

Supply chain analysis of agricultural and plantation commodities in North Maluku, Indonesia

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Abstract. *Ajam MR, Rasulu H, Ashari R, Tridtitanakiat PC, Murtini ES, Jabid AW, Kamaluddin AK, Nurjannah S, Fatmawati M, Rozaki Z, Abdullah H. 2026. Supply chain analysis of agricultural and plantation commodities in North Maluku, Indonesia. Asian J Agric 10 (1): g100122. <https://doi.org/10.13057/asianjagric/g100122>. North Maluku is an archipelagic province in eastern Indonesia where agricultural and plantation supply chains are shaped by dispersed geography and reliance on maritime transport. This study applied a qualitative approach, combining in-depth interviews and field observation. Thirty informants were purposively selected, consisting of 15 farmers, 5 intermediaries, and 10 local traders engaged in agricultural distribution. The research examined supply chain structures, transport modes, and logistical constraints across seven major islands—Hiri, Halmahera, Bacan, Obi, Morotai, Sula, and Taliabu. The results identified five distinct supply chain typologies. Types 1-3 are associated with local vegetable distribution and short intra-island flows from farmers to end consumers, local retailers, or collectors. Type 4 reflects inter-island trade networks, commonly used for locally abundant fruits and for imported products such as carrots, potatoes, and garlic. Type 5 is for the plantation crops, such as nutmeg, cloves, and coconuts, which are largely export-oriented and involve the longest chain with multiple intermediaries. Across all types, profitability is strongly influenced by transport costs and weather-dependent marine disruptions, affecting both the availability and price stability of agricultural products as essential commodities. To enhance food security and reduce dependency on external sources, there is a need to strengthen local agricultural production through crop diversification, infrastructure development, and targeted farmer support initiatives. The results provide insights into how archipelagic geography shapes agricultural supply chains and point to strategies for building more resilient and equitable food systems.*

Keywords: Agricultural supply chain, food security, horticultural commodities, inter-island trade, small islands

INTRODUCTION

North Maluku is a province in eastern Indonesia, which is an archipelago with Halmahera Island as its largest island. About 80% of its area is sea and 20% is land area (BPS Maluku Utara 2023). This makes farming more difficult, especially as the population grows and pressure on land increases (Georgeou et al. 2022). Food in the archipelago is produced locally through agriculture, but as the crop is frequently insufficient, imports are made to meet the demand (Hidayana et al. 2022; Thow et al. 2022). The limited land availability also affects agricultural productivity, as most farming systems are small-scale and depend on traditional methods. Consequently, food security in the province remains highly dependent on external supply and efficient inter-island distribution networks.

Agriculture remains vital to the North Maluku Islands' food security, despite fisheries being the most dominant natural resource sector. North Maluku is known as a producer of nutmeg, cloves, coconut, cocoa, and coffee, which have been exported to many countries (BPS Maluku Utara 2023). Moreover, rice production averages 14000 tons/year, and a variety of vegetables and fruits are cultivated by smallholder farmers (BPS Maluku Utara 2023). Despite this level of production, the province's annual rice demand, estimated at more than 110,000 tons based on population size and national per-capita consumption (BPS Indonesia 2023), far exceeds the local production/supply. As a result, there is significant reliance on external sources for various agriculture commodities, indicating possible inefficiencies or constraints in local supply chain.

Understanding and addressing these challenges increasingly involves the use of analytical frameworks such as Value Chain Analysis (VCA) in agricultural studies. This analysis provides a structured approach to examine the activities involved in producing and delivering agricultural goods (Kaplinsky and Morris 2000). In addition, the supply chain is the flow of products from the earliest production process to delivery to the final customer, which includes various parties, starting from producers, retailers, and other parties (Sjah and Zainuri 2020; Bhat et al. 2021). In this study, VCA is applied to trace agricultural and plantation supply chains in North Maluku, making it possible to link production, distribution, and logistical constraints in a single framework. In small islands and remote regions, logistical issues significantly influence food system resilience. Case study on Pacific Island Countries highlighted the impact of the lack of infrastructure and inefficient supply chains on the food loss (Ross and Bryceson 2019; Amato-Ali et al. 2025). These findings align with conditions in North Maluku, where cold chain facilities are limited and maritime logistics are often unreliable (Masudin and Safitri 2020; Yudha and Roche 2023).

Several studies on agricultural commodity supply chains have been conducted in North Maluku, such as the *mulu bebe* banana variety in East Sahu District (Dadi and Kholil 2020), the copra agro-industry in East Halmahera District (Rosidi et al. 2017), and the copra supply chain in Sula Islands District (Sutoni 2020). However, these studies mainly focus on a single commodity in isolated regions, lacking a comprehensive overview of the broader agricultural and plantation supply chain across multiple islands. This study explicitly extends beyond prior single-commodity analyses by examining multiple commodities and mapping inter-island distribution collectively, thereby addressing a critical gap in understanding how agricultural supply chain operate in an archipelagic context.

