國立臺灣大學管理學院企業管理碩士專班

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Master’s Thesis

為台灣中小型農業市場蔬果剩食提供全方位解決方案:企業ESG經營

Provide Integrated Solutions to Meet the Taiwanese Agriculture Market: ESG Management

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中文摘要

台灣農產業常因需求波動、氣候不穩定、蔬菜外觀不符合通路規格，以及儲存與冷鏈設施不足，而面臨蔬菜過剩問題。農民因此經常產生大量剩餘農作物，導致食物浪費與收入損失。本論文提出設立一座蔬菜加工廠作為可行解方，旨在連結供給端（蔬菜農民與供應商）與需求端（雙北地區的長照中心、養老機構及其他高齡照護單位），建立穩定且高效率的供需鏈，協助農民與蔬菜商減輕剩菜壓力，並穩定供應營養蔬菜給實際有需求的照護體系。

本商業提案以加工廠為營運核心，打造一個重視 ESG（環境、社會、治理）理念的永續生態系統。工廠將剩餘蔬菜進行清洗、切割與包裝，製成便利即用的蔬菜產品，讓原本可能遭棄置的作物轉化為具價值、可日常食用的食材。除加工外，亦提供最佳化的配送安排，確保蔬菜能高效、準時送達照護單位。此一整合模式有助於農民與供應商創造穩定收益，減少浪費，並支援高齡與弱勢族群的膳食需求。

本篇論文所提出的商業模型旨在建立一套具擴展性與永續性的運作體系，進一步強化台灣農業經濟與社會照護的整體韌性。透過加工與配送的有效整合，不僅可將剩食轉化為可用資源，也有助於串聯農業與照護體系；此模型具備了跨區域推廣潛力，對於全球減少食物浪費與推動永續糧食系統，亦將帶來實質貢獻。

關鍵字：農業，永續發展，蔬菜剩食，長照體系，作業研究，運輸物流配送

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Abstract

Taiwan's agricultural sector is often burdened by surplus vegetables arising from fluctuating demand, unpredictable weather, and inadequate storage infrastructure. As a result, farmers frequently face unsold produce, leading to significant food waste and income losses. This thesis proposes the establishment of a vegetable processing factory as a practical solution to bridge the gap between the supply market, comprising vegetable farmers and suppliers, and the demand market, which includes long-term care centers, nursing homes, and elderly institutions. By creating this direct connection, the model not only reduces surplus-related costs for farmers but also provides a reliable channel for distributing nutritious vegetables to those in need.

Through this factory-centered approach, the business will create an ESG-oriented ecosystem that adds value to surplus produce. It will repurpose leftover vegetables by cleaning, cutting, and repacking them into convenient, ready-to-use products, transforming waste into valuable food supplies. The factory will offer optimized scheduling services, ensuring efficient and timely distribution of processed vegetables to care institutions. This integrated model provides farmers or distributors with a stable income stream, minimizes waste, and supports the food needs of Taiwan's elderly and vulnerable populations.

Ultimately, the proposal aims to develop a scalable and sustainable system that enhances Taiwan's agricultural economy and social welfare. By efficiently linking suppliers with demand through processing and distribution, it transforms surplus into opportunity, improves food security, and builds resilience in farming and care sectors. This model could also be replicated in other regions facing similar challenges, contributing to global efforts to reduce food waste and promote sustainable food systems.

Keywords: Agriculture, ESG, Leftover, Long-term Care Center, OR, Transportation

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1. OVERVIEW

1.1. Background

Food waste has emerged as a pressing global issue in recent years, with significant environmental and economic consequences. According to the United Nations Environment Programme (*UNEP Food Waste Index Report 2024*, 2024), approximately 19% of global food production was wasted in 2022, totaling around 1.05 billion tons. This waste was primarily generated by households (60%), followed by the food service sector (28%) and the retail industry (12%). The Food and Agriculture Organization (FAO, 2019) also estimates that 13.2% of food is lost between harvest and retail, meaning a waste of all the natural resources used for growing, processing, packaging, transporting, and marketing food.

In the Asia-Pacific region, food loss and waste are significant concerns that require coordinated, strategic actions to address their impact on climate change, food security, and the overall economy. According to FAO’s 2019 research, the estimated amounts of food lost in Central and Southern Asia, where Taiwan is geographically situated, total food loss and waste are estimated to be between 20% and 21%. These combined losses are not only a food security issue but also an environmental one, accounting for approximately 8% to 10% of global greenhouse gas emissions. Eighteen Member countries concluded during an FAO virtual consultation that the region continues to waste excessive amounts of food (FAO, 2019).

In 2014, the total amount of leftovers recycled was estimated at 72 million tons by the Taiwan Environmental Protection Administration (EPA, 2014). However, this figure is considered to be underestimated as it only accounts for a portion of the recycled food waste. Since 2003, Taiwan's total amount of food waste has been approximately 96 kg per capita, decreasing to 52 kg per capita by 2014. Using a Mass Flow model derived from FAO's framework, Taiwan's total food loss and

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waste is estimated at 3.68 million tons per year, or 158.41 kg per capita, with consumption waste (80.09 kg per capita) accounting for the most considerable portion (Taiwan EPA, 2014).

According to the FAO’s *Food Wastage Footprint: Impacts on Natural Resources* report (2013), Asia, particularly industrialized Asia and South & Southeast Asia, accounts for the largest volume of global vegetable wastage due to the region’s significant share of global vegetable production and consumption (FAO, 2013). Additionally, according to the FAO’s *Global Food Losses and Food Waste* report (2011), in developed Asian regions, vegetables account for approximately 43% of total food waste (FAO, 2011). On average, each person in the Asian area, where Taiwan is located, discards around 100 kilograms of vegetables per year.

1.2. Research Problem

As an island nation with year-round vegetable production, Taiwan faces distinct challenges in managing agricultural waste. The high perishability of vegetables, combined with their vulnerability to climate variations and fluctuations in market demand, often leads to frequent overproduction and post-harvest losses. Despite growing awareness of sustainability and food system resilience, Taiwan still lacks comprehensive and integrated approaches to managing vegetable waste.

According to the study titled "負責任的生產和消費食品模式研議: The Responsible Food Production and Consumption Models" by the CTCI Foundation (2020), Taiwan experienced substantial food consumption losses between 2007 and 2018. Fruits (950,000 tons), grains (850,000 tons), and vegetables (830,000 tons) were the top three categories with the highest levels of loss; in another study done by the Homemakers United Foundation in 2016, titled "台灣量販店及超市處理剩食調查: Survey on the Handling of Food Waste in Taiwan's Hypermarkets and Supermarkets", vegetables, fruits, and meat were identified as the most commonly wasted

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categories among various types of discarded food in Taiwan (Homemakers United Foundation, 2016).

Given that vegetables consistently appear as one of the top categories in both production-side losses and retail-level waste, they represent a critical area for intervention. Unlike fruits or meat, vegetables are more perishable, often bulky, and generally have a lower unit value, which makes them more likely to be discarded throughout the supply chain, from farms to markets.

This issue is compounded by the lack of access to modern agricultural technologies that could help these farmers store, process, or preserve their surplus more effectively. Surplus vegetables quickly perish without adequate refrigeration, preservation techniques, or food processing equipment, leaving farmers with few options to recover their losses. A farmer's profitability will be impacted, leading to unnecessary greenhouse gas emissions and resource depletion.

In addition to lacking access to specific technologies, many Taiwanese small and medium-sized farmers lack the economic scale in terms of volume and connections to enter large distribution channels for their surplus vegetables. Except for the trading market where normal farmers trade their fruit, vegetables, and Flowers, farmers are often disconnected from broader markets and have limited access to supply chain networks, which makes it difficult for them to reach buyers interested in purchasing surplus produce. Without established relationships with food processors, wholesalers, or alternative markets, farmers struggle to find efficient ways to move excess inventory, leading to further waste.

The business's primary focus is on reducing vegetable food waste, to identify practical opportunities to improve efficiency in vegetable waste collection, redistribution, and processing for small- and medium-scale farmers in Taiwan.

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2. MARKET ANALYSIS

This section is divided into two sections: Supply and Demand markets. To analyze the external factors of the given market, a PEST analysis will be conducted.

2.1. PEST Introduction

PEST is a model that utilizes environmental scanning to analyze four key ecological factors: political, economic, social, and technological. It is often used as an external analysis when conducting market research, providing a company with a general insight into environmental factors. PEST analysis is a practical strategic tool that helps companies understand the growth and decline of the market, the industry's current situation, and potential operations and directions.

2.2. Supply Market

2.2.1. Supply channels in Taiwan

Taiwan's vegetable market is shaped by a multi-channel trading system that reflects the nation's agricultural diversity and evolving distribution practices. These platforms range from traditional wholesale markets to emerging direct marketing and retail channels. Each plays a unique role in determining how vegetables are priced, transported, and consumed. Cold chain technologies, retail logistics integration, and consumer behavior trends increasingly influence the overall system.

The following figure is Taiwan’s vegetable supply market distribution flow compiled by the author based on data collection and field notes.

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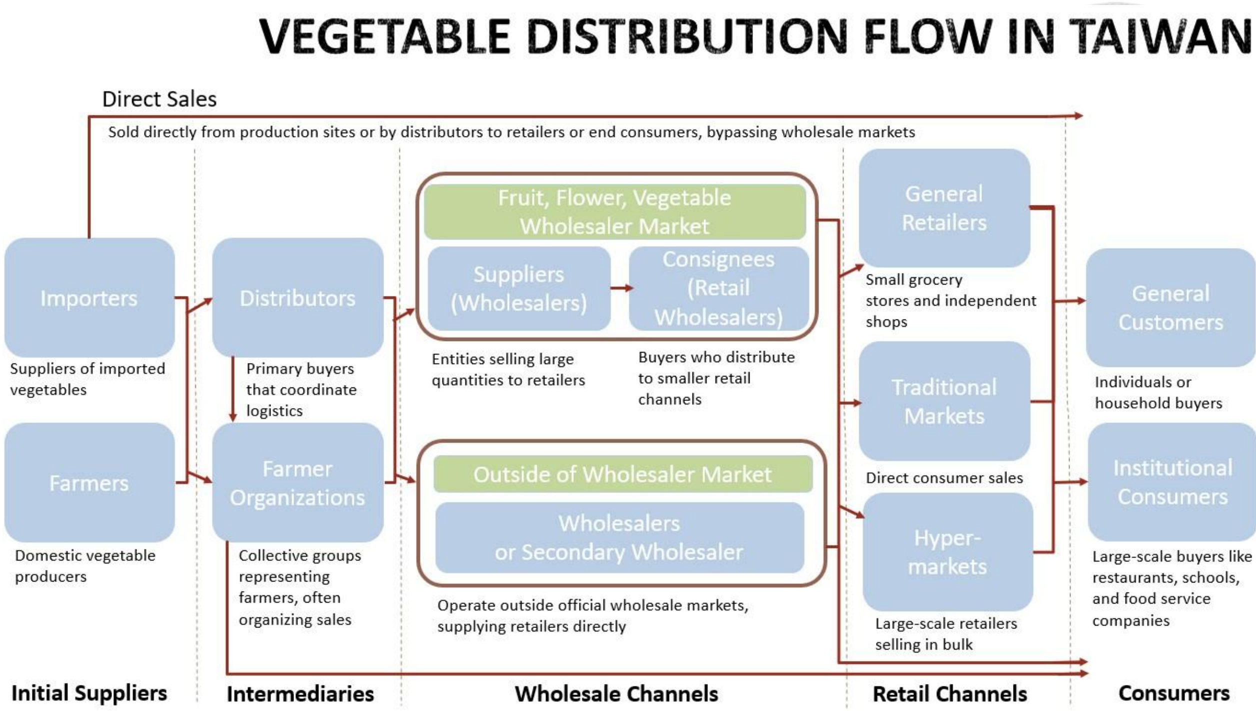

Figure 1 Vegetable Distribution Flow in Taiwan

<u>Traditional Agricultural Product Wholesale Markets</u>

Wholesale markets have long served as Taiwan's primary trading platform for fresh vegetables. Regulated by the *Agricultural Products Market Trading Law*《農產品市場交易法》, these markets operate as non-profit public utilities, providing structured and transparent mechanisms for price formation. Primary transaction methods include auction, negotiation, and bidding, with auctions dominating the pricing process. For instance, over 90% of Taipei Fruit and Vegetable Wholesale Market prices are established via public auction, making it a crucial reference point for price indices nationwide.

Grading and classification into "special 特," "excellent 優," and "good 良" tiers help establish upper, middle, and lower wholesale prices, exerting an anchoring effect on prices in other channels. However, wholesale markets have experienced stagnation in transaction volume in recent years due to the growth of alternative, more flexible channels.

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In 2019, 48 wholesale vegetable and fruit markets in Taiwan handled 1,447,340 tons of vegetables, representing 52.81% of the total national vegetable production volume of 2,740,743 tons and 49.39% of the total domestic vegetable consumption volume of 2,942,181 tons. This indicates that while wholesale markets remain a significant channel for vegetable distribution, their dominance is gradually declining as alternative sales channels expand (Fair Trade Commission 我國農畜產品產業概況生產運銷通路交易制度研究, 2020).

Modern Retail Channels: Supermarkets, Hypermarkets, and CVS

Chain supermarkets, hypermarkets, and convenience stores increasingly source vegetables directly from farmers, agricultural cooperatives (合作社), or farmers' associations(農會), bypassing wholesale markets altogether. These channels offer larger scale and lower costs, emphasizing value-added pricing based on packaging, traceability, and branding, rather than weight alone. This trend reflects a consumer shift toward quality, convenience, and food safety.

Integrated logistics systems enable these retailers to deliver produce more efficiently, reducing spoilage and increasing shelf life. Supermarkets serve as high-throughput platforms, able to absorb surpluses quickly and perform a market-balancing role distinct from the price-anchoring function of wholesale markets.

Direct Sales Channels: Farmers' Groups and Joint Marketing

An increasingly important channel in Taiwan is direct sales, especially those organized by farmers' groups through joint marketing systems. These channels feature lower price spreads and transaction costs than wholesale markets and benefit both producers and consumers. By reducing the number of intermediaries, direct marketing enhances price efficiency, ensures greater income retention for farmers, and increases product freshness upon arrival at the consumer end. Promoting such direct marketing systems is essential for improving the transparency and sustainability of

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Taiwan's agricultural distribution model.

The Role of Cold Chain Systems

Expanding cold chain infrastructure has become a cornerstone of modernizing Taiwan's vegetable distribution. Cold chains ensure continuous temperature control from farm to end consumer, preserving freshness, extending shelf life, and significantly enhancing food safety and value.

By integrating cold chains with retail logistics and processing systems, Taiwan has dramatically improved the distribution efficiency of fresh vegetables. Large agricultural enterprises increasingly invest in integrated cold chain logistics centers, linking production, processing, and marketing within a single system. These centers often mirror the functions of wholesale markets, and their rise has contributed to a decentralization of price formation, where pricing power is no longer concentrated solely in traditional wholesale hubs.

Price Formation Influences on Farmers

Beyond the structural dynamics of trading platforms, various external and unpredictable factors influence vegetable pricing in Taiwan. These include:

- Extreme weather events, such as typhoons or droughts, disrupt supply.
- Shifts in transportation and marketing patterns, such as the rise in e-commerce or last-mile delivery.
- Changes in consumer behavior, with increasing demand for convenience and food traceability.
- Irregular human interventions, including price manipulation, market monopolies, or speculative hoarding, can distort standard market mechanisms.

Currently, the only fully transparent and public pricing data is provided by the Taipei

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Wholesale Market, forming the statistical base for official vegetable price indices. Emerging direct channels often lack such transparency, with prices varying based on purchase volumes, relationships, and contractual terms, making them harder to benchmark for policymakers and smallholders alike. Hence, for small- and medium-sized farmers without access to proper cold chain technology or stable retail partnerships, the wholesale market often remains the primary outlet, even if it provides thinner margins.

2.2.2. Vegetable Leftover Analysis

<u>National Leftovers volume</u>

According to Taiwan's 2023 (Minguo 112) Food Balance Sheet, the annual vegetable loss was estimated at 271,800 tons, equivalent to 271,800,000 kilograms (Council of Agriculture, Executive Yuan, 2024). The primary source of vegetable waste in Taiwan is the total yearly supply of vegetables, with waste estimated at approximately 10% of the total supply volume based on the calculation method provided by the Fair-Trade Commission (2020).

