough sweetness (manifesting at retail)	- injection of ethephon on fruits (Ethrel)	<i>not identified</i>	Yes (on inferior eating quality)
(F/I) Harvest Maturity Determination	<i>not identified</i>	<i>not identified</i>	<i>not identified</i>	No
(F/I) Harvesting	<i>Non-marketable rejects:</i> mechanical damage (fruit cracking, severe compression, crown removal)	- rough handling at harvest (twist-and-bend harvesting method)	5.042%	Yes
(F/I) Hauling	<i>Non-marketable rejects:</i> mechanical damage (severe compression, fruit cracking, severe bruising, fruits falling from container)	- rough handling (tossing of pineapples) - long distance hauling - inappropriate hauling containers - poor road conditions	0.946%	Moderate
(I) Field Sorting	<i>Non-marketable rejects:</i> overripe, severe insect and pest damage, immature, mechanical damage (fruit cracking, severe compression), severe deformation, crown removal	- rough handling such as throwing of fruits and fruit dropping	3.409%	Yes
	<i>Marketable rejects:</i> butterball	- non-uniformity in sorting classification	32.853%	Yes (on income & profits)
(I) Loading onto Transport Vehicles	<i>Non-marketable rejects:</i> not identified	- non-usage of protective barriers, dividers, pallets	<i>not identified</i>	Moderate
	<i>Marketable rejects:</i> irregular ripening pattern	- alternate piling and stacking - spraying of ethephon (Ethrel)	<i>not identified</i>	Yes (on inferior eating quality)
(I) Transport	<i>Non-marketable rejects:</i> overripe, decay	- temperature build up in vehicle - poor transport conditions - manner of loading	3.313%	Yes
	<i>Marketable rejects:</i> ripe, deformed, mechanical damage, compression damage	- temperature build up in vehicle - poor transport conditions - manner of loading	2.250%	Yes

<sup>1</sup> (F) farmer; (I) transporter (assembler-wholesaler)

Additionally, high rates of losses are attributed to rough handling during postharvest operations, including harvesting, hauling, field sorting, and transport. The repercussions of rough handling have a substantial impact on fruit quality, leading to non-marketable rejections, particularly due to mechanically-damaged fruits. To mitigate these losses, it is imperative to introduce improvements in postharvest handling practices, emphasizing careful handling and appropriate techniques to preserve fruit quality.

Field sorting also emerges as a critical point in the value chain, where the challenge of sorting standardization significantly contributes to losses. Furthermore, the practice of pre-harvest ethylene treatment on fruits several days before actual harvest and spray applications before transport stands out as critical loss points in the chain. These practices have adverse effects on eating quality and ripening at the consumer level. Measures should be undertaken to counteract the impact of inferior eating quality, and improvements in these practices can be highly beneficial. It is imperative that strategies for implementation and standardization be regulated by concerned institutions, including local governments.

The identification of critical loss points within the ‘Queen’ pineapple value chain underscores the urgency of introducing strategic interventions to reduce losses and enhance the overall efficiency of the system. These interventions, encompassing both technical improvements and regulatory measures, are essential for ensuring the economic viability and sustainability of the ‘Queen’ pineapple industry while providing consumers with high-quality fruit products.

#### **5.10 Factors affecting Losses among ‘Queen’ Pineapple Farmers**

The analysis of average losses at the farm level involves a comprehensive understanding of various farming characteristics, socio-economic factors, and practices employed by ‘Queen’ pineapple farmers. From Table 39, a significant difference in farm losses is observed between small and large farms. Notably, smaller farms, characterized by plantations covering less than 1.0 hectare, consistently incur significantly higher losses compared to their larger counterparts.

Table 39. Summary statistics for average farm losses based on selected farm and farmer characteristics, Camarines Norte, Philippines, 2023.

Characteristics	Farm Loss (%)	t-test	p-value
Farm size			
big (1.0 ha and above)	12.499		
small (less than 1.0 ha)	18.231		
difference	-5.732***	-2.6961	0.0076
Farm topography			
sloping areas	15.752		
flat terrain	13.577		
difference	2.175	0.9858	0.3254
Distance from farm to collection area			
short (less than 1.0 km)	15.388		
long (1.0 km and beyond)	15.391		
difference	0.004	-0.0017	0.9987
Harvesting container			
jute sacks	16.438		
<i>sagad or kareta</i>	15.697		
difference	0.740	0.1629	0.8709
Time of harvesting			
afternoon to evening	16.392		
midnight to early morning	14.369		
difference	2.023	0.8527	0.3948
Age			
young (40 years and below)	13.156		
old (41 years old and above)	15.501		
difference	-2.344	-0.9373	0.3497
Membership in Organization			
no active membership	15.498		
with active membership	14.438		
difference	1.059	0.4948	0.6212

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

According to majority of farmer-respondents, heightened losses in smallholder farms can be attributed to their constrained access to certain resources including inadequate availability of farm equipment, harvesting tools and containers, and financial capital for some operations such as hiring farm laborers. Limited resources directly influence the efficiency of farm operations, consequently contributing to high losses at the farm level.