Agricultural supply chains in North Maluku face challenges due to limited infrastructure and the complexity of inter-island distribution. As an archipelagic province, transportation relies on sea routes, which are irregular, weather-dependent, and high in cost. High port tariffs and limited shipping services increase the distribution burdens,

especially in remote areas (Amin et al. 2021). The absence of cold chain facilities, such as refrigerated storage and containers, contributes to post-harvest losses and deteriorating food quality in Eastern Indonesia (Masudin and Safitri 2020; Yudha and Roche 2023). These issues reduce market competitiveness and increase reliance on imported goods. Some of these imported horticultural products are similar to those produced locally, such as chili and tomatoes, meaning they compete in the same market. In several cases, local supply cannot meet demand consistently due to seasonality and distribution constraints, allowing imports to fill the gap while simultaneously putting pressure on the competitiveness of local products.

Therefore, this study aims to describe the supply chain of agricultural and plantation commodities in North Maluku. Building on the preceding overview of local production and consumption levels, this study identifies key actors, traces the flow of agriculture products from production to market, and highlight logistical constraints in inter-island distribution. By applying a value chain perspective to regional context, this study expected to provide a better understanding of food system in archipelago and offer basic insights that support policy to strengthen local food security.

MATERIALS AND METHODS

Study area

Data collection was carried out in villages where most of the population works in agricultural and plantation sectors, as well as distribution locations for agricultural and plantation commodities (warehouses, markets, etc.) in the North Maluku Archipelago Region, Indonesia. The study covered several major islands, including Hiri, Bacan, Obi, Taliabu, Sula, Morotai, and multiple sites in Halmahera (West Kao, Goal, Subaim, Koli, Kosa, and Wairoro Indah). These locations were selected to represent the region's diverse agroecological conditions, ranging from volcanic upland horticulture on smaller islands to extensive plantation crops such as cloves, nutmeg, and coconut on larger islands. The study area is shown in Figure 1.

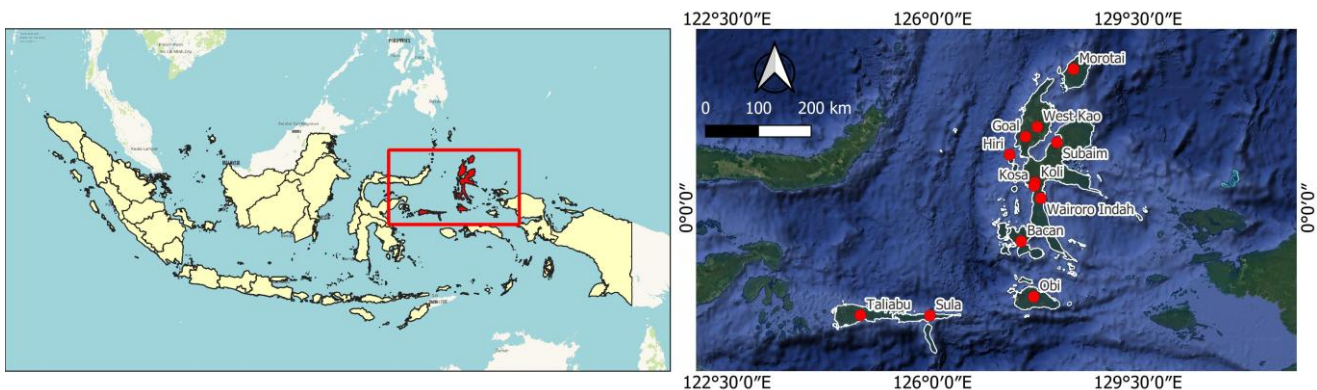


Figure 1. Study site on the North Maluku Archipelago, Indonesia

These sites also capture the logistical variation of agricultural trade, as inter-island connectivity depends heavily on maritime transport with limited supporting infrastructure such as cold storage, port facilities, and farm-to-market roads. The dependence on sea transport and inadequate facilities often constrain the movement of agricultural products between islands, reducing distribution efficiency. Consequently, transportation costs tend to be higher, and market access for local farmers becomes more limited, particularly for perishable commodities.

Data collection

This study used a qualitative research approach to explore how agricultural and plantation commodity supply chains operate in North Maluku. Data were collected through in-depth interviews and direct observation. The research focused on understanding local supply chain structures, transport modes, and logistical constraints. Respondents were selected using purposive sampling to ensure they had experience with agricultural production and distribution. A total of 30 informants were interviewed, consisting of 15 farmers, 5 intermediaries, and 10 local traders. The number of informants was determined based on data saturation, where additional interviews no longer yielded new insights or information relevant to the study objectives. This approach ensured that the collected data were sufficient to capture the diversity of perspectives within the agricultural value chain while maintaining depth in qualitative analysis.

The participants were chosen based on their active roles in distribute agricultural goods between islands and their knowledge of supply chain practices. The purposive approach was justified because supply chain activities are spatially concentrated in specific production and distribution hubs, making targeted selection more appropriate than random sampling. However, this method may introduce bias by over-representing well-connected actors and under-representing peripheral ones. To mitigate this, primary data were complemented with secondary sources from Statistics Indonesia, provincial agricultural reports, and prior studies, which helped triangulate findings and improve validity. Interviews were semi-structured for 15-30 minutes and conducted in person. The interview instrument used a semi-structured interview guide, containing a list of key questions that could be further explored based on responses of informants. Therefore, the interview instrument in this study was primarily descriptive and qualitative, focusing on informants' experiences in the upstream to downstream supply chain and the factors influencing inter-island distribution in North Maluku. Observations were carried out by observing and documenting the production and distribution processes of agricultural and plantation commodities.