If distributed evenly across the national population of 23,400,220, this waste translates to approximately 11.64 kilograms of recoverable vegetables per person per year.

$$\frac{271{,}800{,}000kg}{23{,}400{,}220people} \approx 11.62\ kg/person$$

Based on the daily recommended intake, this additional amount of vegetables could supply each person with:

$$\frac{11.62kg}{0.28713kg/day} \approx 40.45\ days$$

Given the recommended daily vegetable intake of 287.13 grams per person (0.28713 kilograms), this surplus could potentially supply everyone with vegetables for approximately 40.45 additional days annually.

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Leftover sources: Across the Supply Chain

Vegetable loss and waste—often referred to as "leftovers" in the context of agricultural surplus—occur at multiple stages across the food supply chain. These losses represent inefficiencies in food systems and translate into environmental and economic burdens. According to the FAO's 2011 Global Food Losses and Food Waste Report and corroborated by follow-up studies such as the 2019 FAO report on food loss reduction and Taiwan's CTCI Foundation's Responsible Food Production and Consumption Models Report, the major contributors to vegetable loss are concentrated in the production, post-harvest, and consumption stages.

1. **Agricultural Production (On-Farm Losses)**

   The agricultural production phase is consistently identified as the largest contributor to vegetable loss in both global and local analyses. In Taiwan, 32.43% of total vegetable loss originates at this stage, according to the CTCI Foundation. Similarly, FAO's 2013 Food Wastage Footprint report emphasizes that this stage is critical for vegetable wastage in Industrialized Asia. Common causes of production-stage losses include:

- Mechanical damage during harvest,
- Rejection of produce post-harvest for not meeting aesthetic or contract standards,
- Weather-related damage, pests, and diseases,
- Overproduction triggered by unexpected price drops or supply gluts, resulting in left-behind crops,
- Use of unsuitable crop varieties,
- Poor harvesting techniques.

These factors cause direct waste and often prevent produce from entering the supply chain, rendering recovery and redistribution difficult.

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2. **Post-Harvest Handling and Storage**

The post-harvest phase accounts for 19.64% of vegetable losses in Taiwan. This includes spoilage, degradation, and handling losses during sorting, packing, and farm-level storage. A recurring issue is the lack of adequate storage facilities, such as freezing storage, which is critical for maintaining the freshness of vegetables post-harvest. Without temperature-controlled environments, produce deteriorates rapidly, especially in Taiwan's humid and warm climate.

3. **Transportation**

Although categorized separately, transportation loss is closely tied to post-harvest inefficiencies. According to FAO (2019), fruits and vegetables in Eastern and South-eastern Asia experience a median loss of 8% during transit. The absence of refrigerated trucks or controlled environments exacerbates this problem, leading to spoilage before the products reach distribution centers or processors.

4. **Processing and Packaging**

Losses at this stage are relatively minimal, with the CTCI Foundation reporting 0.88% of total vegetable loss during processing and packaging. While this indicates relatively efficient processing operations, the rejection of misshapen or damaged vegetables before processing may contribute indirectly to overall waste.

5. **Distribution (Wholesale and Retail Channels)**

Distribution, including wholesale markets and retail outlets, contributes to 17.34% of vegetable loss. Losses occur due to:

- Rejection based on cosmetic standards (e.g., size, color, shape),
- Damage incurred during transportation or temporary storage, and
- Inventory turnover pressure, where produce close to expiration is discounted or discarded.

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In retail, the aesthetic grading of vegetables (often demanded by consumers or imposed by retailers) leads to the elimination of perfectly edible but non-standard produce. This issue is particularly prominent in chain supermarkets and large distributors, emphasizing visual uniformity.

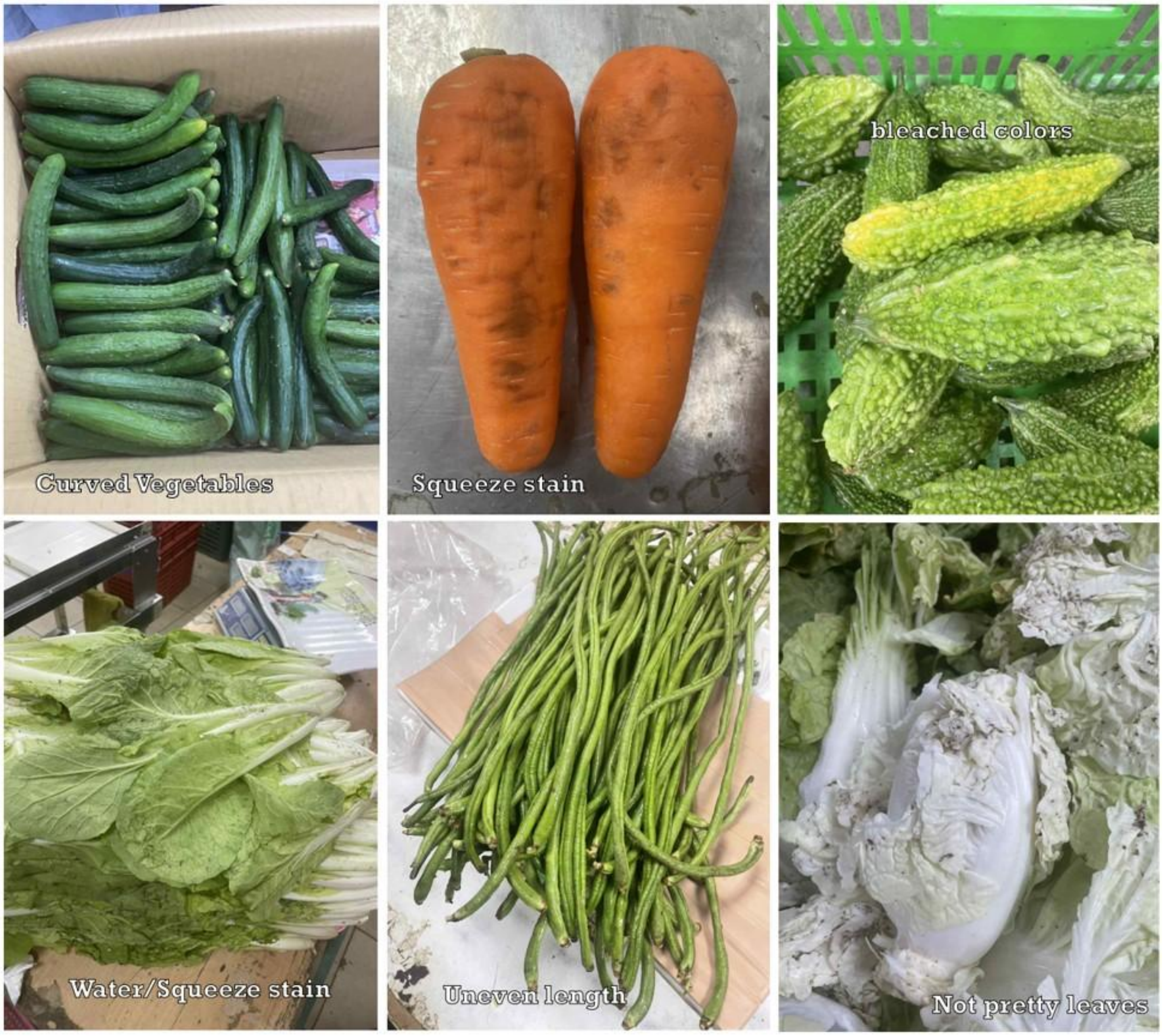

Figure 2 Vegetable considered "aesthetic unqualified"(格外品) ; Note: Provided by Bi Lo Cun Organic Farm

6. Consumption (Households and Food Services)

The consumption stage—households and food services—accounts for 29.71% of vegetable waste. This is the second largest source of vegetable loss, particularly in high-income economies

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where food affordability and portion size contribute to over-purchasing and waste. Key contributors include perishability, lack of meal planning, and poor storage practices.

2.2.3. Target Sources of the leftovers

The combined total of Production (32.43%), post-harvest (19.64%), and Distribution (17.34%) accounts for nearly 70% of all vegetable loss in Taiwan, clearly identifying the upstream and midstream stages of the supply chain as the most critical points for intervention. In response, the proposed business model strategically focuses on sourcing vegetable leftovers directly from production farms and wholesale distributors, where waste is most prevalent.

Large quantities of vegetables are discarded at the production stage due to overproduction, strict grading requirements, and market price fluctuations that make harvesting economically unviable. Meanwhile, at the distribution stage, significant losses occur due to retail-driven aesthetic standards, which lead to rejecting edible but non-conforming produce. By targeting these two key sources—on-farm surpluses and wholesale distribution rejections—the business aims to recover high-quality, underutilized vegetables that would otherwise be wasted. This approach addresses a significant gap in the current food system and enhances resource efficiency and food security.

The business will focus on partnering with small or medium-sized production farms to divert non-standard but edible produce that would otherwise be left unharvested, and on collaborating with wholesale vegetable distributors to recover surplus stock that fails to meet retailer specifications.

2.3. PEST Analysis – Supply Side

Taiwan's vegetable agriculture market is shaped by various external influences that affect the potential for reducing surpluses and implementing circular food initiatives.

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Political factor

Politically, Taiwan has increasingly emphasized food security, sustainable agriculture, and rural development. The government supports circular economy principles through policies and education, promoting local production, food processing, and waste reduction. However, agricultural policy gaps remain, as existing regulations often fail to address issues such as overproduction and market mismatches that result in surplus or unsellable vegetables.

In practice, leftover vegetables are mostly left to rot in fields or handled through composting, pig farming, or informal donations. Some farmers allow civilians to collect surplus produce, but no law mandates or incentivizes systematic donation or resale. Although the Draft of the Food Bank Law (食物銀行法草案) includes a donation exemption clause, it has not been legislated, and current laws still leave donors exposed to potential civil, criminal, or administrative liability. While food donations must comply with the Food Safety and Hygiene Management Act (食品安全衛生管理法), which prohibits trading expired food, welfare groups and food banks must follow strict guidelines. Food waste reduction relies heavily on discounts, promotions, and collaboration with NGOs, but stronger policies and legal clarity are still needed.

Vegetable waste at the farm level in Taiwan is exacerbated by limited insurance and compensation mechanisms. Current crop insurance schemes often exclude losses stemming from market rejection due to cosmetic imperfections or size deviations, which are common reasons for produce being discarded. Farmers also face bureaucratic challenges in accessing available government support; complex application procedures and a digital skills gap, especially among older farmers, hinder participation in subsidy programs.

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Furthermore, the absence of a coordinated, government-led system for redistributing surplus or off-grade vegetables means that edible, yet non-standard produce frequently goes to waste instead of being redirected to alternative markets or social uses.

Incentivizing farmers to turn surplus produce into value-added products or donate it to social welfare is encouraged. Stronger partnerships between farmers, local governments, and non-profits can enhance coordination and success across the supply chain.

Economical factor

Farmers in Taiwan face significant economic challenges due to fluctuations in market prices. Small and medium-sized farmers are particularly vulnerable to oversupply and price instability, often resulting in edible vegetables being discarded because prices fall below harvesting costs. This demand-supply imbalance reduces income and drives vegetable waste at the production level.

Harvesting low-grade or cosmetically imperfect produce is usually not cost-effective. Most small farmers rely on wholesalers or local markets that reject such produce, limiting incentives to recover and reuse it. Value-added agriculture—such as transforming surplus vegetables into minimally processed or preserved products for institutional use—offers a promising way to increase income. However, the success of these models depends on the availability of practical and affordable supply chain solutions.

Current logistics barriers, including limited economies of scale and a lack of access to cold storage or processing, further restrict market opportunities for surplus produce. Instead of depending on advanced digital systems, a more realistic approach involves building localized, integrated logistics, such as aggregation hubs, shared storage, and coordinated delivery networks.

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Rather than relying on advanced digital tools, developing localized, integrated systems—from farm-side collection to delivery at central kitchens in nursing homes—offers a more accessible solution. Aggregation hubs, shared storage and processing facilities, and coordinated logistics can help lower costs, streamline operations, and ensure a reliable product flow between farms and long-term care institutions.

Social factor

Social perceptions of food quality heavily influence on-farm waste. In Taiwan, both consumers and retailers tend to favor visually perfect produce, leading to the rejection of edible vegetables that are misshapen, blemished, or irregular in size. This aesthetic bias discourages farmers from harvesting imperfect crops, even when they are nutritionally sound, and reinforces a system where cosmetic standards outweigh practical use.

The aging farming population further compounds the issue. Many older farmers lack the physical capacity or technological familiarity to explore alternative uses for surplus produce, such as processing, redistribution, or coordination with food banks. This demographic trend also contributes to resistance toward adopting new models or tools that could help reduce waste, such as direct-to-institution sales or local cooperative processing systems.

While some community support exists, such as farmers informally donating leftovers to neighbors or local charities, these efforts are often unstructured and inconsistent. These goodwill actions do not scale into a reliable solution for managing surplus without proper infrastructure, incentives, or legal clarity. Enhancing training, awareness, and organized donation mechanisms could strengthen social systems to better support waste reduction and community food security.

Technological factor

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Technological limitations play a key role in on-farm food waste among small and medium-sized farmers in Taiwan. Many lack access to affordable post-harvest equipment such as sorting machines, cold storage, or drying systems, which are essential for preserving quality and extending shelf life. Without these tools, surplus vegetables quickly become unmarketable, especially in warm, humid climates where spoilage is rapid.

Digital connectivity in the agricultural sector also remains underdeveloped. Farmers have limited access to or familiarity with digital tools such as farm management systems, real-time supply-demand platforms, or mobile marketplaces. This restricts their ability to respond quickly to market shifts, connect with alternative buyers, or coordinate surplus redistribution, often resulting in missed opportunities to reduce waste.

In addition, many farms still rely heavily on manual practices for harvesting and grading. These labor-intensive methods can be inconsistent and inefficient, making it difficult to standardize quality or make timely decisions about which produce is worth collecting. Moreover, there are few scalable systems that connect farmers to food processors, cooperatives, or institutional buyers who could repurpose surplus vegetables, leaving a technological gap in transforming waste into value.

Compounding these issues is the demographic reality of Taiwan's farming population. According to 2024 data from the Directorate-General of Budget, Accounting and Statistics (DGBAS, 2024), the average age of Taiwanese farmers is 64, with over 63% aged above 50. This aging population may lack the motivation, physical capacity, or digital literacy to adopt high-tech solutions such as IoT or data-driven farm management tools. As a result, many farmers continue relying on familiar but outdated methods, making technological adoption and innovation in waste reduction particularly challenging.

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2.4. Demand Market

In seeking a demand market for sourcing and utilizing leftover vegetables in Taiwan, the aging population presents a significant opportunity.

2.4.1. Aging Population Overview in Taiwan: Key Demographic Trends

Population aging is a global trend driven mainly by declining fertility rates and increased life expectancy, and Taiwan is among the countries experiencing one of the most rapid demographic shifts. Taiwan officially became an "aging society" in 2018, when individuals aged 65 and older made up over 14% of the population. By the end of 2024, the elderly population had grown to approximately 4.49 million, representing 19.18% of the total population, up from 2.6 million (11.15%) in 2012. This marks a staggering 73% increase in just 12 years.

According to projections from the National Development Council’s Department of Human Resources Development, Taiwan is expected to enter the stage of a “super-aged society” in 2025, with over 21% of its population aged 65 and above, a proportion that is expected to reach nearly 30% by 2035. Figure 3 below gathers data on Taiwanese aged 65 or older for the past 12 years. The denser color throughout the years indicates the increase in the elderly population in Taiwan.