In terms of topography, ‘Queen’ pineapples in flat terrains faced lower losses than those in sloping plantations. However, there is no significant difference in their losses. In addition, pineapple plantations with longer distance from farm to collection center, particularly beyond 1.0 km, faced slightly higher losses than those with shorter

distances. However, there is no significant difference in losses and this can be attributed to the same poor road conditions regardless of farm distance.

When evaluating specific harvesting practices, the use of jute sacks as field containers resulted in higher losses compared to the use of *sagad* or *kareta*. Additionally, harvesting during the afternoon and evening hours led to increased farm losses compared to early harvest hours. This phenomenon can be attributed to prolonged sunlight exposure on pineapples and the challenges faced by farmers during unfavorable low-light conditions. Despite varied practices, there are no statistically significant differences in both harvest containers and the timing of harvesting.

Certain demographic factors reveal that older farmers in the area tend to experience higher farm losses than younger farmers. In addition, farmers who are members of farm-related organizations exhibit lower rates of losses. Although demographic attributes exhibited different levels of farm losses, the analysis did not establish any significant differences in the observed losses.

Further analysis of the factors influencing losses among ‘Queen’ pineapple farmers is employed using multiple linear regression model. Numerous factors exert a significant impact on the farm losses experienced by ‘Queen’ pineapple farmers (Table 40). Notably, the years of farming experience is a significant factor, with a negative correlation indicating that farmers with greater experience tend to incur lower farm losses. This can be attributed to the honed skills of experienced farmers, particularly in the nuanced practices of cultivating ‘Queen’ pineapples. Their extensive experience leads to well-established and practiced harvesting and handling techniques, resulting in reduced losses compared to those with limited farming experience.

Table 40. Regression results for factors affecting farm losses among farmers in Camarines Norte, Philippines, 2023.

Variables	Regression coefficients
yearfarming	-0.00164* (0.000936)
dsmall	0.0944*** (0.0240)
labo	-0.0587** (0.0255)
down	-0.0426** (0.0194)
yieldperha	-4.12e-06*** (9.13e-07)
age	0.000908 (0.000971)
gender	0.0196 (0.0203)
cropperiod	0.000341 (0.00434)
edu1	0.00960 (0.0241)
Constant	0.166** (0.0720)
Observations	209
R-squared	0.160
F(9,199)	4.73
Prob> F	0

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The size of the farm also plays a significant influence in farm losses, particularly for farms with less than 1.0 hectare. Despite the prevalent smallholder demographic in the region, those with smaller farms, below the 1.0-hectare threshold, experience higher losses than their counterparts with larger landholdings.

Farmer location is also a significant determinant, especially for farmers in Labo. ‘Queen’ pineapple farmers in this area experienced significantly lower farm losses compared to neighboring farming communities. This can be attributed to the active cooperation fostered among farmers and their participation in farming-related organizations. Notably, the Labo Progressive Multi-Purpose Cooperative (LPMPC) has played a vital role, facilitating technical knowledge sharing, providing shared equipment, and granting access to shared services. These collaborative efforts enhance

farming operations and contribute to lower losses at the farm level.

Ownership status of the land also significantly influenced farm losses. Farmers who own the land experienced fewer losses compared to farm tenants or those who lease the land for cultivation. The increased control and ownership empowered land-owning farmers, enabling more flexible and comprehensive field operations resulting to reduced losses.

Pineapple yield is another key factor impacting farm losses in Camarines Norte. A positive influence exists between increasing yields and lower losses, aligning with the trend observed in farm size. Farms with lower pineapple yields are more susceptible to higher losses. Additionally, adherence to recommended planting density of 30,000 plants per hectare for ‘Queen’ pineapples is emphasized. Deviating from this density recommendation, either planting beyond or below, can compromise pineapple quality and quantity, thus influencing losses in farm-level operations.

### **5.11 Interventions and Best-Fit Solutions to Improve the System**

The assessment of the handling practices throughout the ‘Queen’ pineapple value chain in Camarines Norte has provided valuable insights into the strengths, relationships, and, most notably, the vulnerabilities of the handling system in ensuring the delivery of high-quality pineapples to end consumers.