Data analysis

Information from in-depth interviews and observations was analyzed using a qualitative descriptive approach. Data were manually coded to identify key patterns related to supply chain actors, product flows, and logistical constraints. The resulting codes were grouped and refined

into themes that explained the typology of supply chains across the islands. The analysis process followed the stages of data reduction, data display, and conclusion drawing (Miles and Huberman 1994). To enhance the credibility of the findings, data from interviews were triangulated with field observations and secondary sources such as statistical reports and previous studies.

RESULTS AND DISCUSSION

Distribution of agriculture and plantation commodities

Farmers in North Maluku generally cultivate various types of commodities such as food crops, horticulture, and plantation. Food crops, specifically cassava and sweet potatoes, are planted in almost all regions. Horticulture is cultivated on a large scale to a household scale, specifically in regions far from the economic center. The plantation products produced are nutmeg, cloves, coconut, and cocoa, which are superior products.

Agricultural products are transported through three main routes (Figure 2), namely (i) within the North Maluku Islands, (ii) from outside the province, and (iii) to outside the North Maluku. Route 1 is primarily for horticulture products and locally produced fruits, with distribution occurring both within each island and to nearby islands. Route 2 covers agricultural products entering North Maluku from outside the province (imported), which are transported through sea routes from Manado and Surabaya to Ternate. From Ternate, the products are then sold directly in traditional markets and redistributed to other islands in North Maluku. Common imported products such as shallots, garlic, potatoes, apples, and pears, most of which are not widely cultivated in North Maluku because the local agroclimatic conditions are not suitable for producing them.

The number of islands in North Maluku is estimated at 837, spread across 10 districts (BPS Maluku Utara 2024). The distance between islands varies from 10 km to 200 km. The largest island is Halmahera Island (17,780 km²), but the center of the economy is Ternate Island (76 km²). Ternate Island has become the economic center of North Maluku, where fruit and vegetable products from external regions are imported in and distributed (Figure 2). Locally cultivated agriculture products are also widely distributed through Ternate due to its superior accessibility, port facilities, and transportation infrastructure (Amin et al. 2022).

The agricultural center is mainly located on Halmahera Island, specifically in North Halmahera District, West Halmahera, and Tidore Islands City. Horticultural businesses in these three regions used an intensive farming system, making the harvest quite abundant. The harvest was distributed within Halmahera Island, Ternate, and Tidore Islands. South Halmahera District, particularly Bacan Island, also supports an intensive system (BPS Maluku Utara 2024) with products being distributed to the surrounding islands. On smaller islands, such as Hiri Island, horticulture is generally small-scale and limited to

household consumption, making these areas dependent on products from other islands.

Supply chain

Agricultural and plantation commodities in North Maluku are grouped into three distinct groups based on product type and distribution patterns: local horticulture,

imported horticulture, and plantation crop products (Table 1). Each group involves a different number of actors and distribution complexity, so the supply chain can generally be categorized into five types: Types 1-3 for intra-island trade, Type 4 for inter-island trade, and Type 5 for export trade.