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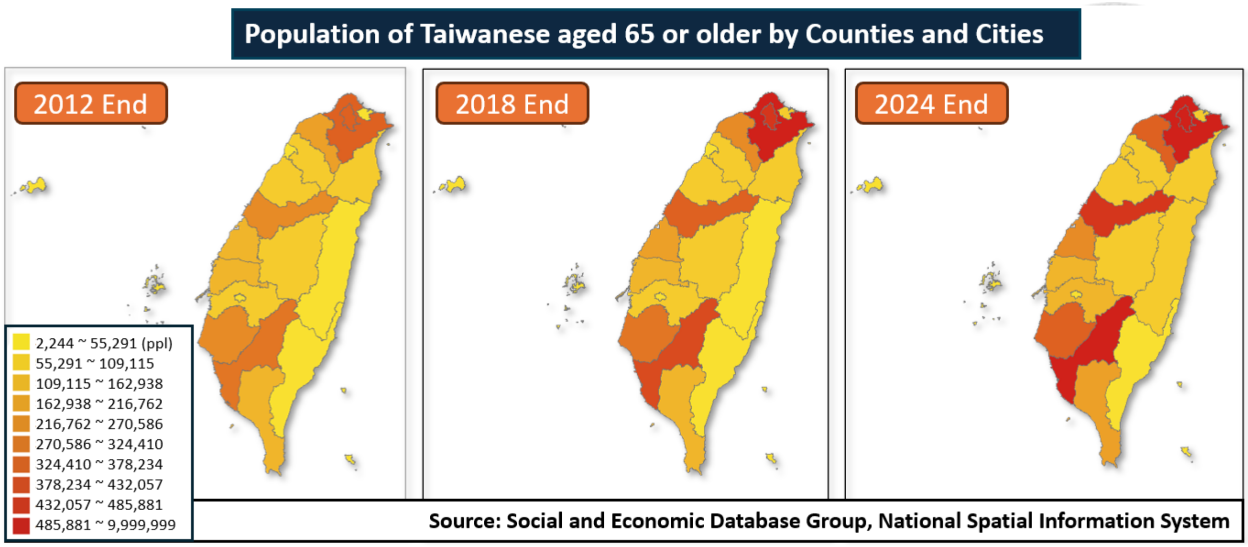

Figure 3 Population of Taiwanese Aged 65 or older by Counties and Cities

Notably, this transition—from crossing the "aged society" threshold in 2018 to "super-aged" status in just seven years—underscores an urgent need for sustainable and health-oriented food solutions tailored to older adults. As the elderly population continues to grow, so too does the demand for accessible, nutritious meals that meet their dietary and health needs. This demographic shift presents a timely and strategic opportunity to repurpose surplus agricultural produce, especially leftover vegetables, for use in elderly care settings. Long-term care centers and community-based meal programs offer viable and socially impactful distribution channels, aligning environmental sustainability with improved senior nutrition.

Taiwan's aging trend is further reinforced by a rising median age, a shrinking overall population, and a sharply increasing old-age dependency ratio, indicating that fewer working-age individuals will be available to support a growing number of elderly citizens. This adds pressure to social services and healthcare systems, creating openings for innovative, cross-sector solutions.

Aging is a nationwide phenomenon. All 22 administrative regions in Taiwan have already surpassed the 14% elderly threshold, and as early as 2020, several areas—including Chiayi County,

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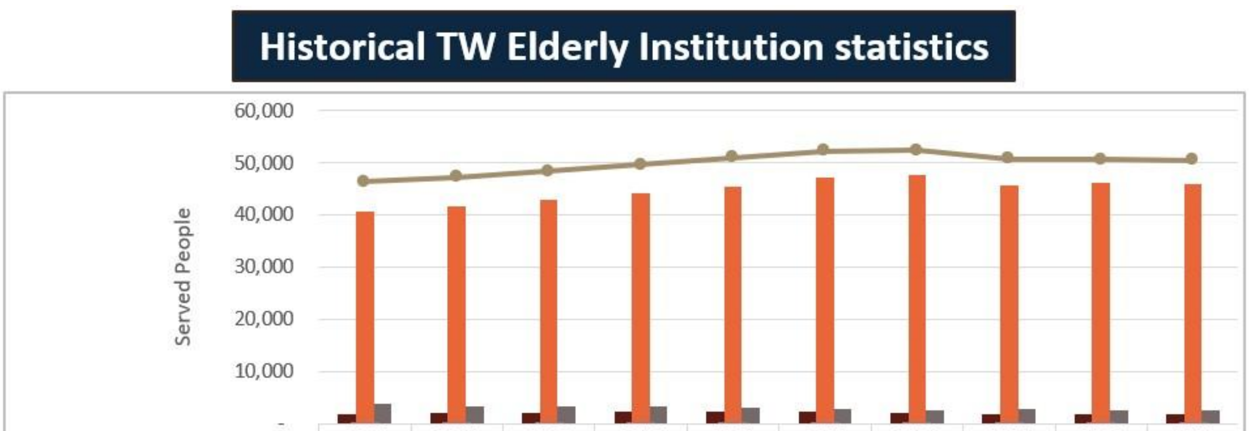
Taipei City, Nantou County, Yunlin County, Keelung City, and Pingtung County—had already exceeded the 20% mark, officially becoming "super-aged" regions. These regional disparities emphasize the importance of localized responses and highlight the aging population as a crucial market segment for developing resilient, socially responsible food distribution networks.

2.4.2. Demand Channels for Elderly Care in Taiwan

Taiwan's rapidly aging population is driving a substantial and ongoing increase in demand for elderly care services. Figure 4 shows that during the past 10 years, the served elderly population continues to rise, and there is a growing prevalence of chronic conditions such as hypertension, diabetes, stroke, and heart disease. These health issues often result in greater physical dependency, underscoring the urgent need for comprehensive, accessible, and long-term care resources tailored to the aging population.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Long-term Care Institutions	1,874	2,059	2,098	2,273	2,262	2,219	2,038	1,927	1,884	1,847
Nursing Institutions	40,492	41,690	42,839	44,011	45,409	47,114	47,530	45,717	46,063	45,951
Caring Organization	3,869	3,347	3,297	3,231	3,166	2,784	2,607	2,863	2,459	2,534
Dementia Care Institutions	62	59	61	60	129	127	122	116	109	114
Total	46,297	47,155	48,295	49,575	50,966	52,244	52,297	50,623	50,515	50,446

Source: Social and Family Affairs Administration, MOHW and County and City Government

Figure 4 Historical Taiwan Elderly Institution Statistics

To meet this demand, Taiwan has developed a diverse elderly care ecosystem that includes both institutional and community-based service models:

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Residential Institutions (住宿型機構)

These are the cornerstone of Taiwan's long-term care infrastructure, providing 24-hour care and support to seniors who can no longer live independently. Key facility types include:

- Elderly Care Institutions (老人照顧機構) – Offer daily assistance, personal care, and supervision.
- Nursing Homes (養護機構) – Provide intensive nursing care, often for residents with significant medical needs or disabilities.
- Elderly Welfare Institutions (老人福利機構) – Focus on general elder support in a residential setting.

Long-Term Care Centers (長照機構) and Community-Based Service Models

Under the Long-Term Care 2.0 policy, Taiwan has expanded the availability and range of care through community-integrated service models, including:

- A-Type: Community Integrated Service Centers (社區整合型服務中心) – Serve as local hubs coordinating care planning, referrals, and case management.
- B-Type: Complex Service Centers (複合型服務中心) – Provide on-site services such as meals, rehabilitation, day care, and temporary stays.
- C-Type: Alley Long-Term Care Stations (巷弄長照站) – Operate at the neighborhood level, offering basic care, companionship, and monitoring.

Home-Based and In-Home Services

These services support seniors who remain in their homes but require ongoing assistance:

- Home Care Services (居家照顧) – Includes personal hygiene, mobility support, and daily care tasks.

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- Home Nursing & Rehabilitation (居家護理與復能服務) – Provide medical treatments and physical therapy directly in the home.

Day Care and Temporary Care Facilities

- Adult Day Care Centers (日間照顧中心) offer structured day programs that include meals, supervision, and social interaction, relieving the burden on caregivers.
- Short-Term and Respite Care (短期/喘息服務) – Temporary care services aimed at supporting family caregivers or handling transitions after hospital discharge.

Specialized Dementia and Cognitive Care

Integrated into both institutional and community settings, these units focus on managing cognitive decline and related behavioral needs in elderly populations.

Government Policy Support and Public Infrastructure

The Taiwanese government is critical in shaping and supporting the elderly care system. Through the advancement of the Long-Term Care 2.0 initiative, the government has prioritized both physical and emotional well-being among the elderly population, promoting services that integrate mental health assessments, counseling, and social engagement alongside traditional care. In parallel, the sector is undergoing a digital transformation, with increased adoption of innovative technologies and data-driven tools to improve care accuracy, efficiency, and personalization.

Key agencies, including the Ministry of Health and Welfare, the Taipei City Social Affairs Bureau, and local Long-Term Care Management Centers, are actively involved in service implementation, regulation, and resource coordination. Their presence across Taiwan's administrative regions ensures a strong, reliable infrastructure to support the expansion, standardization, and long-term sustainability of elderly care services.

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2.4.3. Target Elderly Care Demand Channels

Building on the overview of Taiwan's elderly care services industry in the previous chapter, the next step is to identify appropriate channels for redirecting vegetable leftovers. Among the various types of care facilities, elderly care institutions, nursing homes, and long-term care residential centers emerge as particularly suitable partners for establishing a stable and continuous supply of surplus vegetables.

The three types of facilities mentioned form the foundation of Taiwan's long-term care system, delivering essential support, healthcare, and daily nutrition to a growing elderly population. As residential institutions (住宿型機構), they operate 24 hours a day and accommodate seniors who live on-site, requiring consistent meal provision, healthcare supervision, and round-the-clock support. This makes them ideal channels for a stable and sustainable supply of vegetables, especially those that can be processed or prepared in-house.

Unlike outpatient or day-based services, residential care centers typically maintain on-site kitchens or food preparation capabilities, allowing for direct integration of fresh produce into their daily meal programs. Their scale of operation, long-term occupancy model, and continuous demand for food make them particularly suitable for partnerships focused on sustainable food sourcing. Broader long-term care services, including community-integrated models under the ABC system, complement this core group by extending services into neighborhood-based care stations and complex service centers, but residential centers remain the most consistent and high-volume demand hubs.

The growing demand presents both social challenges and market opportunities. Institutions are under increasing pressure to provide nutritious, affordable meals as elderly residents frequently face chronic conditions and functional limitations. However, disparities in care resources persist,

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particularly in remote or island areas, where workforce shortages happen and limited access impacts service delivery. Addressing these challenges calls for coordinated policy support and innovative, cross-sector collaboration.

A promising strategy is to form sustainable partnerships between agricultural producers and residential care institutions. With proper infrastructure, **elderly care institutions**, **nursing homes**, and **residential long-term care centers** can act as reliable distribution points for surplus or recovered vegetables, helping meet their dietary needs while reducing food waste. Pilot programs, such as those in Taichung (Charity Food Exchange Platform at Feng Yuan Fruit and Vegetable Wholesale Market), have successfully channeled surplus produce to elderly community services.

As Taiwan advances toward a super-aged society, integrating surplus vegetable supply into long-term residential care centers offers a mutually beneficial solution. It enhances nutritional quality for seniors, strengthens sustainability in food systems, and opens new, socially responsible market channels for farmers, contributing to a more resilient and inclusive care and agricultural ecosystem.

2.5. PEST Analysis – Demand Side

Political factor

Long-term care centers and nursing homes in Taiwan must adhere to strict food safety regulations, such as those outlined in the Food Safety and Hygiene Management Act (食品安全衛生管理法). These rules prioritize consistency, traceability, and hygiene, often leading institutions to reject surplus or irregular-looking vegetables, even if they are perfectly edible. The emphasis on visual and handling standards reflects a risk-averse approach, where any perceived deviation from the norm increases concern about foodborne illness, especially in settings serving

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vulnerable elderly populations.

Another significant political barrier is the lack of legal clarity surrounding food donations. Current laws do not exempt donors or recipient institutions from civil, criminal, or administrative liability in the event of a food-related incident. This legal uncertainty discourages long-term care centers from accepting surplus produce or participating in food recovery initiatives, even when the products meet safety standards. Until comprehensive legal protections are put in place—such as a legislated version of the Food Bank Law (食物銀行法草案)—institutions may remain hesitant to engage with surplus redistribution systems.

Procurement policies also pose structural challenges. Many public care facilities are bound by rigid government procurement frameworks, which require them to purchase food through formal bidding processes or pre-approved vendors. These bureaucratic procedures make it difficult to source from non-traditional suppliers such as farms or food recovery hubs, even when such channels offer fresh, affordable, and nutritious options. The institutional demand market remains inaccessible primarily to local surplus producers without policy adjustments to enable more flexible procurement.

Economical factor

Many long-term care centers in Taiwan operate under tight food budgets, limiting their ability to buy premium produce. This makes them more open to affordable options like surplus or second-grade vegetables, as long as safety and quality are ensured. However, fluctuations in vegetable supply can disrupt consistent meal planning, making it difficult for institutions to rely on informal or unstable sources.

Food waste also creates hidden costs. Overordering, poor storage, and inconsistent deliveries often lead to spoilage, driving up disposal, labor, and compliance expenses. Variable

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quality or supply can increase waste if ingredients are unusable or require extra prep time.

Partnering with suppliers of pre-processed surplus vegetables offers economic value. It reduces labor and storage needs, while aggregating supply across farms helps smooth out fluctuations. These partnerships can help care centers more reliably access safe, low-cost ingredients.

Social factor

In long-term care centers and nursing homes, meals must meet specific nutritional and texture requirements to support the health and comfort of elderly residents. Ingredients must be soft, easy to chew, and nutritionally balanced. Any inconsistency in quality, such as overripe, underripe, or unevenly textured vegetables, can compromise meal preparation and safety, making consistency a critical concern. This makes institutions cautious when considering surplus or irregular-looking produce, even if it is otherwise safe and edible.

Social perceptions also play a role in food acceptance. There is often a stigma attached to using surplus or donated vegetables, with concerns that such food may be lower quality or unfit for regular institutional meals. These attitudes can influence purchasing decisions and how staff, residents, and families perceive the care being provided. Without clear communication, transparency, and reassurance about safety and quality, surplus-sourced meals may face resistance from within the institution or the broader community.

Additionally, many care centers operate within a culture that values routine and stability. Institutions often rely on long-term vendor relationships and predictable delivery schedules to maintain operational efficiency. Introducing alternative sourcing models, such as those based on surplus recovery or variable farm supply, may be disruptive or risky. For such systems to be adopted, they must align with institutional norms and demonstrate reliability, consistency, and

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clear benefits in both cost and care quality.

Technological factor

Vegetable waste varies daily, and if long-term care facilities are to cooperate effectively with farmers, technological tools will be essential for forecasting short-term vegetable demand, whether for the next day or several days ahead. Adding to this complexity, care centers are geographically scattered and vary significantly in size; some serve only a handful of residents, while others accommodate dozens. This diversity creates inconsistent and unpredictable demand patterns, making manual coordination difficult and prone to inefficiencies. Larger facilities may use digital procurement or inventory systems, often incompatible with informal suppliers like surplus hubs or small farms. In contrast, smaller centers typically rely on manual planning by owners or staff and lack tools for tracking food waste or optimizing purchases. Without appropriate digital support, institutions across all scales face challenges in coordinating timely, accurate orders and reducing avoidable waste.

2.6. PEST Analysis summary

Linking farmers' leftover vegetables with long-term care centers and nursing homes offers a practical solution to food waste and food insecurity. By establishing integrated operational systems that connect small and medium-sized farmers with institutions willing to accept surplus produce, the business model can turn surplus into usable ingredients for eldercare while addressing farmers' market limitations. Shared infrastructures such as cold storage, sorting facilities, and central kitchens help reduce costs and ensure food safety across the supply chain.

The model depends on partnerships among farmers, local governments, non-profits, and care institutions to ensure long-term success. Policy support, such as donor liability protection and redistribution incentives, can boost farmer participation. Training in post-harvest handling and

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basic processing further strengthens system efficiency. While both sides face constraints, their needs are complementary: farmers need stable outlets for surplus, and care centers need affordable, nutritious processed food. As a result, **<u>a vegetable processing factory</u>** becomes a coordinated, efficient system to bridge the gap between these two markets, turning waste into value and supporting a sustainable food economy.

3. RESEARCH FRAMEWORK AND KEY INSIGHTS

3.1. Research Aim

This research aims to assess the feasibility and effectiveness of establishing a vegetable processing facility that connects small- and medium-sized vegetable farmers with elderly care institutions. The proposed model addresses two pressing issues in Taiwan: the increasing volume of post-harvest vegetable surplus and the specific dietary needs of an aging population. The study explores reducing food waste while ensuring a stable and nutritious vegetable supply for long-term care centers by creating a centralized system for processing surplus vegetables into formats suitable for the elderly.

Taiwan's year-round vegetable production, market fluctuations, and short shelf life often lead to overproduction and economic losses for farmers. At the same time, care institutions face growing demand for soft-textured, easily digestible vegetables tailored to elderly diets. This business model investigates the potential to create value from agricultural waste by building collaborative supply chains between producers and care facilities. The goal is to **promote sustainability**, **reduce the destruction cost from vegetable suppliers**, **improve farm-level income**, **and enhance public health** through <u>a more resilient and socially responsible food system</u>.