By scrutinizing the activity system within the ‘Queen’ pineapple value chain and delving into the functions and practices of the primary stakeholders, our analysis has identified and estimated qualitative and quantitative losses, both preharvest and postharvest in nature. These losses are further categorized into marketable and non-marketable rejects. It is essential to recognize that the causes of these losses play a pivotal role in determining the extent of loss acquisition, thereby allowing us to pinpoint critical loss points within the chain.

These critical loss points serve as potential entry points for interventions and strategic opportunities aimed at enhancing the efficiency of the ‘Queen’ pineapple handling system. In this context, these interventions must be seamlessly integrated into

the existing system, tailored to effectively minimize losses along the chain, and ultimately preserve the quality of ‘Queen’ pineapples.

Regarding the perception of farmers on the overall efficiency of the handling and distribution system within the ‘Queen’ pineapple value chain, a substantial majority (67.77%) view the current system as efficient and effective (Figure 81). However, a significant portion also perceives the system as inefficient, primarily due to issues in their existing practices and external factors that adversely affect their operations, leading to pineapple losses.

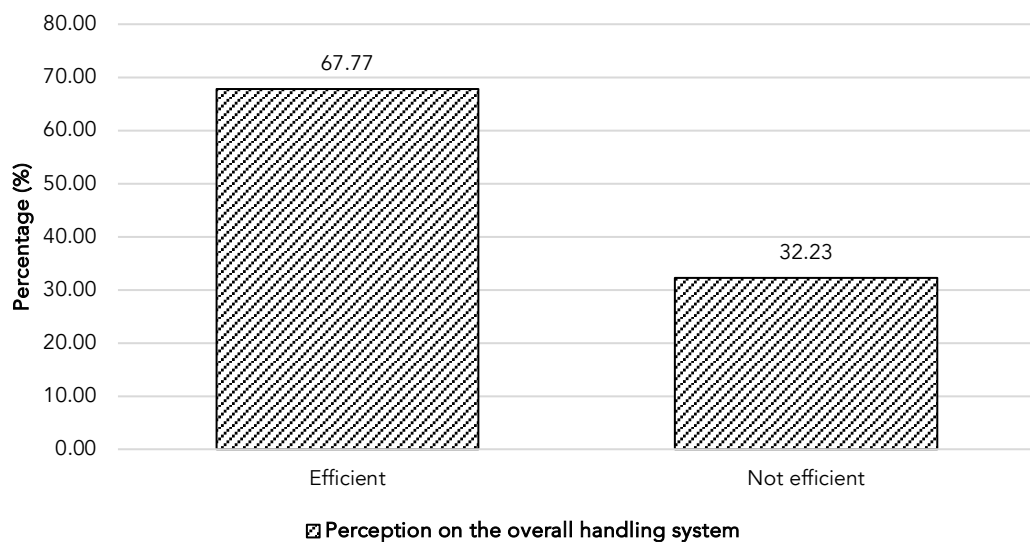


Figure 81. Farmer’s perception on the efficiency of the handling system of ‘Queen’ pineapples, Camarines Norte, Philippines, 2023.

Although the perception of overall efficiency is high, it is noteworthy that a striking 97.63% of the surveyed farmers express a readiness to adopt interventions and strategies aimed at enhancing the efficiency of ‘Queen’ pineapple handling (Figure 82). The willingness to adopt such measures underscores the recognition that improvements are not only necessary but also vital for the sustainability of their operations and the industry as a whole.