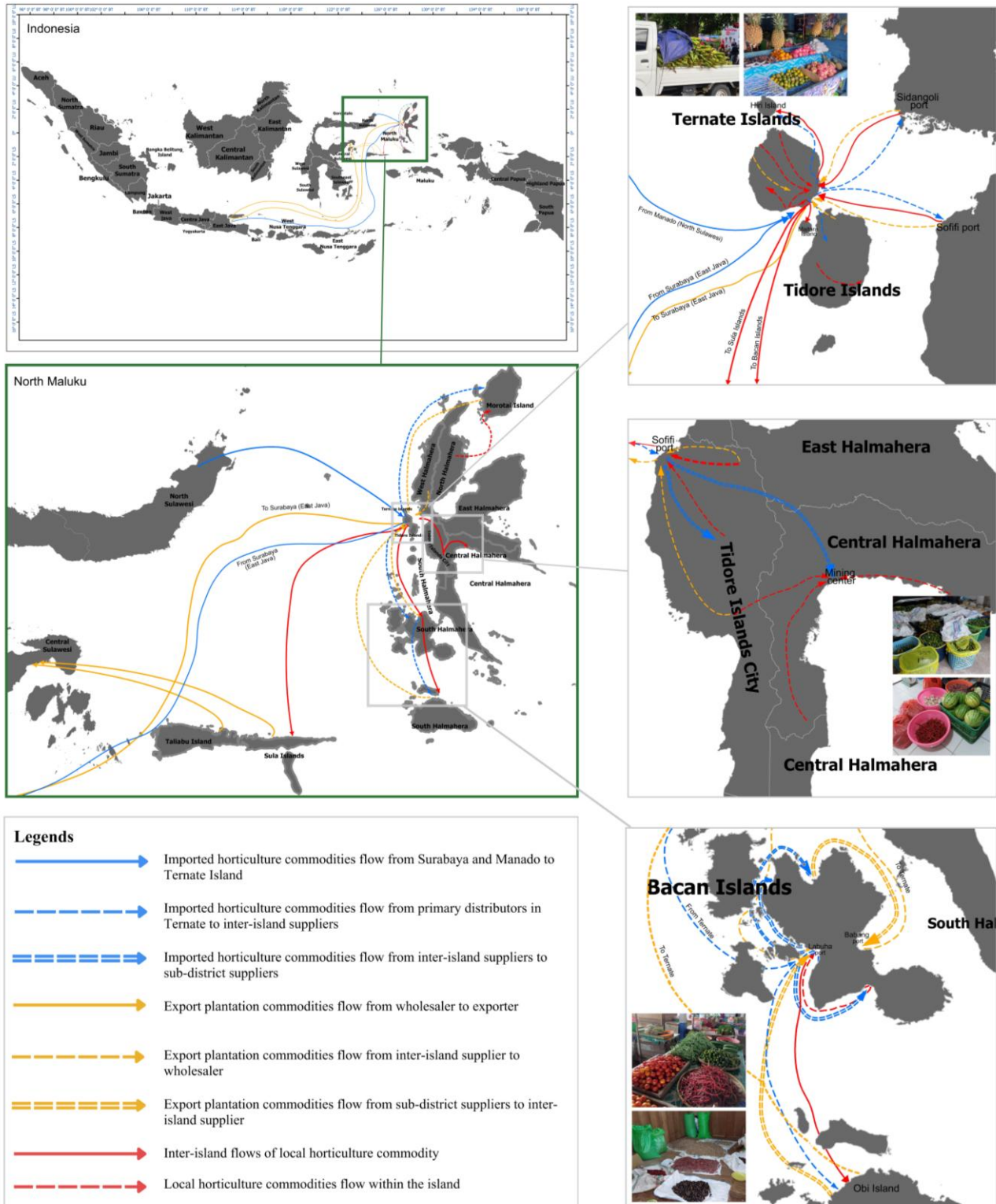


Figure 2. Agricultural and plantation distribution within, from outside, and to outside North Maluku, Indonesia

The supply chain for local commodities (Figure 3), such as leafy vegetables, local oranges, bananas, and lime, is cultivated by farmers in rural areas and marketed primarily for local consumption. In this supply chain, local products are distributed both within the island (Type 1-3) and through inter-island trade (Type 4). Distribution by land and sea modes, the cost depends on the length of the product's supply chain.

Imported products, in this case referring to products sourced from outside the province, are handled by the main

distributor in Ternate, which receives shipments through sea freight (Figure 4). These are then sold to inter-island distributors who transport the goods to other islands within North Maluku. Large-scale traders within each island distribute to retailers in urban and semi-urban markets, who finally sell to consumers. Sea transportation plays a very important role in this supply chain in distributing products to various islands. The supply chain for the imported products is categorized in Type 3 for trade within Ternate Island and Type 4 for distribution to other islands.

Table 1. Commodity groups and supply chain type in North Maluku, Indonesia

Commodity group	Commodities / Products	Supply chain type
Local Horticulture	Fruits: Dragon fruit, local orange, lime, kaffir lime, papaya, banana, watermelon Vegetables: Water spinach, spinach, bean, cassava leaves, cucumber, tomato, vegetable fern, mustard green, eggplant, summer squash Staple foods: Cassava, sweet potato, corn	1-4
Import Horticulture	Herbs and spices: Chili pepper, lime leaves, bay leaves, lemon grass, basil Fruits: Apple, pear, orange, grapes Vegetables: Cabbage, carrot, tomato Staple foods: Potato	3-4
Exported plantation crops	Herbs and spices: Chili pepper, cayenne pepper, shallots, garlic Clove, nutmeg, cacao, copra	5