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3.2. Research Objective

1. To analyze the supply potential of surplus or underutilized vegetables from small- and medium-sized farms in the Taoyuan area and from vegetable wholesalers in the Greater Taipei Area.
2. To identify the specific processing requirements (e.g., cut size, texture, and cooking readiness) of vegetables for elderly-friendly meals in long-term care institutions.
3. To design a cost structure for establishing and operating a vegetable processing facility, including equipment, labor, utilities, and logistics.
4. To evaluate the logistics and distribution framework, including transportation frequency, cold chain requirements, and delivery costs between the processing facility and elderly care institutions.
5. To assess the market demand, procurement practices, and willingness of long-term care institutions to source processed vegetables through this proposed supply chain.
6. To estimate the model's potential environmental and social impacts, particularly regarding food waste reduction, local agricultural resilience, and sustainable supply chain practices.
7. To conduct qualitative interviews with key stakeholders, including small- and medium-sized farmers, vegetable wholesalers, vegetable processing factory owners, central kitchen owners, and managers of elderly care institutions, to understand their needs, limitations, and willingness to participate in the proposed model.

3.3. Research Methodology and Design

This study adopts an exploratory and applied research design to evaluate the feasibility of establishing a vegetable processing facility that connects small- and medium-sized vegetable farmers with elderly care institutions. The aim is to address the oversupply of farm produce and

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the specific dietary needs of elderly consumers through a structured and sustainable supply chain model.

Given the practical and multi-stakeholder nature of the research problem, a mixed-methods approach is employed. This integrates qualitative insights from key stakeholders and quantitative modeling related to cost, logistics, and market feasibility. The combined approach ensures the proposed solution is grounded in operational reality and data-driven analysis.

Stakeholder Interviews (Qualitative Component)

As the author is currently based in Taipei City, semi-structured interviews are conducted with five key stakeholder groups located in the Greater Taipei Area and Taoyuan region for logistical convenience. The targeted demand market focuses on elderly care institutions within the Greater Taipei Area, while the supply market primarily consists of small- and medium-sized vegetable producers in Taoyuan and the broader Northern Taiwan region:

1. **Small—and medium-sized vegetable farmers in Taoyuan:** Assess the types, volumes, and seasonality of surplus vegetables, understand the main reasons for leftovers, and evaluate their willingness to engage in a procurement model involving either donation or low cost.
2. **Vegetable wholesaler in the Greater Taipei Area:** to explore the availability of underutilized produce and assess the feasibility of integrating existing supply channels.
3. **Vegetable processing factory owner in Taipei:** to understand current processing capabilities, capacity constraints, and operational costs.
4. **Owner of the Central kitchen serving elderly care institutions in the Greater Taipei Area: to** examine their menu planning, logistics dispatch, procurement standards, and openness to third-party processing partners.

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5. **Manager of long-term care institutions in the Greater Taipei Area** (e.g., nursing homes, elderly day care centers): to identify daily vegetable consumption volumes, processing preferences (e.g., cut size, softness), and willingness to switch to locally processed supply.

Thematic analysis of the interview responses helps uncover shared challenges, logistical constraints, and strategic opportunities that shape the practical implementation of the proposed facility.

<u>Cost and Logistics Modeling (Quantitative Component)</u>

A bottom-up cost model needs to be developed to evaluate the financial viability of the vegetable processing facility. This includes:

- Capital expenditures for facility setup and equipment,
- Operational expenditures such as labor, utilities, and routine maintenance,
- Per-unit processing costs, and
- Transportation and cold chain logistics for delivery from farms to the facility, and from the facility to urban demand points.

Real-world pricing assumptions are informed by online research and stakeholder inputs to produce a realistic economic projection.

<u>Demand and Market Feasibility Assessment</u>

This component assesses the demand side of the supply chain. A market analysis needs to be conducted to help determine the potential scale and sustainability of the model:

- Estimate daily vegetable consumption volumes across a representative sample of elderly care institutions,
- Understand institutional procurement preferences regarding price, quality, delivery frequency, and food safety.

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- Evaluate the overall willingness of institutions to adopt processed vegetable sourcing from a local facility.

Impact Evaluation

The study also includes an assessment of the proposed intervention's broader environmental and social implications. This includes:

- Scenario analysis of food waste reduction through the recovery and redistribution of surplus vegetables,
- Local economic development indicators, such as increased income stability for farmers and job creation within the processing facility,
- Sustainability metrics, focusing on transportation efficiency, local sourcing resilience, and circular economy practices.

3.4. Data Collection and Analysis

3.4.1. Overview of Data Sources

This study adopts a qualitative-driven data collection approach, primarily through in-depth interviews with existing stakeholders in the proposed supply chain, supplemented by online data research to support cost modeling and market analysis. In-depth interviews were conducted one-on-one with stakeholders across both the supply and demand sides, including small- and medium-sized farmers, vegetable wholesalers, processing facility operators, central kitchen providers, and managers of elderly care institutions.

These interviews used open-ended questions and a semi-structured format to allow flexibility and deeper exploration of each participant's operational realities, challenges, and perspectives. This method enabled the collection of rich, context-specific insights that are critical to evaluating the practical feasibility of the business model. In addition, secondary data—including

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pricing benchmarks, logistics parameters, and regulatory information—was gathered through online sources and government databases to supplement the interview findings and support quantitative analysis throughout the proposal.

3.4.2. Analysis of Vegetable Supply Potential (capacity)

As mentioned in the earlier chapter 2.2.2, Taiwan produces approximately 271,800 tons of vegetable leftovers annually, and sourcing a consistent and accessible supply remains a challenge for startup operations, particularly in the early stages. As the author is currently based in Taipei, this study focuses on supply sources in Northern Taiwan, particularly the Greater Taipei Area and Taoyuan region. Although Southern Taiwan accounts for a larger share of national agricultural output, starting in the north offers greater logistical feasibility for early operations. The shorter transportation distances, proximity to demand centers, and easier coordination with stakeholders make this regional approach practical for consolidating and processing leftover vegetables at a manageable scale.

Based on stakeholder interviews, two promising supply channels have been identified. A small- and medium-sized farm operator in Taoyuan, Bi Lo Cun Organic Farm (碧蘿村有機休閒農場), which collaborates with numerous upstream and downstream partners, reported that vegetable leftovers can range from 150 kg to over 10 tons per day, depending on the season and market dynamics. This variability underscores the importance of building flexible sourcing relationships. In addition, the owner of Northern Taiwan's largest vegetable wholesaler, VegeKing (菜霸子股份有限公司), expressed a strong commitment to social responsibility and indicated a willingness to contribute approximately 750 kg of surplus vegetables daily as a goodwill initiative. This support reflects their interest in participating in projects that align with environmental, social, and governance (ESG) principles, as well as their commitment to giving back to society by helping

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reduce food waste and supporting vulnerable populations.

Considering these supply sources and the processing capacity of a small-scale vegetable facility, the business plans to handle 750 kg to 1 ton of vegetables per day in the first year. As operations stabilize and sourcing networks expand, the supply volume is expected to grow to 2 tons per day in the second year. From the third year onward, with improved logistics, equipment, and transportation resources, the operation could scale to handle 3 to 5 tons of food daily, maximizing both food recovery and social benefits.

3.4.3. Analysis of Market Demand in Elderly Care Institutions

To identify and quantify the demand market for surplus vegetable distribution, this study targets elderly care demand channels, including nursing homes, residential long-term care centers, and elderly welfare institutions, as mentioned in the previous chapter 2.4.3. These institutions are selected due to their relatively stable and predictable daily meal service needs, as they operate 24 hours and are expected to provide regular meals to their residents.

The population served is estimated based on the number of registered beds in each institution, assuming that each bed represents one individual receiving full-time care and daily meals. The total bed counts were collected from official statistics provided by the Ministry of Health and Welfare (MOHW) as of the end of 2024. As the study focuses on the Greater Taipei Area, additional data were obtained from the Department of Social and Family Affairs under the MOHW, the New Taipei City Department of Health, and the Taipei City Department of Health. These sources provided detailed facility-level data, ensuring an accurate representation of potential demand in the region.

Based on dietary recommendations, the average daily vegetable intake per person is approximately 287.13 grams, or 0.29 kilograms. Therefore, the estimated daily vegetable

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consumption demand for the selected institutions can be calculated by multiplying the number of individuals (derived from institutional bed counts) by 0.29 kilograms. This formula provides a practical basis for estimating the quantity of surplus vegetables that could be supplied to meet daily nutritional needs. Accordingly, the potential volume of vegetable leftovers required for redistribution is determined by this daily per capita intake multiplied by the total population served across all partnered elderly care facilities.

Description	Medical Institutions	Long-term Care Institutions	Other Caring Center
Types of Institutes	-Health Center -Hospital **-Nursing Homes** -Home Care Nursing Service -Physical/Occupational Institutes -Clinic -Pharmacy	-Home-based -Community-based **-Residential** -Comprehensive	**-Elderly welfare institutions** -Welfare institutions for the disabled -Corporate body Foundation -Social Welfare Groups -Labor Cooperatives
Points of delivery	204 points	28 points	305 points
People served	9,765 people	10,002 people	13601 people
Vegetable consumption in kg	3.96 ton/day	0.69 ton/day	2.83 ton/day

Table 1 Category of the Demand Market, Delivery Volume, and People Served

Based on the above calculation method, the estimated total vegetable demand for serving the vulnerable elderly population in the Greater Taipei Area amounts to approximately 7.48 tons per day. This figure includes three major types of institutions:

- Nursing homes, with 9,765 individuals served across 204 facilities, require an estimated 3.96 tons of vegetables per day.

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- Long-term care centers, serving 10,002 individuals across 28 facilities, require approximately 0.96 tons per day.
- Elderly welfare institutions, with a total of 13,601 individuals across 305 facilities, require about 2.83 tons of vegetables daily.

These demands, as shown in Table 1, provide a concrete reference for determining the potential scale and feasibility of surplus vegetable redistribution efforts in the region.

3.4.4. Stakeholder Profile

Social Welfare Center Owner

One interview was conducted with the owner of Fun Care Home (玩學樂園), a social welfare center responsible for managing daily operations, resident services, and food provision. Mr. Fauzy Wu, the owner of the institution, and Ms. Xiao Ling, the manager, represent the demand side of the vegetable redistribution model within elderly care settings.

Small-to-Medium-Sized Vegetable Farmer

A field interview was conducted with Bi Lo Cun Organic Farm (碧蘿村有機休閒農場), a small-to-medium-scale vegetable farm. Mr. Chia-Hao Wu, the owner of the farm, is engaged in local production and supply to regional markets. This stakeholder represents the supply side at the farm level, where surplus produce may originate.

Central Kitchen Owner

Ms. Weng, the owner of JinYu Central Kitchen (金羽食堂), participated in the interview. Central kitchens provide prepared meals to various institutions, and this stakeholder operates at the intersection of food preparation and distribution, playing a role in linking raw ingredients to end-users.

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Vegetable Processing Factory Manager

An interview was conducted with Ms. Zi-Yin Lai, the owner of Gao Feng Agricultural Products Enterprise (高峰農產企業社), a vegetable processing factory. A vegetable processing factory is involved in converting raw agricultural products into portioned, ready-to-use items. This stakeholder represents an intermediary role between suppliers and institutional kitchens.

Large Vegetable Wholesale Distributor

The final interview was conducted with Mr. Steven Wang, the owner of VegeKing (菜霸子股份有限公司). VegeKing is a vegetable wholesale distributor that manages large-scale vegetable transactions across various markets. This stakeholder handles high-volume flows of produce and is positioned between farm-level supply and downstream buyers.

3.4.5. Summary of Key Findings

This section presents qualitative insights derived from field interviews and direct observations conducted with five key stakeholders across the vegetable supply and elderly care sectors. The insights highlight practical challenges and system limitations that must be addressed to enable the effective redistribution of surplus vegetables.

1. Farmer Participation Depends on Cost and Convenience

Small and medium-sized farmers are primarily focused on economic survival. If the cost of harvesting and transporting leftover vegetables outweighs the financial return—or if the redistribution process is unreliable—they are unlikely to participate. Many would prefer to let vegetables rot in the field rather than invest more labor or resources into low-yield collection efforts. Without an efficient, cost-lowering system that connects surplus supply with ready demand, it is challenging to secure sustained farmer engagement.

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2. Wholesale Distributors Generate Higher Surplus Volumes

Compared to farmers, large vegetable wholesale distributors produce greater surplus due to strict appearance standards and customer expectations for uniformity. While farmers can choose to leave unsellable vegetables unharvested—avoiding additional effort—distributors must actively remove and dispose of imperfect or excess stock. As a result, distributors are a more consistent source of large-volume surplus, often willing to offer such produce at no cost since it would otherwise be discarded. With the right collection and delivery system, wholesale distributors represent a highly practical and scalable source of leftover vegetables for redistribution.

3. Surplus Vegetables Are Supplied in Raw and Bulk Form

Vegetable leftovers gathered from farms or wholesale markets are typically in raw, unprocessed form and packaged in bulk. These include large heads of cabbage, multi-kilogram quantities of carrots, or leafy greens with stems and roots still attached. While suitable for traditional food markets, such formats are not immediately usable in elderly care institutions. Their size, condition, and volume pose logistical and operational challenges for facilities that require portion-ready, processed ingredients.

4. Lack of On-site Capacity to Handle Raw Processing

Most elderly care institutions do not have the labor capacity or kitchen infrastructure to process large quantities of raw vegetables. Interviews revealed that these facilities prioritize efficiency and rely heavily on pre-portioned ingredients delivered from central kitchens. Especially for smaller centers serving fewer than 50 individuals, hiring additional kitchen staff to wash, peel, and chop raw produce is not economically viable. This makes it difficult for such institutions to directly adopt unprocessed surplus vegetables.

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5. Elderly Diets Require Special Vegetable Preparation

In addition to limited staffing, the dietary needs of elderly residents further increase preparation demands. Many recipients require vegetables in softer forms—such as mashed, pureed, or blended into juice—which adds another layer of processing beyond basic chopping. Serving vegetables in these specialized formats is essential for both safety and nutrition, but is not feasible without the proper tools and trained staff. This reinforces the need for vegetables to be delivered in pre-processed, elderly-friendly formats.

6. Central Kitchens Rely on External Vegetable Processing

To address these challenges, many elderly care institutions outsource food preparation to central kitchens. These kitchens often serve a diverse range of clients, including school lunch programs, corporate meal services, and other institutional catering needs, and operate under high-volume, time-sensitive conditions. As such, they prefer to receive ingredients that are already cleaned, cut, and portioned. Vegetable processing is commonly outsourced to specialized factories

3.4.6. Demand-Supply Matching and Feasibility Assessment

This chapter analyzes the potential to match surplus vegetable supply with the daily consumption needs of elderly care institutions. It outlines the scale of demand and available supply, setting the foundation for evaluating whether the redistribution model is viable within current operational constraints.

Demand-Side Estimates

As established in earlier analysis, the total estimated daily vegetable demand from elderly care institutions across the Greater Taipei Area is approximately 7.48 tons. This includes nursing homes, long-term care centers, and elderly welfare institutions, all of which require regular, scheduled meal services for their residents. These institutions represent a stable and predictable

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demand channel, making them ideal targets for surplus vegetable redistribution efforts.

Supply-Side Estimates and Conditions

In the initial year of operation, the expected supply of surplus vegetables—sourced from small to medium-sized farms and wholesale distributors—is estimated at 1 to 1.5 tons per day. These vegetables are typically raw and unprocessed, often delivered in bulk quantities and irregular in size or appearance. Common items may include oversized carrots, large cabbages, or leafy greens with minor blemishes. While still edible and nutritious, such produce requires cleaning, cutting, and sorting before it can be used in institutional kitchens. Given the limited supply, early delivery efforts will prioritize institutions with larger populations or those located in high-demand clusters.

3.4.7. Cost and logistics estimate

The evaluation points are the key logistical and cost-related considerations involved in delivering surplus vegetables from farms and wholesalers to elderly care institutions. It focuses on the practical limitations of transportation, processing, storage, and labor—factors that directly impact the operational viability of the redistribution model in its early stage.

1. Operational Logistics Constraints

Translating the limited daily vegetable supply into institutional deliveries requires careful logistical planning. In the early phase, the expected supply volume ranges from 1 to 1.5 tons per day—an amount that can be handled by two 3.5-ton trucks, each with a capacity of around 1 ton. However, the primary constraint lies not in truck volume, but in delivery reach. The number of institutions a truck can visit in a single day directly affects how much supply can be distributed. Therefore, routing must prioritize clusters of institutions with higher population density or higher vegetable demand to ensure efficient delivery coverage and maximum impact.