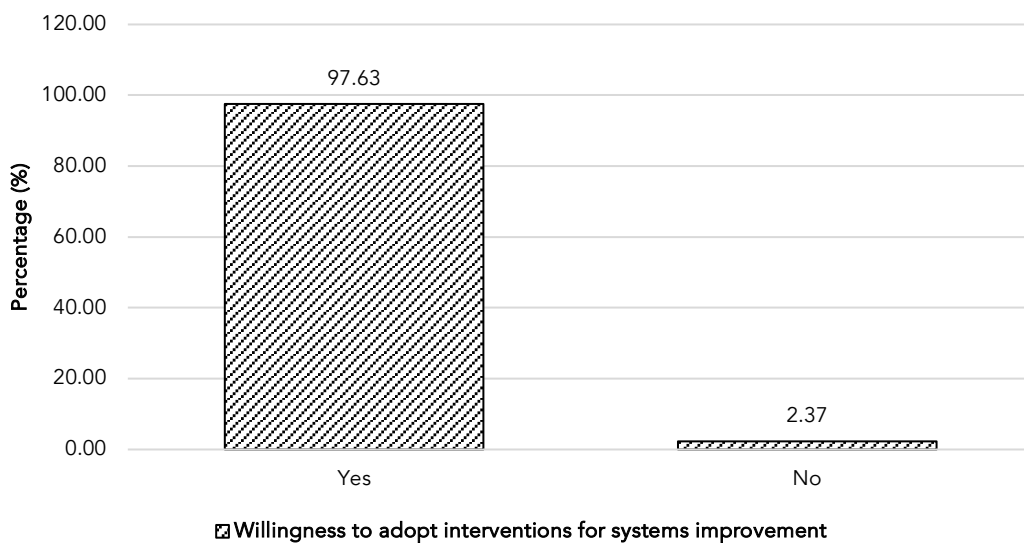


Figure 82. Farmer's willing to adopt interventions for systems improvement in the 'Queen' pineapple value chain, Camarines Norte, Philippines, 2023.

These interventions and strategies, if proven to be technically efficient, socially acceptable, and economically viable within the context of the 'Queen' pineapple value chain in the area, hold the potential to deliver significant benefits. They will not only bolster the resilience of farmers and other stakeholders in the chain but also enhance the overall competitiveness of the pineapple industry.

#### 5.11.1 Improvement in Practices and Creating an Enabling Environment

In assessing both farm and farmer profiles, along with the diverse practices employed, variations from these elements were identified to have significantly influenced the level of losses of 'Queen' pineapple farmers in Camarines Norte. Implementing enhanced management practices and creating a more enabling environment for the targeted stakeholders could prove instrumental in addressing these challenges.

To address the challenge of significant losses among smallholder farmers, it is recommended that interventions be designed to enhance resource accessibility. This could involve targeted initiatives such as providing subsidized access to farm equipment, tools, and harvest containers. Additionally, financial support programs or

capacity-building initiatives aimed at improving the financial resilience of small farms may prove beneficial.

While immediate scaling up of operations may pose challenges, a viable intervention to address the issue of small-scale farming involves the implementation of a clustering program among pineapple farmers. This strategy entails the pooling of resources, encompassing labor, farm tools and equipment, technologies, and access to markets. These collaborative mechanisms can contribute to enhance the overall farm practices, ultimately reducing losses.

Various studies conducted in the Philippines highlighted the positive impacts of farm clustering and consolidation initiatives. These include notable increases in production and income levels for farmers, and improved access to essential resources, technologies, and markets (Montiflor et al., 2008; Rola et al., 2013; Oakeshott, 2018). Therefore, promoting the adoption of such clustering programs could potentially foster more sustainable and efficient agricultural practices among farmers. Such interventions can empower smallholder farmers, improving their operational efficiency and reducing losses in 'Queen' pineapple.

Whether plantations are situated in flat or sloping terrains, there are no observed differences in the farm losses incurred by farmers. In terms of management in the region, farmers and policymakers can allocate resources and implement risk mitigation strategies uniformly across different terrains since topography does not influence farm losses significantly.

Farm losses also demonstrate a consistent pattern, regardless of the distance covered by farmers. Despite having no significant differences in losses, the prevailing poor road conditions in the area remain a significant challenge. To address this issue, strategic interventions aimed at enhancing infrastructure and upgrading farm-to-market roads are necessary. By investing in improved road networks, these interventions not only contribute to the reduction of losses but also foster a more resilient and efficient distribution system.

To improve overall farm outcomes, it is also recommended to reconsider the use of jute sacks as field containers, exploring the necessary modifications on the use of *sagad* or *kareta* that have demonstrated lower associated losses. Moreover, promoting early harvest hours could mitigate losses attributed to extended sunlight exposure and unfavorable working conditions during late harvesting. Recognizing higher losses incurred by older farmers, targeted support programs focusing on this demographic group could prove beneficial. Additionally, encouraging membership in farm-related organizations may be a strategic approach to reducing farm losses, fostering collaboration, and sharing best practices among farmers. While demographic factors appear to influence losses, further investigation and tailored interventions are essential to address these nuances and enhance the overall farm efficiency.

In addition, drawing upon the insights from the regression analysis, several targeted recommendations can be formulated to optimize farm practices and minimize losses among ‘Queen’ pineapple farmers. Among these recommendations are:

a. *Investing in Training and Knowledge Transfer.* Encouraging initiatives for knowledge transfer and training programs, especially targeting farmers with limited experience. By equipping less experienced farmers with the refined techniques employed by their more seasoned counterparts, the overall farming community can benefit from reduced losses.

b. *Supporting Smallholder Farmers with Limited Landholdings.* Recognize the unique challenges faced by smallholder farmers, particularly those with less than 1.0 hectare of land. Implement targeted interventions such as access to shared resources, cooperative farming models, and financial assistance to empower smaller farms in optimizing their operations and minimizing losses.