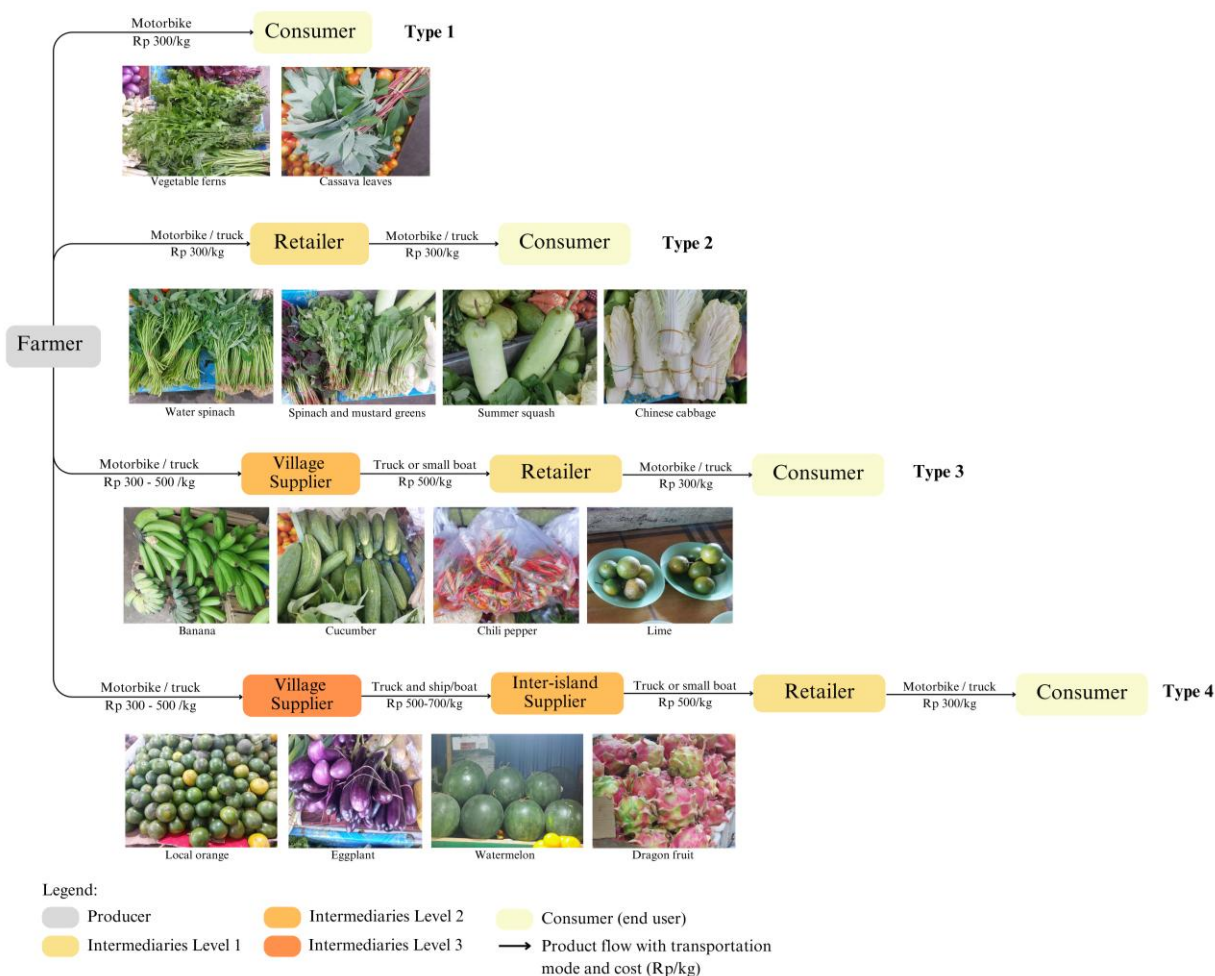


Figure 3. Local horticultural supply chain in North Maluku, Indonesia

Several of the horticultural commodities imported from outside the province are actually the same types of products that are produced locally, such as chilli pepper and tomato. This situation generally occurs because local supply is unable to meet market demand consistently, both in terms of volume and year-round availability. Production at the farm level tends to fluctuate due to seasonality, limited cultivation technology, and the lack of adequate post-harvest handling and storage facilities. As a result, distributors often rely on external sources to maintain stable supply for retailers, especially when local stocks become insufficient. In addition to availability, differences in quality and grading standards also play a role. Products sourced from outside the province often have more uniform quality and longer shelf life because they are supported by better cold-chain logistics, making them more competitive in the market. This underscores the broader issue of local product competitiveness, which relates not only to supply quantity but also to quality, continuity, and distribution efficiency.

Plantation products such as nutmeg, cloves, and coconuts are cultivated mainly for the export market and only a small proportion for local use. The chain generally involves farmers, local collectors, and suppliers who may either supply local markets or sell to external buyers for

inter-island trade (Figure 5). The supply chain for this group is the longest among the other groups because it involves many intermediaries, both in on-island and inter-island trade. Therefore, the supply chain is categorized as Type 5. Sutoni (2020), who examined coconut supply chain on Sula Island, showed that the number of levels affected the profit obtained. In Type 5, the engagement of many suppliers is often unavoidable because the location of the farmers is far from Ternate. This also appears to be the case in the nutmeg trade on Banda Island, Maluku, which has a similar type of supply chain where suppliers have a crucial role in distribution (Baso et al. 2023). Suppliers also play an important role in the distribution of other agricultural commodities, especially given the logistical challenges posed by the archipelagic landscape.

For each type of supply chain, the distance to distribute agricultural products varied. Transportation was through two modes: land for intra-island transport and sea for inter-island transport. Sea transportation is also used for transporting agricultural products to other regions within the same island, generally where the land road infrastructure is not connected. The transportation mode, distance, and distribution duration of each supply chain type are shown in Table 2.