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Additionally, processing and cold storage coordination play a key role. Surplus vegetables must be picked up, processed, and delivered on a tight, integrated schedule. Cold storage capacity should be optimized—ideally 2 to 3 tons—to balance cost efficiency and inventory turnover. Although processing does not need to occur all at once, the system must be able to process 1.5 to 2 tons daily, either in advance for the next day or during delivery hours. While the processing workflow is essential, the primary logistical challenge remains the optimization of delivery routes and timing, which will be addressed through operations research in later planning phases.

2. Cost, Labor, and Infrastructure Planning

As a startup operating in its first year, maintaining a lean and cost-effective setup is essential. The operation will rely on minimal staffing, basic cold chain infrastructure, and compact processing space. Equipment and storage units should be scaled to fit actual daily volume, avoiding underutilization that would increase fixed costs. Small, refrigerated trucks and efficient use of shared or rented facilities can help reduce upfront investment.

Strategic decisions about routing, delivery schedules, and institutional targeting must also take into account fuel costs, labor hours, and cold chain integrity to control recurring operational expenses. These constraints form the practical baseline from which the system can grow into a scalable and self-sustaining model.

3.4.8. Conclusion: Toward a Centralized Vegetable Processing Solution

The analysis of demand, supply, and operational constraints highlights the need for an integrated system to bridge the gap between surplus vegetable supply and the operational realities of elderly care institutions. At the center of this solution is the establishment of a centralized vegetable processing factory, which provides essential value-added services beyond simple aggregation. This facility would not only clean, cut, and portion raw surplus vegetables into usable

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forms but also coordinate delivery logistics, ensuring that the processed produce reaches institutions in a timely, usable state. By consolidating fragmented farm- and wholesale-level leftovers and aligning them with the specific needs of elderly care facilities, the factory serves as a critical intermediary. Its dual function—processing and delivery—creates a complete service loop that adds efficiency, reliability, and flexibility to the redistribution model. This centralized approach enables small-scale surplus to be transformed into a structured, scalable food support system that delivers both social and operational value.

3.5. Importance and Significance of the Study

A key challenge in Taiwan's agricultural sector is the fragmentation of surplus resources across small- and medium-sized farms. These farmers typically operate independently, rely on traditional workflows, and lack access to digital or logistical networks that can connect them efficiently with institutional buyers, such as nursing home kitchens. The absence of a centralized system for aggregating, storing, and delivering leftover vegetables means that even when there is a surplus, it cannot be moved quickly or economically to where it's needed. Farmers lack the financial, technical, and infrastructural capacity to coordinate distribution independently, and institutional kitchens often lack the resources to source directly from multiple small suppliers.

Linking farmers' leftover vegetables with the channels in need provides the right platform for both the supply and demand sides. A full-fledged company that acts as a regional hub can create a vital solution to this systemic problem, consolidating the leftover vegetables from nearby farms or wholesalers, sorting, storing, and processing them, and then using transportation planning to dispatch deliveries to nursing homes' central kitchens on a reliable schedule.

Functioning as a connector with dedicated logistics operations, the company alleviates the burden on both farmers and buyers. It introduces predictability and efficiency where currently

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there is friction and waste. This new model not only enhances food system resilience and minimizes waste but also empowers traditional farmers to participate in sustainable food distribution without requiring them to invest in high-tech solutions or complex infrastructure themselves. It becomes a replicable, impact-driven supply chain solution grounded in regional realities.

Moreover, the business goal solution of recreating values for vegetable waste closely ties with the global trend by lowering own food waste: United Nations calls for the halving of per-capita global food waste at the retail and consumer levels and the reduction of food losses along production and supply chains, including post-harvest losses by 2030 (SDG Sustainable Development target 12.3). This act would add significant implications for the fight against climate change as well.

3.6. International Reference Cases in Vegetable Leftover Utilization

3.6.1. Overview of Global Approaches to Food Waste and Vegetable Surplus

Globally, governments, nonprofits, and private organizations are increasingly implementing circular economy models to reduce food waste and recover value from surplus agricultural produce, especially vegetables. These models often rely on coordinated logistics, centralized or distributed processing, and partnerships with social service organizations to redirect edible surplus to where it is most needed. In this section, we highlight several documented cases that demonstrate how different countries have successfully built systems to recover leftover vegetables, reduce waste, and serve vulnerable populations.

3.6.2. Documented Cases of Leftover Vegetable Programs Internationally

1. Italy: Ortomercato & Banco Alimentare

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One example is Italy's Ortomercato in Milan, which partners with Banco Alimentare, a national food bank network. Unsold produce from the wholesale market is collected daily by volunteers and distributed to local charities. In 2017 alone, 460 tons of fresh fruits and vegetables were recovered through this system, with an emphasis on same-day or next-morning delivery to maintain freshness. The Milan model has served as a reference for other cities seeking to organize surplus food recovery operations (Interreg Europe, n.d.).

2. Israel: Leket Israel

In Israel, the national food bank Leket Israel organizes thousands of volunteers and staff to collect leftover vegetables from farms, packinghouses, and orchards. In 2014, it redistributed over 20 million pounds of surplus produce to NGOs, community kitchens, and care centers. This model reduces waste while strengthening ties between producers and social institutions, effectively integrating logistics and food access goals (BioCycle, 2015).

3. Australia: OzHarvest

Australia's OzHarvest leads the food rescue movement by collecting surplus vegetables from supermarkets, wholesalers, and growers. The food is redistributed to over 1,800 charities, including facilities serving elderly and vulnerable populations.

4. Belgium: Get Wasted Circular Food Platform

Similarly, Belgium's Get Wasted project in Antwerp piloted a circular food platform that converts surplus vegetables into soup for local schools and food services, using a digital platform to connect suppliers with community needs (EIT Food, n.d.; OzHarvest, n.d.).

5. United Kingdom: FareShare

In the United Kingdom, FareShare plays a central role in redistributing surplus food from large retailers and food producers to charities and community groups. Significant quantities of

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vegetables are rescued and allocated to organizations such as elderly care homes, soup kitchens, and food banks. The model emphasizes food safety, efficient redistribution, and collaboration with commercial partners to manage inventory and logistics effectively.

FareShare's system also incorporates warehousing and cold chain management, ensuring that rescued vegetables maintain nutritional value upon delivery. Its integration with national retailers highlights the importance of formalized, long-term partnerships in sustaining vegetable recovery operations at scale. The model offers a practical example of how logistics and scheduling systems can align surplus food flows with public benefit (Parfitt, Barthel, & Macnaughton, 2010).

3.6.3. Insights for Application in the Taiwan Context

The above shared international examples reveal a diverse set of strategies that adapt to local agricultural conditions, supply chain realities, and community needs. Common success factors include rapid collection logistics, partnerships with civil society groups, and infrastructure for short-term storage or processing. While Taiwan's agricultural supply is decentralized and smaller in scale, these global practices demonstrate that with coordinated logistics and proper institutional partnerships, surplus vegetables can be effectively recovered and reused.

In Taiwan, a centralized vegetable processing and delivery model—supported by optimization tools from operations research—can benefit from these precedents. Especially relevant are models that combine daily surplus collection with immediate redistribution, aligning closely with the needs of elderly care institutions. These cases offer valuable insights for designing a cost-efficient and socially impactful circular economy system rooted in Taiwan's unique agricultural and demographic context.

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4. DETAILED PRODUCT & SERVICE

4.1. Processing Factory Design

4.1.1. Features Overview

The design of the vegetable processing factory plays a critical role in ensuring operational efficiency, food safety compliance, and future scalability. This section outlines the key design considerations that form the foundation of the proposed facility.

As the author lives in Taipei City, the target market is aimed at the Greater Taipei Area (Taipei and New Taipei City). Below shows the geographic map in the counties of Taipei City and New Taipei City, and the author will explain how the vegetable processing factories are selected under what type of criteria and considerations.

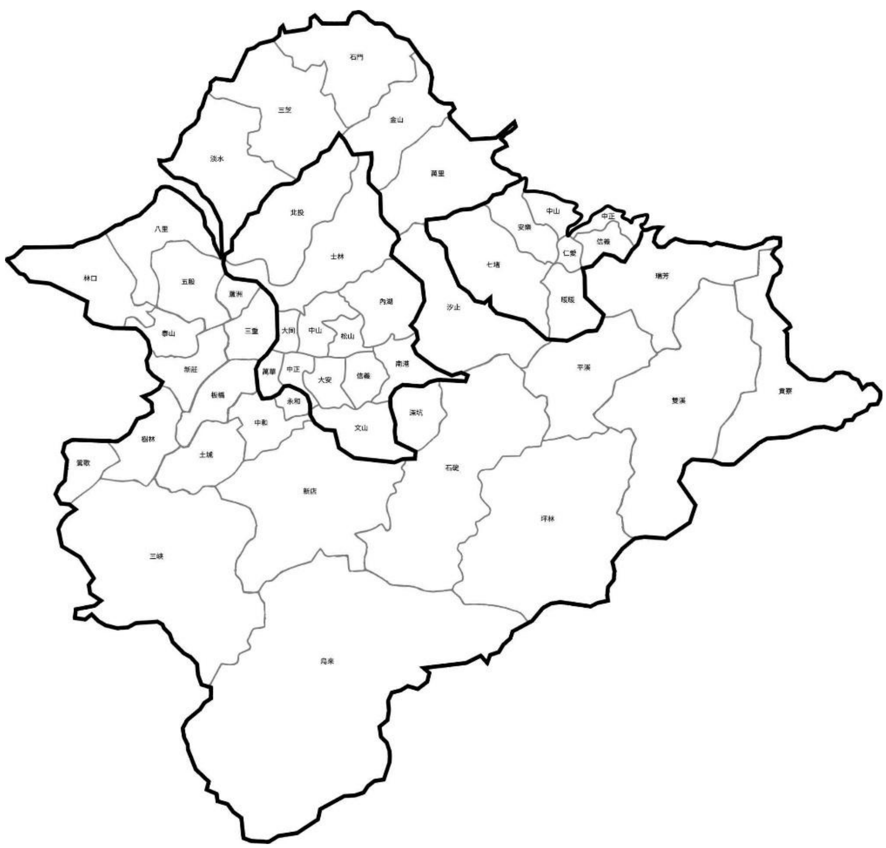

Figure 5 Greater Taipei Area Map

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Location Rationale

The selection of the factory location is guided by two key considerations to support both supply-side efficiency and demand-side delivery:

1. Proximity to Vegetable Wholesale Markets

To ensure the timely sourcing of surplus and off-grade vegetables, the factory aims to be located near major wholesale markets. In Taipei City, these include the First Fruit and Vegetable Wholesale Market in **WanHua (萬華)** area and the Second Fruit and Vegetable Wholesale Market in Binjiang Street, located at **ChongShan (中山)** area. In New Taipei City, key markets include the SanChong Fruit and Vegetable Wholesale Market in **SanChong (三重)** area and the Banqiao Fruit and Vegetable Wholesale Market in **Banqiao (板橋)** area. Being close to these hubs helps reduce inbound logistics time and cost, while providing access to a steady supply of raw materials.

2. Accessibility to Major Highways

In parallel, districts such as **WuGu (**五股**)**, **ShuLin (樹林)**, and **LinKou (林口)** are prioritized for their convenient access to major highway interchanges. These locations provide strong logistical advantages for both sourcing from central and southern Taiwan farms and distributing processed vegetables to urban institutions in Taipei and New Taipei City.

This **dual-location strategy**—close to both supply hubs and key distribution corridors—enables the factory to operate efficiently within the time-sensitive constraints of daily fresh vegetable processing and delivery.

Figure 6 below demonstrates the six candidate locations considered for establishing the vegetable processing factory in the Greater Taipei Area, including **WanHua(萬華), TuCheng (土城), Banqiao (板橋), WuGu (**五股**)**, **ShuLin (樹林)**, and **LinKou (林口).**

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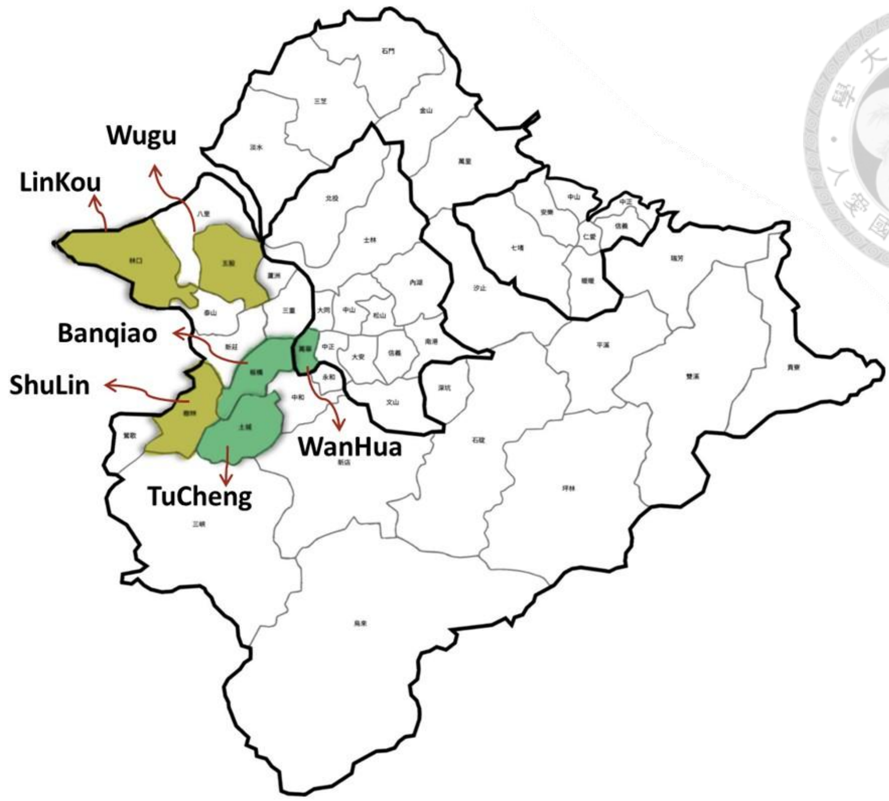

Figure 6 Greater Taipei Area Site Selection Area Candidates

Processing Capacity

The facility is designed to handle a daily throughput of 2 to 3 tons (2,000 to 3,000 kilograms), aligning with growth projections through the third year of operation. The spatial design and equipment selection also allow for modular expansion to support future increases in demand.

Factory Size and Zoning

The internal layout of the facility is organized into clearly defined zones to streamline workflow and maintain hygiene standards. These zones include:

- Receiving and weighing area for raw vegetables
- Cold storage and Dry goods area
- Sorting area
- Washing and initial inspection area

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- Cutting and processing area (slicing, dicing, shredding)
- Packaging and labeling section
- Dispatch zone, including the temporary stock placement zone
- Disinfection zone

To support a daily processing volume of approximately 2 tons, the factory should occupy at least 60 ping (approximately 198 square meters). This space allocation allows for smooth movement between zones, appropriate spacing for equipment, and compliance with food safety and workflow separation requirements.

Equipment List

To meet processing and quality standards, the factory will be equipped with:

- Industrial vegetable washing machines
- Multi-function vegetable cutters and slicers
- Vacuum sealing machines for hygienic and efficient packaging
- Refrigerated storage units and chillers to maintain cold chain standards

Food Safety Compliance

The facility will operate in full compliance with HACCP (Hazard Analysis and Critical Control Points) and ISO 22000 food safety management systems. Standard operating procedures (SOPs) will be implemented across all production areas, with regular staff training to ensure consistent hygiene, traceability, and quality control.

Sustainability Features

In consideration of long-term environmental impact, the facility incorporates sustainability measures where feasible. These include wastewater treatment systems for processing residues and the potential future installation of solar panels to reduce energy consumption and carbon footprint.