c. *Promoting Farmer Cooperatives and Collaborative Efforts.* Emphasize the importance of cooperative farming models, exemplified by the success in Labo. Foster the establishment and growth of farmer organizations, like the Labo Progressive Multi-Purpose Cooperative (LPMPC), to facilitate technical knowledge sharing, resource

pooling, and collective efforts in overcoming challenges, ultimately leading to lower losses.

d. *Empowering Land-owning Farmers.* Recognize the positive correlation between land ownership and reduced losses. Encourage policies and programs that empower farmers to own their land, providing them with increased control over field operations, fostering flexibility, and contributing to lower losses.

e. *Optimizing Pineapple Yield through Best Practices.* Encourage adherence to recommended planting density, specifically the suggested 30,000 plants per hectare for ‘Queen’ pineapples. Promote awareness about the impact of deviating from this recommendation, emphasizing the correlation between higher yields and lower losses. This could involve extension services, training, and outreach programs.

Based on the value chain analysis, postharvest losses also resulted from the rough handling practices of various actors involved, particularly in postharvest handling operations. Therefore, the modification and improvement of traditional practices in the field can be instrumental in effectively mitigating these losses. To achieve optimal quality at the time of harvest, it is essential to incorporate proper harvesting tools, such as clippers and gloves, and adopt careful harvesting methods instead of the manual snapping of pineapples without the aid of these tools. This method will substantially reduce the incidence of mechanical damages such as fruit cracking and crown removal.

Furthermore, rough handling during the hauling of harvested pineapples from the farm to the collection area exacerbates mechanical damage. Tossing the fruits during this process further intensifies these damages. While the use of sorting aids like gloves is already in practice, it is equally imperative, especially for farmers and hired haulers of the traders, to place significant emphasis on the careful hauling of the pineapples. Improvements in loading and transport practices include filling-up the vehicle to its actual loading capacity, use of pallets, dividers, and liners, and ensuring proper ventilation within transport vehicles, particularly during long-distance journeys to wholesale markets. These measures, which are specifically targeted for assembler-

wholesalers (transporters), can reduce compression damage and prevent temperature build-up within the vehicle, ultimately reducing the likelihood of fruit rejections upon arrival at the destination markets.

Use of appropriate tools, containers, and adopting careful handling of ‘Queen’ pineapples are simple and cost-effective, yet highly efficient techniques. These measures have the potential to substantially reduce the risk of incurring losses and ensure the preservation of the produce’s quality throughout the handling process.

Further, in implementing these recommendations, a holistic and collaborative approach involving government agencies, agricultural extension services, farmer organizations, and other stakeholders is crucial. By addressing these factors and tailoring interventions to specific challenges, it is possible to enhance the overall resilience and success of ‘Queen’ pineapple farming in Camarines Norte.

#### 5.11.2 Development of Simple and Cost-effective Postharvest Technologies

While several operations are already carried out in the field, other postharvest technologies can be explored to effectively reduce losses and ensure the quality of ‘Queen’ pineapples. These technologies are intended to extend the shelf life of pineapples thereby extending their marketable life.

Waxing, a postharvest technique widely utilized in other commodities, offers a can be explored. The use of natural food-grade waxes or fruit coatings presents an opportunity to extend the shelf life of pineapples while simultaneously enhancing their visual appeal. Given the inherent perishability of pineapples and the substantial losses experienced in the region due to rapid ripening and decay, it becomes imperative to look into the possibilities of developing and adopting a natural preservation system for ‘Queen’ pineapples. Such a system has the potential to play a pivotal role in preserving the quality of freshly harvested pineapples, contributing to reduced losses and improved market readiness.

The study area’s lack of available storage and cooling facilities, especially during periods of pineapple overproduction, forces farmers to contend with overripe

and decaying fruit. Given the susceptibility of pineapples to water loss, which is equivalent to loss in marketable weight, and fast ripening accompanied by decay, there is a pressing need to explore proper storage techniques and protocols that can mitigate losses stemming from overripe fruits and decay. The development of low-cost cooling and storage systems specific to ‘Queen’ pineapples holds the potential to deliver significant benefits to farmers and traders. These systems can maintain optimal temperature conditions, ultimately enhancing the fruit's marketability and reducing postharvest losses.

### 5.11.3 Actual Loss Assessments and Pilot Demonstration of Technologies

While the estimates derived from stakeholder interviews offer valuable insights into the nature, causes, and extent of losses within the ‘Queen’ pineapple value chain, it is essential to validate these findings through actual loss assessment methods involving quality profiling and evaluation of pineapples at various points along the handling chain. Augmenting these estimates with actual loss assessments provides an accurate depiction of losses occurring within the ‘Queen’ pineapple value chain in Camarines Norte. This approach is requisite for identifying critical control points where actual quantitative and qualitative losses occur, thus guiding the industry towards evidence-based postharvest interventions.