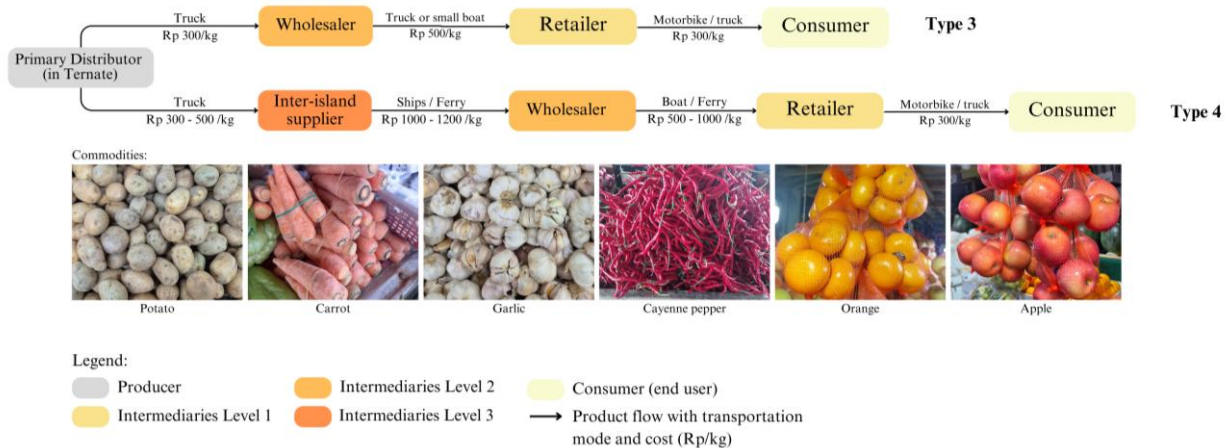


Figure 4. The imported horticultural crops supply chain, from the primary distributor in Ternate, North Maluku, Indonesia, to consumers

Type 5

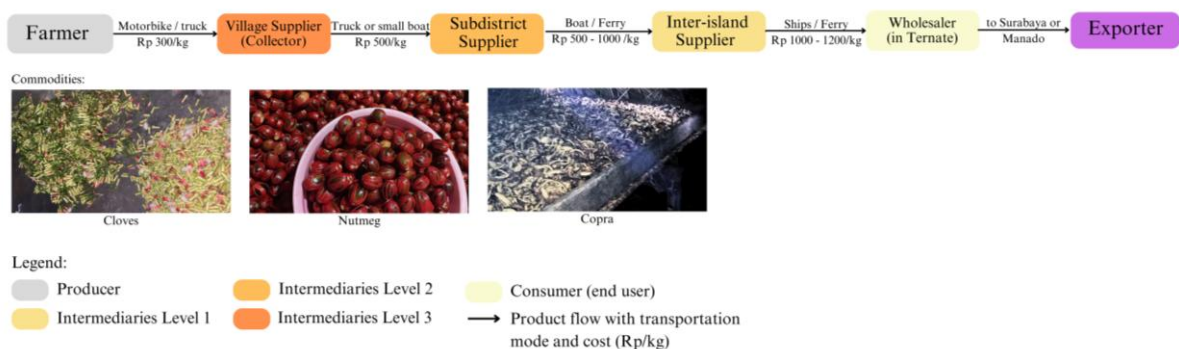


Figure 5. Plantation crops supply chain in North Maluku, Indonesia

Profit margin is a term used to express the difference between the price paid to the first seller and the final buyer. Margin can be used to calculate marketing efficiency and transportation costs. Table 3 shows the average prices, costs, and margins for agricultural and plantation commodities cultivated in North Maluku. For products originating from outside Maluku Utara, the margin was calculated from the purchase price after the goods arrived

in Ternate, transportation within North Maluku, and the selling price to consumers. The average profit margin percentage for commodities (Table 3) is 23.11%. Local products have the highest average margin at 25.25%, followed by imported horticultural products at 20.28%, and exported plantation crops at 19.5%. The percentage with the lowest margin (9%) is garlic and the highest (50%) is grape.

Table 2. Distance, type of transportation mode, and distribution duration of each supply chain type in North Maluku, Indonesia

Characteristic	Type 1	Type 2	Type 3	Type 4	Type 5
Distance (km)	<5	5-100	100-200	>500	>500
Type of transportation mode	Land: motorbike, pickup truck	Land: motorbike, pickup truck Marine: Long-tailed boat	Land: motorbike, pickup truck Marine: Big ship	Land: motorbike, pickup truck Marine: Big ship	Land: motorbike, pickup truck Marine: Big ship
Distribution duration	30 mins-4 hours	1-4 hours	1-2 days	3-7 days	>5 days
Transportation cost (Rp kg ⁻¹)	100 - 500	500-700	1100 - 1300	2100 - 3000	2300 - 3000*

Note: *: Transportation cost from farmer to wholesaler

Table 3. Profit margins of agricultural and plantation commodities cultivated in North Maluku, Indonesia