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4.1.2. Factory Layout

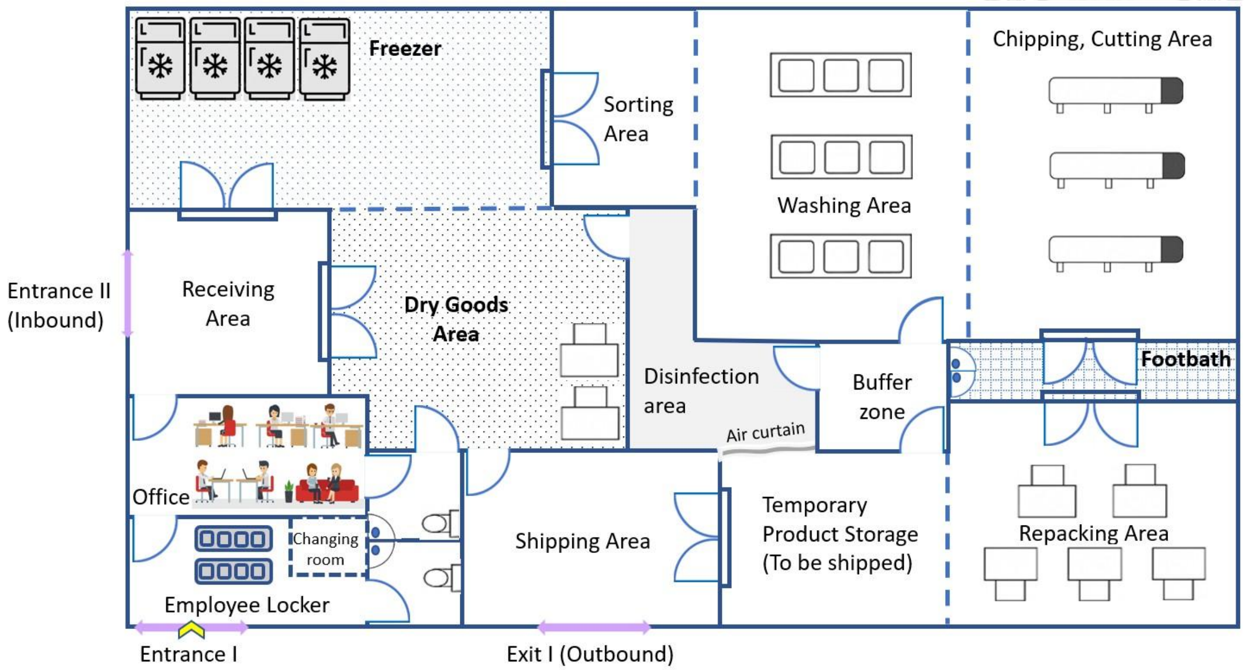

Figure 7 Vegetable Processing Factory Layout

Here is a brief explanation of each functional area in your vegetable processing factory based on the layout, visually displayed in Figure 7:

Receiving and Weighing Area for Raw Vegetables

Located near *Entrance II (Inbound)*, this area is the first stop for incoming vegetables. Fresh produce is unloaded, checked for quality, and weighed to ensure accurate inventory tracking. This step is critical for maintaining traceability and managing stock for daily processing.

Cold Storage and Dry Goods Area

Adjacent to the receiving zone, the *Freezer Area* stores perishable vegetables at appropriate temperatures to maintain freshness, while the *Dry Goods Area* houses non-perishable supplies like packaging materials, seasonings, or dry ingredients. This separation ensures temperature-sensitive items are preserved properly.

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Sorting Area

After storage, vegetables are moved into the *Sorting Area*, where they are categorized based on size, type, or quality. This stage removes visibly defective items and organizes the vegetables for specific processing workflows like washing, cutting, or direct repacking.

Washing and Initial Inspection Area

Vegetables enter the *Washing Area* where they are thoroughly cleaned with water or disinfectants. This step ensures hygiene and is often paired with a visual *initial inspection* to remove any remaining dirt, pests, or damaged parts before further processing.

Cutting and Processing Area

After cleaning, vegetables requiring further processing are transferred to the *Chipping, Cutting Area*. Here, they are mechanically sliced, diced, or shredded depending on end-product requirements. Equipment in this area is tailored for high-volume, consistent processing.

Packaging and Labeling Section

Processed vegetables are moved to the *Repacking Area*, where they are portioned, sealed, and labeled with relevant product information (e.g., type, weight, expiration date). Proper packaging ensures product safety and traceability during transportation and storage.

Dispatch Zone, Including the Temporary Stock Placement Zone

Products ready for delivery are temporarily held in the *Temporary Product Storage* (To be shipped) area. This buffer enables batch organization before dispatch through the Shipping Area, leading directly to *Exit I (Outbound)* for distribution to end users like Long Care Centers or retail outlets.

Disinfection Zone

This zone, located just before entering the clean area (buffer zone), serves as a hygiene

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checkpoint. Personnel and materials pass through an *Air curtain* and other sanitation steps to prevent contamination, maintaining a food-safe processing environment.

<u>The footbath and handwashing area</u>

This area serves as a crucial hygiene barrier between the cutting/processing area and the repacking zone. Before entering the repacking area—where products are directly handled for final packaging—staff must pass through this sanitation checkpoint. Here, they disinfect their hands and footwear to minimize the risk of contamination, maintain strict food safety standards in the clean zone, and ensure that only personnel who have completed proper hygiene procedures can access the sensitive repacking and labeling environment.

4.2. Service scope – Processing and Delivery

4.2.1. Processing Service

The core of the factory's value lies in its ability to transform surplus vegetables from small to medium-sized farms and wholesale distributors into ready-to-use ingredients tailored to institutional foodservice needs. These vegetables, often excluded from retail markets due to appearance or irregular sizes, are still fresh and nutritious, making them ideal for value-added processing.

<u>Raw Material Source</u>

Vegetables are received daily from trusted farm partners and wholesalers. Each batch is weighed and recorded, with initial sorting conducted to separate unusable portions.

<u>Sorting and Quality Control</u>

All incoming produce undergoes visual inspection by trained personnel. Spoiled or damaged portions are removed to ensure only high-quality, food-safe vegetables enter the processing line.

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Processing Types

The factory supports various processing methods to meet diverse institutional needs, including:

- Washing
- Cutting (sliced, diced, shredded)
- Blanching is applied when required to extend shelf life or meet preparation preferences.

Processing Schedule and Labor Allocation

Vegetables are categorized by weight and structure to guide workflow planning and staffing. The main categories are:

- Flowers and fruits, mainly Lightweight produce: e.g., bell peppers, mushrooms, celery
- Leafy vegetables: e.g., cabbage, spinach, Chinese cabbage
- Root vegetables: e.g., carrots, potatoes, taro

A typical session can process 1.5 to 2 tons of mixed vegetables—washed, cut, and packaged—within 3 hours of continuous operation. This modular labor system ensures scalability and efficiency depending on daily demand. Recommended labor allocation is as follows:

1. For medium-scale processing (1.5–2 tons per session), **Total staff: 4 people**

- 1 person – washing
- 1 person – machine feeding
- 1 person – quality inspection
- 1 person – weighing, packaging, and stacking

2. For large-scale processing (3 tons or more per day), **Total staff: 7 people**

- 3 people – washing
- 2 people – machine feeding

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- 1 person – quality inspection
- 1 person – weighing, packaging, and stacking

Packaging Options

Processed vegetables are vacuum sealed to preserve freshness, reduce contamination risks, and extend shelf life. Portions are customized according to the daily requirements of each client institution, typically organized in weight-based batches.

Customization

The factory's flexible workflow allows for customization of processing methods, cut styles, and packaging quantities. This supports institutional dietary planning, reduces kitchen labor, and minimizes ingredient waste at the client's end.

Pricing Model

A unit-based pricing model (NTD/kg) will be finalized based on confirmed demand volume and processing specifications. This price will reflect labor, energy, packaging, and operational costs while remaining competitive within the institutional foodservice supply market.

4.2.2. Delivery Service

To ensure that processed vegetables reach end users in a timely and fresh condition, the factory integrates a direct delivery system as part of its service model.

Delivery Network

The primary delivery targets include nursing homes, long-term care centers, and elderly care institutions across Taipei and New Taipei City. These clients require daily, reliable delivery of safe and ready-to-use ingredients.

Fleet Management

Given the scale of operations, the factory employs a lean delivery model using two

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refrigerated vehicles. Each vehicle supports a morning delivery route covering multiple institutions. As the business grows, this fleet model is scalable to meet increased demand.

<u>Cold Chain Maintenance</u>

All vehicles are equipped with refrigeration systems to maintain cold chain integrity, minimizing spoilage risk and ensuring food safety throughout transportation.

<u>Logistics Cost Structure</u>

The delivery system operates on a fixed-cost basis. Drivers are employed on a full-time, monthly salary to support operational consistency. During peak seasons or promotional periods, additional trips may be arranged with hired drivers, typically at a per-trip cost (e.g., NTD 1,800).

<u>Service Frequency</u>

Deliveries are made daily to ensure ingredient freshness and support kitchen operations that rely on day-to-day supply predictability.

<u>Tracking and Communication</u>

A basic real-time tracking system will be implemented to improve order visibility and communication with partner institutions. This ensures accountability, transparency, and a responsive logistics operation.

4.3. Daily Capacity Assumption

4.3.1. Demand Points and Total Vegetable Requirements

In Chapter 3.4.3, the author has collected data for the total daily vegetable demand across different types of long-term care institutions in the Greater Taipei area, as shown below. The values represent estimated needs based on the number of facilities and their average number of residents.

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Facility Type	Number of Sites	Vegetable Demand (tons/day)	Average Residents per Site
Nursing Homes	204	3.96	~48 persons/site
Residential Care Centers	28	0.69	~357 persons/site
Elderly Welfare Institutions	305	2.83	~45 persons/site
Total	**537**	**7.48 tons/day**	—

Table 2 Demand Market - Daily Capacity Assumption

4.3.2. Daily Vegetable Handling and Distribution Capacity

In the initial phase (Years 1–2), the maximum daily vegetable intake capacity is considered 2 tons (2,000 kg), and from Year 3 onward, the target intake capacity increases to 3 tons per day.

Given that the average daily vegetable requirement per distribution site is 13.9 kg/day, and the maximum load per 3.5-ton truck is 1,000 kg; the maximum number of distribution sites that can be served per truckload is calculated as below:

$$\textbf{\textit{Max Sites that can be served per ton}} = \frac{1{,}000}{13.9} = 71.9\ \textbf{\textit{delivery points}}$$

4.3.3. Delivery and Travel Time Estimation

Each distribution site requires approximately 5 minutes for unloading, combined with an average travel time of 8 to 10 minutes between sites.

Therefore, the total time required per site can be expressed as:

Delivery Time per site **=** Unloading Time + Traveling Time = 5 + (8 to 10) = 13 to 15 min

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This time-per-site estimate is critical for determining the maximum number of delivery points a vehicle can serve within a shift. To promote driver well-being and comply with labor standards, each delivery shift is limited to approximately 7.5 hours, equivalent to:

$$\textbf{\textit{Shift Duration}} = 7.5 \text{ x } 60 = 450 \text{ minutes}$$

Truck A is scheduled for two delivery shifts per day:

$$\textbf{\textit{Truck A Delivery Time}} = 2 \text{ x } 450 = 900 \text{ minutes / day}$$

Truck B is allocated one 7.5-hour delivery shift (450 minutes), with the remaining time in its 14-hour workday used for vegetable pickup:

$$\textbf{\textit{Truck B Delivery Time}} = 450 \text{ minutes / day}$$

Combining both vehicles, the total available delivery time per day is:

$$\textbf{\textit{Total Truck A+B Delivery Time}} = 900 + 450 = 1{,}350 \text{ minutes / day}$$

Dividing this total by the average time per delivery site gives the estimated maximum number of delivery points served per day:

$$\boldsymbol{Max\ Sites\ per\ day} = \frac{1{,}350}{13 \text{ to } 15} = 90 \text{ to } 104 \text{ sites / day}$$

This calculation provides a practical upper limit for daily route planning under current vehicle and labor constraints.

4.3.4. Maximum Delivery Capacity and Throughput under Supply Constraints

Under current supply constraints, maximum delivery throughput is determined by both the available vegetable volume and the delivery capacity of the system. Given a daily vegetable supply

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of 2 tons (2,000 kg), and assuming each site receives a two-day supply of vegetables, the per-site delivery volume is calculated as:

$$\boldsymbol{Per\ Site\ Delivery} = 2 \text{ x } 13.9 \text{ kg /day} = 27.9 \text{ kg /day}$$

Thus, the total number of sites that can be served per day is:

$$\boldsymbol{Site\ with\ 2\ tons} = \frac{2{,}000}{27.9} = 72 \text{ sites}$$

Similarly, with an increased supply of 3 tons (3,000 kg) per day, the number of sites that can be served increases to:

$$\boldsymbol{Site\ with\ 3\ tons} = \frac{3{,}000}{27.9} = 107.5 \text{ sites}$$

Rounded to operationally feasible values, this corresponds to approximately 105 sites per day. Theoretically, if 1 ton can supply 71–72 sites under daily delivery (13.9 kg/day), then 2 to 3 tons could potentially serve:

$$\boldsymbol{Max\ Sites} = 2 \text{ to } 3 \text{ tons x } 72\ sites = 144 \text{ to } 216 \text{ sites}$$

However, the actual delivery capacity is limited by available vehicle time and route constraints, as previously calculated, to a maximum of approximately **90 to 104** sites per day.

To reconcile this gap between supply potential and delivery limitations, the system needs to adopt a **two-day delivery model**, and to effectively **double the quantity delivered per site** and cut the delivery frequency in half; that is, to **deliver 2-day volume every day.**

Even if the vegetable supply were unconstrained, scaling up delivery throughput would still require structural expansions, such as additional delivery vehicles, extended delivery hours, or optimization of route clustering.

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4.4. Organization Chart and Personnel Cost Estimation

As shared in Chapter 4.2, the service scope of the factory would include processing and delivery. Besides the factory manager, the labors are categorized under the departments of Supply Chain Management, Processing, Quality Control, Outbound, Logistics, and Other Functions, Figure 8 shows Year 1 to Year 2 organization chart, with assumption to process and deliver daily 1.5 to 2 tons of vegetables.

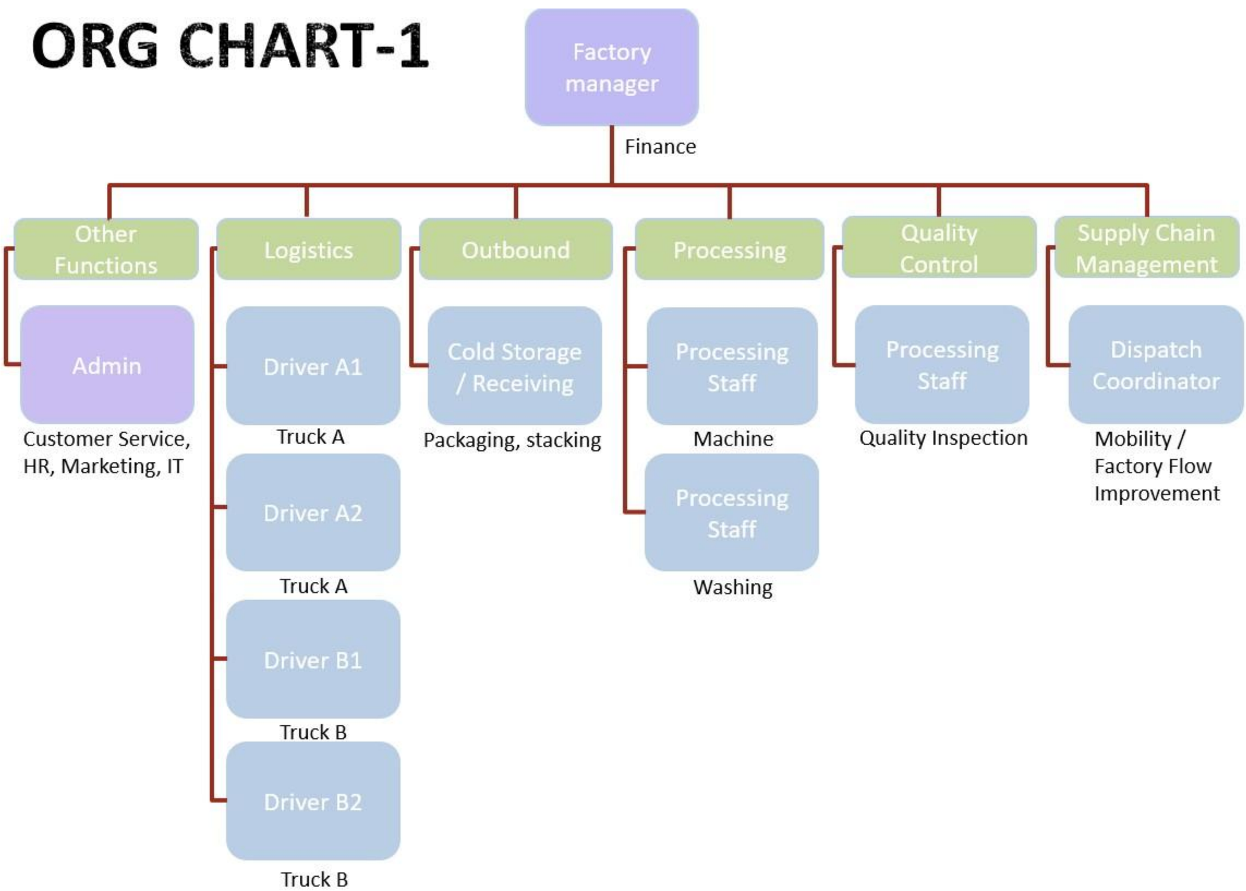

Figure 8 Organization Chart Year 1 and 2

As the business grows over time, in year 3, it is aimed to expand the team to 14 people. Besides the factory manager, the departments of Supply Chain Management, Processing, Quality Control, Outbound, Logistics, and Other Functions remain the same, but there will be new recruits.