In the pursuit of enhancing the system, both existing and newly developed postharvest technologies that may be suitable should be tested under actual commercial handling conditions in the value chain through pilot demonstrations in collaboration with the stakeholders. These strategies aim to ensure the adoption of technologies into the current system. In pursuit of system improvement, it is imperative to fine-tune these technologies, aligning them as best-fit solutions to address the specific challenges identified in the context of ‘Queen’ pineapples.

Furthermore, it is crucial to recognize that technologies and interventions should not only be tailored to the particular commodity but also be attuned to the unique location and situation. Hence, this holistic and comprehensive approach to assessing practices and losses within the ‘Queen’ pineapple value chain, along with the

implementation of targeted interventions, serves as a fundamental step toward industry mainstreaming. It paves the way for improvement opportunities for all key players in the chain and contributes in enhancing the economies of scale.

#### 5.11.4 Capacity Building of Stakeholders

Capacitating all stakeholders within the value chain is essential. By educating them on the importance of loss reduction and providing information on the utilization of postharvest handling technologies, the value chain becomes more efficient. This empowers participants not only to minimize losses but also to enhance the overall quality and safety of ‘Queen’ pineapples. Through knowledge and technology transfer, the value chain can modernize and improve its practices, fostering a culture of continuous improvement.

With reduced postharvest losses and improved product quality, ‘Queen’ pineapples become more competitive in the market. This heightened competitiveness enables stakeholders to participate more effectively in modern value chains, including export markets. As a result, the local industry can expand its reach and increase its market share, bringing economic growth and stability to the region.

Increased incomes for stakeholders, especially small-scale farmers, can alleviate poverty and improve the standard of living in the community. When farmers can earn more from their harvest, they have the means to invest in education, healthcare, and other essential needs, ultimately breaking the cycle of poverty.

#### 5.11.5 Institutional and Industry Support

The government can play a significant role in creating a more enabling environment in the ‘Queen’ pineapple value chain in Camarines Norte. This intervention is vital for reducing postharvest losses, enhancing handling systems and distribution practices, and boosting the overall competitiveness and efficiency of the industry.

A comprehensive analysis of the value chain reveals a lack of standardized practices along the handling chain, which directly impacts postharvest losses. Sorting

and classification strategies, often determined by traders, exhibit a dynamic nature. This dynamic nature makes consistent sorting standards a challenging proposition in the study area. Although government-set standards exist, they remain non-obligatory, leading to the absence of uniform practices in Camarines Norte. Rectifying this issue necessitates the enforcement of quality standards for 'Queen' pineapples to ensure that only high-quality produce enters the market, significantly reducing losses linked to rejected or substandard fruit.

Another aspect of inappropriate practice involves pre-harvest ethylene treatments on pineapple fruits days before actual harvest and spray applications before transport. The inappropriate practices with this induced ripening techniques include treating immature fruits, concentration of ethephon is not controlled, and timing of ethephon spray. Stakeholder interviews highlight these practices as critical loss points within the chain. Their negative impact on eating quality and ripening at the consumer level underscores the urgency of implementing improvements.

On infrastructure development, the government can initiate investments in modern common service facilities such as low-cost cold storage and packinghouses. These facilities can extend the shelf life of pineapples particularly during periods of overproduction. Furthermore, the development and maintenance of road networks and transportation infrastructure are essential for the efficient movement of 'Queen' pineapples from farms to markets. While these operations and investments may entail costs for farmers and traders, the government can facilitate financial access by providing low-interest or subsidized loans to those involved in the 'Queen' pineapple value chain for the acquisition of modern postharvest equipment and facilities.

Regarding extension services, government agencies can take on the responsibility of educating farmers and other value chain stakeholders on best practices in pineapple cultivation, harvesting, and postharvest handling. These educational initiatives can be complemented by training programs focusing on modern postharvest technologies, encompassing waxing, proper packaging, and improved handling practices. Furthermore, the government should actively work to ensure market access

for local pineapple growers by connecting them with potential buyers, both in domestic and international markets.

In summary, the government's proactive involvement is poised to create an environment that not only curtails postharvest losses but also upgrades the overall standards of handling, distribution, and competitiveness within the 'Queen' pineapple industry of Camarines Norte. Such an intervention fosters a sustainable and thriving pineapple value chain, one that delivers significant benefits to both farmers, traders, and consumers.