No	Commodities	Purchase price (Rp kg ⁻¹)	Market price (Rp kg ⁻¹)	Shipping cost (Rp kg ⁻¹)	Margin	
					Rp kg ⁻¹	%
A	Local Horticulture					
	Staple-Food Crops					
1	Corn	10,000	14,000	500	3,500	25
2	Sweet potato	14,000	20,000	700	5,300	27
3	Cassava	12,000	20,000	600	7,400	37
4	Eggplant	5,000	10,000	250	4,750	48
	Fruit					
5	Dragon Fruit	37,000	45,000	1,850	6,150	14
6	Orange	20,000	25,000	1,000	4,000	16
7	Watermelon	13,000	17,000	650	3,350	20
8	Banana	15,000	30,000	750	14,250	48
	Vegetable					
9	Bean	18,000	25,000	900	6,100	24
10	Cayenne pepper	60,000	80,000	3,000	17,000	21
11	Chili pepper	93,000	110,000	4,650	12,350	11
12	Lime	20,000	25,000	1,000	4,000	16
13	Long beans	10,000	15,000	500	4,500	30
14	Cucumber	7,000	10,000	350	2,650	27
15	Tomato	30,000	35,000	1,500	3,500	10
16	Kaffir lime	10,000	15,000	500	4,500	30
B	Imported Horticulture					
17	Grape	43,750	100,000	6,563	49,688	50
18	Apple	35,000	60,000	5,250	19,750	33
19	Dragon Fruit	37,000	45,000	5,550	2,450	5
20	Shallot	46,250	60,000	6,938	6,813	11
21	Garlic	47,500	60,000	7,125	5,375	9
22	Cayenne pepper	60,000	80,000	9,000	11,000	14
23	Chili pepper	83,750	120,000	12,563	23,688	20
C	Exported Plantation Crops					
24	Clove	60,000	80,000	3,000	17,000	21
25	Nutmeg	65,000	80,000	3,250	11,750	15
26	Cacao	70,000	100,000	3,500	26,500	27
27	Copra	13,000	16,000	650	2,350	15

The profit margin range for agricultural and plantation products ranges from 9-50% (Table 3), while those for imported products range from 5-50%, with transportation accounting for 15%. Commodities such as grapes and apples are profitable because the selling price is very high compared to the purchase and transportation costs. Commodities such as cayenne pepper and dragon fruit have very small margins because transportation costs almost equal the difference in selling price, showing that distribution efficiency is very important for profitability. Prices of agricultural and plantation products in North Maluku tend to fluctuate, mainly influenced by the season and weather conditions. During the rainy season, product prices increase because distribution through the sea is hampered by high waves, specifically in December-January.

Discussion

North Maluku's agricultural supply chains are heavily influenced by the region's archipelagic geography, which creates fragmented logistics and high dependency on inter-island trade. This fragmentation leads to both inefficiencies and vulnerabilities, particularly for export-oriented commodities like nutmeg, cloves, and coconuts.

Five supply chain types were identified. Shorter chains (Types 1-3) circulate local vegetables mainly within islands or over short inter-island distances, allowing more direct farmer-to-market transactions. Type 4 represents inter-island trade for local fruits and imported products, while Type 5 covers export-oriented plantation crops, such as

nutmeg (Figure 6), often involving multiple intermediaries. This pattern is consistent with value chain analysis (Kaplinisky and Morris 2000), which shows that longer, multi-tiered chains increase transaction costs and reduce value capture for farmers. Supply chain theory highlights that longer and more fragmented chains increase transaction costs, reduce transparency, and create efficiency losses (Mentzer et al. 2001; Christopher 2016). In North Maluku, these weaknesses are evident in the dependency of Type 5 chains on multiple intermediaries, which not only reduces farmer margins but also amplifies exposure to transport disruptions. Conversely, shorter chains (Types 2 and 3) allow more direct farmer-to-market transactions, but their sustainability depends on production stability and local infrastructure.

Halmahera Island remains the most productive agricultural zone, especially for local fruits (Figure 7). Local markets and mining companies in Halmahera are important buyers. Meanwhile, other islands such as Obi and Bacan depend on supplies from Ternate, especially for high-demand products, such as fruits (local and imported), shallots, garlic, chilies, tomatoes, carrots, cabbage, and potatoes. Other vegetables are also cultivated on these islands, but the prices tend to be higher, making Ternate-sourced products more preferred by retailers. While these trade flows enable regional food access, their centralization in Ternate reflects a structural bottleneck. When a single hub is centralized in one area, island regions become more vulnerable to climate impacts and logistical disruptions (Mycoo et al. 2022; Zittis et al. 2023).



Figure 6. A. Vegetables and spices at Bacan Island Market in North Maluku, Indonesia and B. Nutmeg supply from village suppliers on Obi Island, North Maluku. Source: Author's documentation



Figure 7. Spice and fruit supply from sub-district level suppliers in West Halmahera, North Maluku, Indonesia. Source: Author's documentation

The variation in profit margin between local and imported agricultural products highlights the critical role of distribution efficiency in determining profitability. Some commodities, such as grapes and apples, achieve high profits because the selling price is very high compared to the purchase and transportation costs. These fruits are already sold at high prices in North Maluku, and their shipping costs remain small compared to their market value, allowing traders to maintain wide margins even after long-distance transport. Conversely, commodities such as cayenne pepper and dragon fruit have very small margins because transportation costs almost equal the difference in selling price. These products have lower and more unstable selling prices, and their shipping costs are relatively high, especially because they spoil quickly and often require faster or more frequent shipments. These two contrasting cases show how differences in product value, perishability, and transport needs directly shape profit margins in the region. These two patterns indicate that distribution efficiency is very important for profitability, especially for products transported across fragmented or remote markets. This finding is consistent with broader supply chain efficiency studies, where logistics costs are often the largest determinant of final consumer price in fragmented markets (Lin et al. 2023).