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Figure 9 shows the Year 3 organization chart, assuming the processing and delivery of 3 tons of vegetables daily.

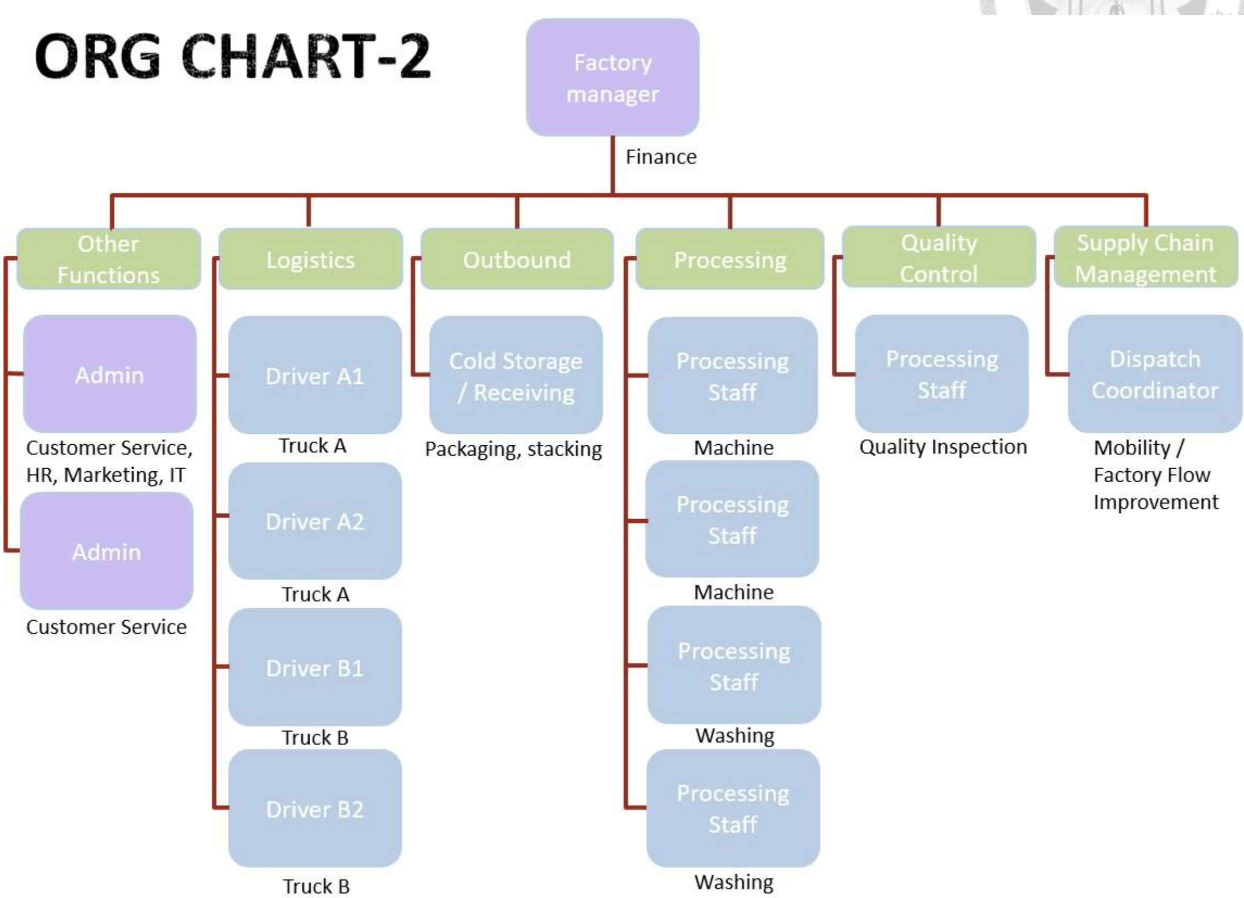

Figure 9 Organization Chart Year 3

The colors in purple are the overhead considered in Operating expenses, which includes the Admin or General Manager (Factory manager)'s salary. The colors Blue are the employees who are considered direct costs for the business, and their salary is included in COGS. This is to distinguish how the costs are considered in the later financial reporting chapter.

The following table presents the estimated monthly and annual labor costs (including staffing) required to support a vegetable distribution and processing operation handling 2 tons per day, covering delivery, processing, administration, and cold storage management.

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Position	Headcount	Monthly Salary (NTD)	Subtotal (NTD)	Finance category
Delivery Drivers	4	40,000	160,000	Operating Expenses
Processing Staff	3	35,000	105,000	
Cold Storage / Receiving	1	32,000	32,000	
Dispatch Coordinator	1	40,000	40,000	
Admin Personnel	1	38,000	38,000	COGS
Factory's General Manager	1	58,000	58,000	
Total (Monthly)	**11**	—	**433,000**	
Total (Annually)	—	—	**≈ 5,196,000**	

Table 3 Processing Expenses - Personnel Cost Estimation

4.5. Cold Storage Capacity and Electricity Demand Analysis

This section compares the technical and cost considerations for cold storage systems sized for 2-ton and 3-ton vegetable handling capacity. The goal is to ensure the facility can support both daily operations and short-term storage without quality degradation.

Category	2-Ton Cold Storage Unit	3-Ton Cold Storage Unit
Storage Capacity	Approx. 2 tons (suitable for early-stage demand)	Approx. 3 tons (2 tons daily intake + 1 ton buffer)
Required Space	4–5 pings (approx. 13.2–16.5 m²)	6–7.5 pings (approx. 19.8–24.8 m²)
Electricity Consumption	Approx. 4–6 kW per hour	Approx. 6–8 kW per hour
Recommended Total Load	8–10 kW (cold storage and basic lighting)	10–12 kW (cold storage + processing equipment)
Electrical Specifications	Three-phase 220V industrial current	Same as left

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Category	2-Ton Cold Storage Unit	3-Ton Cold Storage Unit
Estimated Installation Cost	400,000–500,000 NTD	550,000–650,000 NTD
Operation Time per Day	10–18 hours (night cooling, daytime insulation)	Same as left
Recommended Temperature	0–4°C (leafy vegetables: 3–5°C for 1–2 days)	Same as left
Suitable Daily Processing Volume	Up to 2 tons	Up to 3 tons (with buffer for packaging and output)
Upgrade Flexibility	Limited; suitable for small-scale operations	Higher scalability, can be upgraded to 4–5 tons

Table 4 Cold Storage Capacity and Electricity Demand Analysis

If the operation is expected to expand to **3 tons of vegetables per day** in future phases (e.g., Year 2 or 3), it is advisable to **invest in a 3-ton cold storage unit from the outset**.

This approach offers multiple advantages, including a relatively small additional installation cost of approximately 100,000–150,000 NTD compared to a 2-ton system, the flexibility to maintain buffer stock and support multi-batch delivery schedules, and greater efficiency in long-term utility planning. Early investment in higher capacity storage not only avoids future retrofitting but also ensures smoother scaling of operations with minimal disruption.

4.6. Daily Delivery and Processing Schedule

The factory's daily processing and delivery schedule is expected to start with a supply volume of approximately 1 to 1.5 tons per day in the first year, with operations gradually expanding to handle up to 3 tons per day by the third year. Based on this projected growth, two operational modules are proposed to guide future planning: Module I, designed for a 2-ton daily capacity, and Module II, designed for full-scale daily operations at 3 tons, as detailed in the following sections.

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4.6.1. Model I – Based on 2 Tons Daily Distribution

Time	Processing Tasks	Truck A Tasks	Truck B Tasks
04:00–07:00	Process Batch 1 of vegetables (1 ton)	-	-
07:00–07:30	Processing staff break	Load Batch 1 onto truck	-
07:30–08:30	Process Batch 2 of vegetables (1 ton)	Deliver Batch 1 (Continues until 15:00)	-
08:30–10:00	-		-
10:00–10:30	-		-
10:30–11:00	Processing staff cleanup and shift end		Load Batch 2 (processed in the morning)
11:00–14:00	-		Deliver Batch 2 (Continues until 18:00)
14:30–15:00	-	Return to facility	
15:00–15:30	-	-	
15:30–18:00	-	-	
18:00–18:30	-	-	Return (end of Batch 2 delivery)
18:30–20:00	-	-	First shift rest / Second shift takes over; Pickup Trip 1 (1 ton)
20:00–20:30	-	-	Unload Trip 1 vegetables
20:30–22:00	-	-	Pickup Trip 2 (1 ton)
22:00–22:30	-	-	Unload Trip 2 vegetables
22:30–23:00	-	-	Cold storage: complete 2 tons
23:00–23:30	-	-	Closure of the day

Table 5 Daily Delivery and Processing Schedule - Model I (2 Tons)

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4.6.2. Model II – Based on 3 Tons Daily Distribution

Time	Processing Tasks	Truck A Tasks	Truck B Tasks
04:00–07:00	Process Batch 1 of vegetables (1 ton)	-	-
07:00–07:30	Processing staff break	Load Batch 1 onto truck	-
07:30–08:30	Process Batch 2 of vegetables (1 ton)	Deliver Batch 1 (Continues until 15:00)	Pickup Trip 1 from Taoyuan (1 ton)
08:30–10:00	-		Unload Trip 1 vegetables into cold storage
10:30–11:00	Processing staff break		Load Batch 2 (processed in the morning)
11:00–14:00	Process Batch 3 of vegetables (1 ton)		Deliver Batch 2 (Continues until 18:00)
14:30–15:00	-	Return to the facility	
15:00–15:30	-	Shift change / Load Batch 3	
15:30–18:00	-	Deliver Batch 3 (Continues until 23:00)	
18:00–18:30	-		Return to facility (end of Batch 2 delivery)
18:30–20:00	-		Driver break / Shift change Pickup Trip 2 (1 ton)
20:00–20:30	-		Unload Trip 2 vegetables
20:30–22:00	-		Pickup Trip 3 (1 ton)
22:00–22:30	-		Unload Trip 3 vegetables
22:30–23:00	-	Return from Batch 3 delivery	Cold storage: finalize 2 tons
23:00–23:30	-	-	Closure of the day

Table 6 Daily Delivery and Processing Schedule - Model II (3 Tons)

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4.6.3. Total Working Hours Comparison

Role	2-Ton Model	3-Ton Model
Processing Staff	7 hours	9 hours
Truck A (Driver 1)	8 hours	8 hours (early shift)
Truck A (Driver 2)	—	8 hours (late shift)
Truck B (Driver 1)	8 hours	10 hours
Truck B (Driver 2)	5 hours	5 hours

Table 7 Model I & Model II Total Working Hours Comparison

In summary, the proposed operational model is built to support the reliable daily distribution of up to 3 tons of processed vegetables, reaching around 105 long-term care facilities with a streamlined delivery and processing system.

While current efficiency estimates are based on ideal route and handling times, the model remains flexible and robust under typical operating conditions. Two in-house refrigerated trucks run on alternating shifts to complete multiple delivery rounds, while evening logistics ensure a continuous supply of raw vegetables from farms outside of Taipei area (e.g. Taoyuan) and readiness for the next day's operations.

The balance between processing capacity and cold storage space supports a smooth cycle of daily output and replenishment, minimizing waste. Looking ahead, any expansion to a 4–5 ton daily scale will require strategic investments in infrastructure, manpower, and logistics support.

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5. COMPETITIVENESS ADVANTAGE

5.1. Instrument (OR Module explain optimization)

The factory's value-added service serves as a competitive advantage by leveraging operations research (OR) tools to optimize the scheduling of leftover vegetable deliveries. Through efficient route planning and delivery coordination, the system maximizes the number of delivery points reached each day, while also streamlining the connection between supply sources, demand sites, and the processing facility. This integrated approach not only enhances logistical efficiency but also provides a clearer understanding of the systemic gaps and economic burdens in current food waste handling practices, contributing to more sustainable and resilient operations.

5.2. Computational Experiment

To evaluate the performance of the proposed metaheuristic algorithm, a series of computational experiments were conducted on a system equipped with an Intel(R) 11th Gen Core (TM) i7-1165G7 (2.80GHz) and 16GB of RAM. The implementation was developed in Python, utilizing the OR-Tools 9.10 routing solver as the core engine for constraint handling and metaheuristic optimization. All experiments were executed in a single-threaded environment to ensure consistency and reproducibility of results.

5.3. Strategic Planning for Distribution and Facility Location

5.3.1. Transportation, Routing, and Delivery Planning

<u>Objective Function</u>

The goal of this study is to develop an efficient delivery scheduling system for surplus vegetables that minimizes overall transportation costs and operational burdens, while meeting the required daily delivery volume under fixed constraints on truck capacity and delivery time.

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This objective consists of two main components:

1) **Minimize Total Delivery Distance (→ Fuel Cost)**

Each truck is limited to a 7.5-hour delivery window and a maximum capacity of 1 ton. To reduce operational expenses, the model aims to complete each delivery route with the shortest possible travel distance. Less travel distance translates directly into lower fuel consumption and reduced driver workload.

Minimize: Total Distance (km) ⇒ Lower Fuel Cost

2) **Minimize Number of Delivery Sites (→ Client Service Cost)**

Since each delivery site requires time for unloading, communication, and coordination, fewer delivery points per route means fewer stops, shorter routes, and less time spent overall. By delivering the same total quantity to fewer sites, the model helps maintain revenue while reducing service and management costs.

Minimize: Number of Delivery Points (number of sites) ⇒ Lower Labor & Service Burden

Combined Objective (Flexible Weighting)

In practice, these two objectives can be balanced or prioritized depending on operational goals. A combined cost function can be used to evaluate both distance and point count:

Combined cost (example):

Total Cost = (Fuel Cost per km × Total Distance) + (Service Cost per Stop × Number of Points)

This combined objective supports strategic decision-making for route design, site selection, and customer consolidation, leading to a more sustainable and cost-effective delivery system.

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Constraints Setting

To support the delivery system's operational goals, several real-world constraints must be considered. These constraints reflect limits on delivery time, vehicle capacity, and location-based cost considerations.

1. Constraint A: Shift Time Constraint per Truck

As shared in Chapter 4, each truck can deliver 1 ton as a maximum pre-shift, yet each shift per delivery truck is planned to operate up to 7.5 hours, not considering overtime. The 7.5 hours include both driving time between delivery sites and unloading time at each stop. The delivery route must be planned so that the total time stays within this limit.

SUM (Travel Time between stops + Service Time per stop) $\leq$ 7.5 hours

This constraint is to ensure routes are feasible for drivers within a single working shift and prevent overtime or missed deliveries.

2. Constraint B: Vehicle Load Capacity Constraint

Each truck can carry up to 1 ton (1,000 kg) of vegetables per delivery round. The total quantity delivered across all stops on the route must not exceed this limit.

SUM (Delivery Qty per site) $\leq$ 1000 kg

This constraint is to ensure that trucks are not overloaded, and delivery routes are planned according to realistic load capacity.

3. Constraint C: Delivery Point Minimization Logic

While the total delivery volume is fixed (e.g., 1 ton per truck), it is more efficient to

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deliver to fewer sites with a higher quantity per site. This reduces stop time, administrative burden, and travel distance.

Delivery sites = Min (Number of Delivery Sites); ***Subject to:*** Total Delivered = 1000 kg

This constraint is to serve **the same number of customers (in kg) with fewer stops,** improving cost-efficiency while keeping revenue unchanged.

4. Constraint D: Location Cost Minimization (Scenario-Based)

When choosing among several possible delivery locations (e.g., six sites), the goal is to find the combination of sites that results in the lowest total delivery cost. This cost can be based on either:

- Total distance traveled (in meters or kilometers)
- Number of stops required

Min Total for each site: Total Km × Fuel Cost per km + Number of Stops × Labor Cost per stop

This constraint setting is to choose between the option with the lowest total cost; it may test different delivery combinations and choose the lowest-cost route based on actual distance and stop count. For detailed Prototype OR tool settings, please refer to Appendix D and Appendix E for reference.

5.3.2. Facility Location Optimization in the Greater Taipei Area

As mentioned in 4.3.1, there are a total of 537 demand points in the Greater Taipei Area as the potential customers for the vegetable processing factory, including the Nursing Homes, Residential Care Centers, and Elderly Welfare Institutions. To assess the distances between delivery points and potential factory sites, the author overlays GeoJSON data onto Google Maps

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information, as shown in the figure below.