## SUMMARY AND CONCLUSION

The ‘Queen’ pineapple is a vital agricultural product in Camarines Norte, Philippines, pivotal to the regional economy. However, postharvest losses in the pineapple value chain present a formidable challenge. This study aims to assess postharvest loss factors in the ‘Queen’ pineapple value chain, highlighting areas in need of improvement. By employing a holistic systems approach, the research endeavors to identify key players, characterize postharvest handling practices, analyze the causes and extents of losses at various stages, and pinpoint critical control points for potential improvements.

The study entails surveys and interviews with 211 farmers, complemented by key informant interviews and focus group discussions involving various stakeholders in the ‘Queen’ pineapple value chain. The research area encompasses the top four producing municipalities: Basud, San Lorenzo Ruiz, Labo, and San Vicente. Data analysis techniques, including descriptive analysis, value chain mapping, loss estimations, and identification of critical loss points, facilitate result interpretation and discussion.

The research reveals distinct systems responsible for the ‘Queen’ pineapple value chain’s overall functioning, including the commodity system, the activity system (with a particular focus on postharvest handling and management), the network of actors involved, and product and information flows throughout the production-postharvest-consumption continuum. These elements collectively contribute to the effective management of ‘Queen’ pineapples in the region.

In the value chain, key actors include farmers, assembler-wholesalers (transporters), agents, market wholesalers, retailers, and processors. Additionally, the value chain benefits from the contributions of family laborers and hired workers, each performing specialized tasks at different stages. Farmers and traders, particularly assembler-wholesalers (transporters), assume central roles in this value chain, encompassing both production and postharvest functions. Farmers are responsible for a significant portion of value chain activities, spanning production tasks, harvesting,

and transportation to collection points. Simultaneously, traders, operating as wholesale-transporters, oversee packinghouse operations and logistics to ensure that freshly harvested 'Queen' pineapples successfully reach their intended markets.

The activity system provides a comprehensive overview of all operations within the value chain, with a specific focus on postharvest handling and management, starting from the moment pineapples are harvested until they reach their destination markets. This system highlights the presence of two distinct pricing systems for 'Queen' pineapples: the all-in pricing, which offers a uniform price for all harvested produce, eliminating the need for sorting and price differentiation, and the ladderized pricing system, which involved tiered pricing for 'good' and 'butterball' pineapples.

Furthermore, the value chain is characterized by five distinct product flows. The first flow primarily emphasizes direct retailing within local markets in the province. The second flow is the most extensive in terms of geographical coverage and involves numerous key players. The third flow focuses on regional distribution, extending to neighboring provinces within the region. The fourth flow represents a unique approach, particularly in the final product forms offered to consumers. The fifth flow extends its reach to retail markets beyond the usual destinations in Metro Manila and the region, highlighting its unique market approach.

The study's findings reveal a complex landscape of losses within the 'Queen' pineapple value chain, encompassing both quantitative and qualitative aspects. Notably, there is a substantial pre-harvest loss of 14.928%, underscoring the critical need for loss mitigation measures throughout the entire value chain. Furthermore, aggregate postharvest losses make up 47.812% from harvest to transportation to destination markets, with non-marketable rejections accounting for 12.709% and marketable rejects at 35.103%. It is important to note that although postharvest losses are significant, marketable fruits represent qualitative losses characterized by lower quality and reduced prices. These factors can substantially impact on income and profit losses of stakeholders.

The analysis of farm-level losses considered various factors, revealing that smaller farm (below 1.0 hectare) experience significantly higher losses due to limited access to resources, including farm equipment and financial capital. Topography and distance from the collection center influence losses, with flat terrains and shorter distances associated with lower losses. Harvesting practices, like the use of jute sacks and harvest timing, impact losses, but no significant differences were found. Demographic factors, including age and membership in farm-related organizations, play a role in losses, with older farmers experiencing higher losses and organization members facing lower losses.

Regression analysis further reveals the significance of factors such as farming experience, farm size, location, land ownership, and pineapple yield in influencing losses. Experienced farmers, larger landholders, those in Labo, landowners, and higher-yielding farms exhibit significantly lower losses, emphasizing the importance of collaborative efforts, ownership, and adherence to recommended planting practices in mitigating farm-level losses.

The ‘Queen’ pineapple value chain in Camarines Norte faces several critical loss points within its activity system. Preharvest losses are primarily linked to poor cultural management practices and challenges related to insect and pest infestations. However, there is potential for technical improvements in these pre-harvest activities to minimize losses in the field.