Price fluctuations are also influenced by weather and infrastructural limitations. During the rainy season, high waves disrupt sea transport, especially imported products. In addition, access to several locations in the region is limited due to the lack of infrastructure and port facilities or ship berths (Ralahalu and Jinca 2013). Increasing local production for products, such as tomatoes, shallots, and chilies, could reduce dependency on imports, stabilize prices, and shorten supply chains. Local products tend to have more stable prices due to lower transportation costs (Khandelwal et al. 2021). Distance also affects transportation cost and efficiency, which can discourage farmers from engaging in profit-oriented agribusiness in remote areas (Mariyono 2019). Therefore, establishing local markets on each island is necessary to support local farmers and improve food distribution.

Infrastructure issues, such as poor irrigation, remain a barrier. Most farmers rely on water sources from rivers, rainwater, and water company networks. However, the availability of rainwater has become unstable due to climate change, marked by the shifting of the rainy and dry seasons. This can lead to seedling damage, decreased harvest productivity, as well as attacks by pests and plant diseases (Mycoo et al. 2022). Expanding and repairing irrigation networks is vital to support horticultural expansion. Beyond irrigation, investment in cold storage and grading facilities is crucial for reducing post-harvest losses, as demonstrated in island agro-hub initiatives in the Philippines and the Caribbean (Amjad et al. 2023; Buenaseda and Daloonpate 2024).

Policy recommendations can also be refined by linking them directly to the supply chain types identified in this study. For Type 2 and Type 3 chains (local and sub-district), interventions should focus on strengthening irrigation, seed distribution, and small-scale post-harvest

facilities to stabilize productivity and improve short-distance market integration. For Type 4 chains (inter-island), the establishment of agro-hubs in Sofifi and Bacan with grading, packaging, and cold storage facilities would enable value addition and reduce dependency on intermediaries. For Type 5 chains (imports), policies such as subsidized logistics vessels, agricultural berths at Ternate Port, and preferential tariffs for essential food commodities could reduce shipping costs and stabilize consumer prices. Evidence from maritime logistics programs in other archipelagic contexts suggests that targeted subsidies and centralized processing facilities are effective in lowering price disparities and enhancing farmer competitiveness (Xu et al. 2022; Tsoy and Nurbatsin 2024).

Compared to other island regions globally, North Maluku faces similar systemic constraints in agricultural logistics. Mycoo et al. (2022) emphasized that in Small Island Developing States (SIDS), transport and input costs are major barriers to market efficiency and resilience. In North Maluku, reliance on inter-island trade, particularly via Ternate, indicates a centralized logistics dependency that may increase risks under climate stressors such as extreme weather or disrupted ferry schedules. This finding aligns with Tsoy and Nurbatsin (2024), who stated that the gap in agro-logistics infrastructure in island regions exacerbates income inequality and reduces the competitiveness of smallholder farmers. While these trade flows enable regional food access, their centralization in Ternate reflects a structural bottleneck. Literature on archipelagic and island systems suggests that reliance on a single hub increases vulnerability to climate shocks and logistical breakdowns (Mycoo et al. 2022; Zittis et al. 2023). Recent studies further highlight that, unlike many Pacific Islands where multiple secondary hubs have been established to reduce concentration risks, North Maluku remains highly centralized around Ternate as its sole redistribution hub. This configuration makes distribution relatively efficient under normal conditions but leaves the system vulnerable to single-point disruptions. Moreover, North Maluku's dependency on imported staples such as shallots and garlic contrasts with Pacific island systems, where local root crops form the backbone of food security, underscoring the province's higher reliance on external supply (Connell and Lowitt 2020; Georgeou et al. 2022; Mycoo et al. 2022).

This study is not without limitations. First, the survey sample size was relatively small and may not fully capture the diversity of actors and distribution channels across all islands. Second, the data collection period was limited to a specific seasonal window, potentially biasing the results given the strong seasonal fluctuations in commodity availability and transport costs. Third, reliance on secondary statistical data for production and trade volumes may introduce inaccuracies at the micro level. These limitations call for caution in generalizing the findings but also highlight the need for larger, multi-season, and longitudinal studies to test the robustness of these patterns. Similar research on island food systems emphasizes the importance of repeated seasonal monitoring to capture dynamic changes and mitigate bias (Thow et al. 2022).

In conclusion, the findings emphasize that the unique spatial and logistical context of North Maluku requires differentiated policy responses. Shorter supply chains would benefit from farmer capacity-building and improved post-harvest handling, whereas inter-island trade chains require the establishment of agro-hubs equipped with cold storage and transport coordination. For longer, export-oriented and import-dependent chains, logistics and shipping subsidies could enhance efficiency and resilience. Despite limitations related to sample size and seasonal bias, future longitudinal and multi-season research across islands is needed to capture variability more comprehensively and to provide stronger evidence for building resilient supply chains in archipelagic contexts.

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