Postharvest operations, including harvesting, hauling, field sorting, and transport, suffer from rough handling, leading to significant fruit quality deterioration and non-marketable rejections. To address these issues, it is crucial to implement improvements in postharvest handling practices, emphasizing careful and appropriate techniques to preserve fruit quality. The absence of standardization in field sorting practices also contributes to losses within the value chain. Moreover, pre-harvest ethylene treatment of fruits and spray applications before transport are identified as critical loss points, negatively impacting the fruit’s taste and ripening at the consumer level. It is imperative to establish regulatory and implementation strategies to solve these issues and promote standardization.

Identifying these critical loss points underscores the urgency of implementing strategic interventions to reduce losses and enhance the efficiency of the ‘Queen’ pineapple value chain. These interventions, combining technical improvements and regulatory measures, are essential for the industry’s economic viability and sustainability, ultimately ensuring the delivery of high-quality fruit products to consumers.

From the critical loss points identified, implementing interventions and strategies that are technically efficient, socially acceptable, and economically viable holds great potential for delivering significant benefits within the value chain. To specifically reduce postharvest losses, addressing issues related to rough handling during both harvesting and transportation is key. This can be achieved through the adoption of proper tools such as clippers and gloves for harvesting, as well as the use of handling aids like pallets, dividers, liners, and ventilation during transport. These improvements will result in minimized mechanical damage and maintained produce quality. Furthermore, exploring various postharvest technologies, including waxing for preservation and implementing cost-effective cooling and storage systems, can extend the shelf life of ‘Queen’ pineapples. This approach will reduce losses due to rapid ripening and decay, ultimately enhancing the marketability of the produce in the region.

To ensure the success of these interventions, it is essential to validate insights from stakeholder interviews with actual loss assessments. Conducting practical handling trials to integrate postharvest technologies and tailoring interventions to the specific commodity, location, and situation are vital steps toward improving the industry and achieving economies of scale within the ‘Queen’ pineapple value chain in Camarines Norte. Additionally, empowering all stakeholders in the chain through education and technology transfer will enhance efficiency, improve pineapple quality and safety, and modernize practices. This, in turn, will improve competitiveness in local and export markets, increase incomes, and contribute to poverty alleviation and overall economic growth in the community.

Government intervention is crucial to enhance the ‘Queen’ pineapple value chain in Camarines Norte. This includes addressing the lack of standardized practices,

particularly in sorting and pre-harvest treatments, improving infrastructure, road networks, and transportation, and facilitating extension activities and market access. Such interventions will ultimately foster a sustainable and thriving pineapple value chain that benefits farmers, traders, and consumers, while reducing postharvest losses and boosting competitiveness.

In conclusion, this research underscores the urgency of addressing postharvest losses in the ‘Queen’ pineapple value chain in Camarines Norte. Policymakers, agricultural institutions, and industry stakeholders should prioritize interventions that enhance postharvest handling practices, reduce losses, and promote sustainability. Initiatives should focus on technology adoption, knowledge sharing, and collaborative efforts among value chain actors to ensure the prosperity of the ‘Queen’ pineapple industry, while improving food security and the livelihoods of the stakeholders involved.

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**Appendix 1. Correlation matrix for variables used in assessing the factors affecting farm losses.**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) yearfarming	1.000								
(2) dsmall	-0.138	1.000							
(3) labo	-0.173	0.009	1.000						
(4) down	0.130	0.079	0.015	1.000					
(5) yieldperha	-0.027	0.423	-0.054	0.044	1.000				
(6) age	0.477	0.001	-0.054	0.065	0.038	1.000			
(7) gender	0.164	-0.018	0.036	0.097	-0.077	0.032	1.000		
(8) cropperiod	0.010	0.025	0.122	-0.021	-0.079	0.076	-0.038	1.000	
(9) edu1	0.106	0.156	-0.105	-0.074	0.037	0.200	0.087	-0.035	1.000

**Appendix 2. Results of multiple linear regression analysis.**

Variable	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
yearfarming	-.002	.001	-1.75	.081	-.003	0	*
dsmall	.094	.024	3.93	0	.047	.142	***
labo	-.059	.025	-2.31	.022	-.109	-.009	**
down	-.043	.019	-2.20	.029	-.081	-.004	**
yieldperha	0	0	-4.51	0	0	0	***
age	.001	.001	0.94	.351	-.001	.003	
gender	.02	.02	0.97	.334	-.02	.06	
cropperiod	0	.004	0.08	.937	-.008	.009	
edu1	.01	.024	0.40	.691	-.038	.057	
Constant	.166	.072	2.30	.022	.024	.308	**
Mean dependent var		0.149	SD dependent var			0.154	
R-squared		0.160	Number of obs			209	
F-test		4.731	Prob > F			0.000	
Akaike crit. (AIC)		-205.689	Bayesian crit. (BIC)			-172.266	

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1