The red dots represent the Nursing homes, while the green dots represent the Residential Care Centers; the black dots show the Elderly Welfare Institutions, and the blue icons represent the six potential factory sites. The yellow dot represents one of the vegetable supply sources, the vegetable wholesaler distributor in Banqiao.

On the right side, the GeoJSON script captures information on the Google Map, including the Institution name, the address and region of the delivery point, the corresponding geometry data in Longitude and latitude, and its working hours, if applicable, on Google Maps.

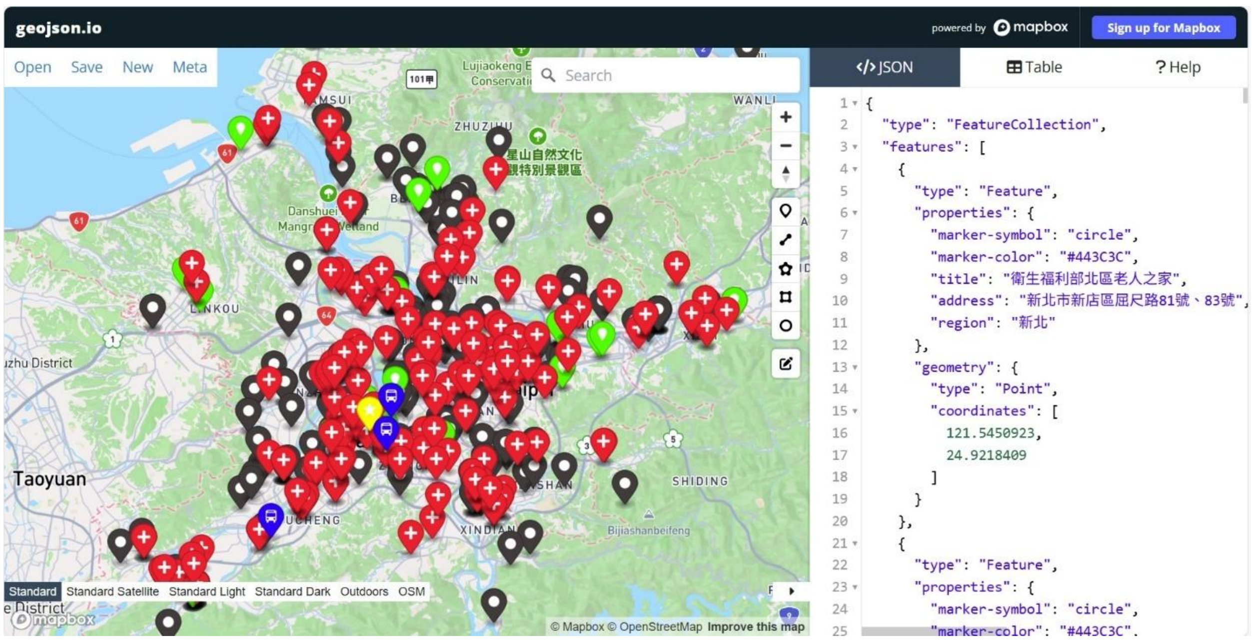

Figure 10 GeoJSON Map - Delivery Points, Factory sites, Sourcing sites

The operational research component of this study evaluates delivery efficiency across two models—daily delivery of 1 day's volume versus delivering 2 days' worth of vegetables per trip, covering both 2-ton and 3-ton scales. By using the six potential factory locations, the author has selected each area a possible location on the map to run the Operational research script. The findings reveal substantial efficiency gains when **shifting to a 2-day delivery model**. The results

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presented below include the volume of vegetables transported per truck, the delivery time required for each trip, and the corresponding delivery points and distances. As detailed in Sections 4.6.1 and 4.6.2, each trip aims to take approximately 7.5 hours to finish delivering its 1-ton vegetable leftover. Since delivery volumes are optimized to either 2 or 3 tons, outcomes with **shorter total distances** or **fewer delivery points** are considered more efficient.

Figure 11 on the next page illustrates that when delivering a one-day supply of vegetables to each location, completing the shipment of 2 tons of vegetables requires servicing approximately 60 care centers. Green markers at the processing site indicate feasible solutions, while the red marker in the **WuGu** area shows that this site cannot meet the 2-ton delivery target within the 7.5-hour constraint. Therefore, taking into account all delivery orders, the **WuGu (五股)** site would be considered infeasible according to operations research analysis.

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Model I - 2ton (Frequency:daily delivery)

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WanHua萬華, wsqqke3r5	D1	2,000	1,124	19	445,712	61
	D2	2,000	1,128	19	442,839	61
	D3	2,000	1,090	18	409,420	61
	D4	2,000	1,129	19	445,075	61
	D5	2,000	1,134	19	443,856	62
	Average	2,000	1,121	19	437,380	61

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ChongHe中和, wsqqk2rmh	D1	2,000	1,095	18	447,471	61
	D2	2,000	1,089	18	443,769	61
	D3	2,000	1,083	18	423,036	60
	D4	2,000	1,093	18	439,159	61
	D5	2,000	1,079	18	434,467	61
	平均	2,000	1,088	18	437,580	61

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
TuCheng土城, wsqq509e0	D1	1,999	1,124	19	442,925	62
	D2	1,999	1,125	19	442,695	62
	D3	2,000	1,074	18	412,810	61
	D4	1,996	1,120	19	461,780	61
	D5	1,999	1,125	19	442,695	62
	Average	1,999	1,114	19	440,581	62

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WuGu五股, wsmg9nqk3	D1					
	D2					
	D3					
	D4					
	D5					
	Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ShuLin樹林, wsqq4z72z	D1	2,000	1,106	18	426,732	61
	D2	1,999	1,133	19	434,820	60
	D3	1,996	1,102	18	429,975	61
	D4	2,000	1,094	18	422,939	60
	D5	2,000	1,094	18	422,939	60
	Average	1,999	1,106	18	427,481	60

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
LinKou林口, wsqq9csby	D1	2,000	1,153	19	507,643	61
	D2	2,000	1,155	19	493,008	62
	D3	1,998	1,155	19	513,062	60
	D4	1,999	1,159	19	513,062	61
	D5	2,000	1,168	19	527,753	61
	Average	1,999	1,158	19	510,906	61

Figure 11 One day vegetable delivery through Model I

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Figure 12 illustrates that when delivering a one-day supply of vegetables to each location, completing the shipment of 3 tons of vegetables requires servicing approximately 115 care centers. The yellow markers mean that if the sites are slightly overrunning the delivery time by 30 minutes, the shipments can be completed, and 3 tons can be delivered to all the care centers. **WuGu(五股)**

Model II - 3ton (Frequency:daily delivery)

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WanHua萬華, wsqqke3r5	D1	2,953	1,767	29	692,352	111
	D2	2,929	1,773	30	690,756	109
	D3	2,914	1,734	29	668,284	108
	D4	3,000	1,775	30	700,927	113
	D5	2,979	1,760	29	697,059	113
	Average	2,955	1,762	29	689,876	111

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ChongHe中和, wsqqk2rmh	D1	2,936	1,723	29	653,719	111
	D2	2,960	1,744	29	689,907	111
	D3	2,867	1,755	29	723,841	106
	D4	2,920	1,757	29	721,022	108
	D5	2,943	1,692	28	630,804	114
	Average	2,925	1,734	29	683,859	110

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
TuCheng土城, wsqq509e0	D1	3,000	1,749	29	651,119	116
	D2	2,996	1,750	29	676,349	115
	D3	2,963	1,771	30	688,449	113
	D4	3,000	1,737	29	653,498	115
	D5	2,926	1,762	29	713,816	110
	Average	2,977	1,754	29	676,646	114

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WuGu五股, wsmg9nqk3	D1					
	D2					
	D3					
	D4					
	D5					
	Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ShuLin樹林, wsqq4z72z	D1	2,936	1,731	29	656,798	110
	D2	2,993	1,770	30	661,280	118
	D3	2,860	1,772	30	719,453	107
	D4	2,928	1,769	29	679,795	114
	D5	2,986	1,748	29	641,852	116
	Average	2,941	1,758	29	671,836	113

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
LinKou林口, wsqq9csby	D1	2,975	1,786	30	720,340	112
	D2	2,971	1,789	30	745,098	111
	D3	2,977	1,789	30	739,970	113
	D4	2,954	1,784	30	740,354	110
	D5	2,955	1,790	30	740,321	112
	Average	2,966	1,788	30	737,217	112

Figure 12 One day vegetable delivery through Model II

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still shows there are no feasible solutions, and only **TuCheng** (土城) can successfully deliver 3 tons within the time frame. Figure 13 below shows that delivering 2-day vegetables to care centers, around 17 delivery points are needed to finish delivering to care centers, reaching the daily volume.

Model I - 2ton (Frequency: 2-day delivery)

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WanHua萬華, wsqqke3r5	D1	2,000	780	13	314,084	28
	D2	2,000	681	11	333,841	17
	D3	2,000	686	11	336,537	17
	D4	2,000	686	11	336,537	17
	D5	2,000	851	14	318,647	31
	Average	2,000	737	12	327,929	22

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ChongHe中和, wsqqk2rmh	D1	2,000	721	12	317,978	17
	D2	2,000	721	12	317,978	17
	D3	2,000	673	11	274,257	25
	D4	2,000	721	12	317,978	17
	D5	2,000	721	12	317,978	17
	Average	2,000	711	12	309,234	19

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
TuCheng土城, wsqq509e0	D1	2,000	676	11	323,531	17
	D2	2,000	676	11	323,531	17
	D3	2,000	676	11	323,531	17
	D4	2,000	676	11	323,531	17
	D5	2,000	676	11	323,531	17
	Average	2,000	676	11	323,531	17

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WuGu五股, wsmg9nqk3	D1					
	D2					
	D3					
	D4					
	D5					
	Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ShuLin樹林, wsqq4z72z	D1	1,998	760	13	356,364	16
	D2	1,998	760	13	356,364	16
	D3	1,998	760	13	356,364	16
	D4	1,998	760	13	356,364	16
	D5	1,998	760	13	356,364	16
	Average	1,998	760	13	356,364	16

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
LinKou林口, wsqq9csby	D1	1,998	838	14	424,399	16
	D2	1,998	838	14	424,399	16
	D3	1,998	838	14	424,399	16
	D4	1,998	838	14	424,399	16
	D5	1,998	838	14	424,399	16
	Average	1,998	838	14	424,399	16

Figure 13 Two-day vegetable delivery through Model I

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Figure 14 on the next page shows that sites other than WuGu is feasible as long as the time is extended 30 minutes, and the delivery points lands between 35 to 45 points; from these result, the conclusion can be made that **TuCheng(土城)** is the better choice for selecting the location for processing factory; However, the business still needs to consider based on the customer's mix. If the delivery points are closer to certain sites, chances are that one of the other sites turns out to be the better option.

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Model II - 3ton (Frequency: 2-day delivery)

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WanHua萬華, wsqqke3r5	D1	2,998	1,082	18	516,183	36
	D2	3,000	1,114	19	528,495	36
	D3	2,998	1,186	20	516,420	36
	D4	3,000	1,114	19	528,495	36
	D5	2,998	1,198	20	518,509	36
	Average	2,999	1,139	19	521,620	36

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ChongHe中和, wsqqk2rmh	D1	2,998	1,093	18	479,444	46
	D2	3,000	1,353	23	521,951	50
	D3	2,998	1,131	19	544,572	36
	D4	3,000	1,112	19	491,502	46
	D5	3,000	1,081	18	507,103	36
	Average	2,999	1,154	19	508,914	43

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
TuCheng土城, wsqq509e0	D1	3,000	1,266	21	557,036	36
	D2	3,000	1,194	20	543,788	36
	D3	3,000	1,201	20	532,685	36
	D4	3,000	1,131	19	542,174	35
	D5	3,000	1,114	19	519,055	36
	Average	3,000	1,181	20	538,948	36

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
WuGu五股, wsmg9nqk3	D1					
	D2					
	D3					
	D4					
	D5					
	Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Processing Site	星期幾	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
ShuLin樹林, wsqq4z72z	D1	3,000	1,200	20	553,072	36
	D2	3,000	1,278	21	531,852	44
	D3	3,000	1,346	22	506,674	57
	D4	3,000	1,201	20	553,090	36
	D5	3,000	1,200	20	553,072	36
	Average	3,000	1,245	21	539,552	42

Processing Site	Weekday	Delivery kg	Delivery time(min)	Delivery time(hr)	Total Distance(m)	Total Delivery Points
LinKou林口, wsqq9csby	D1	2,998	1,251	21	644,162	36
	D2	2,998	1,202	20	613,513	35
	D3	3,000	1,270	21	632,148	36
	D4	3,000	1,233	21	624,841	36
	D5	3,000	1,249	21	613,044	44
	Average	2,999	1,241	21	625,542	37

Figure 14 Two-day vegetable delivery through Model II

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Delivery Frequency & Efficiency

Under the 1-day model, delivering 2 tons per day requires servicing approximately 61–62 delivery points, consuming ~1,100–1,160 minutes and covering 437,000–510,000 meters daily; for 3 tons, the model reaches 110–114 points with 1,730–1,790 minutes of delivery time and 670,000–740,000 meters traveled.

In contrast, the 2-day model significantly reduces operational load:

- Delivering 2 tons every two days only requires 16–22 points, with delivery times between 676–838 minutes (11–14 hrs) and a distance of around 310,000–424,000 meters.
- Delivering 3 tons every two days covers only 36–44 points, with average delivery time of 1,139–1,245 minutes (19–21 hrs) and distance around 508,000–625,000 meters—still lower than the 1-day model.

This clearly proves our previous hypothesis that **delivering every 2 days cuts the number of stops by over 50%**, reduces delivery kilometers, and compresses route time—all while moving the same volume of surplus vegetables. The model offers a leaner logistics footprint and lower cost per kg delivered, making it the preferred strategy.

Site Selection for Processing Facility

Factory location modeling across six New Taipei areas—**WanHua(萬華)**, **ChongHe (中和)**, **TuCheng (土城)**, **WuGu (五股)**, **ShuLin (樹林)**, **LinKou (林口)**—shows that **TuCheng (土城)** stands out as the optimal processing site, because for both 2-ton and 3-ton models, **TuCheng (土城)** consistently exhibits better quality:

- Lowest average delivery points (17–36)
- Shortest distances per day (~323,531 meters for 2-ton and ~538,948 meters for 3-ton)
- Reasonable and consistent delivery times (~11 hrs for 2-ton, ~20 hrs for 3-ton)

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These metrics suggest that **TuCheng(土城)** offers the best logistical positioning to serve the 537 delivery endpoints across New Taipei. Its proximity to highways and central produce hubs enables highly consolidated routes and efficient cold-chain dispatching.

5.3.3. Future Possibilities and Strategic Extensions

Operations Research (OR) offers strong potential for further improving and scaling the surplus vegetable delivery system beyond the current model. In the future, as more long-term care centers join the network or as vegetable supply increases from partnering farms or distributors, OR tools can support more complex decision-making to accommodate higher volumes and expanded service areas. For instance, increasing daily supply from 2 tons to 4 or 5 tons would require exploring the feasibility of deploying additional trucks or upgrading to larger-capacity vehicles. Routing algorithms can then be recalibrated to reflect the new vehicle specifications and delivery constraints. Additionally, deeper collaboration with the demand side, such as coordinating delivery windows with care centers, could enable time-window routing optimization, allowing better alignment between service availability and logistical efficiency.

Beyond routing, OR models could also be used for **facility location optimization**, such as where to build future processing hubs other than the current one, **inventory balancing**, such as how much to keep fresh vs. process or compost, and **dynamic scheduling**, where delivery plans adapt to real-time conditions such as traffic, weather, or last-minute supply changes. As the network expands, predictive models could forecast future demand and supply fluctuations to proactively adjust resources. Together, these applications demonstrate how OR can evolve from a tactical routing tool into a comprehensive decision support system that drives strategic growth and long-term sustainability.

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6. STRATEGY ANALYSIS

This Chapter focuses on evaluating the business model through two key frameworks: the **Value Proposition Canvas** and **SWOT analysis**. While the Value Proposition Canvas helps align the product or service with customer needs and expectations, the SWOT analysis provides a structured overview of internal strengths and weaknesses, also external opportunities and threats.

6.1. Value Proposition Canvas

6.1.1. Value Proposition Canvas Introduction

The Value Proposition Canvas, developed by Alex Osterwalder of Strategyzer, is a strategic tool designed to ensure strong alignment between a company's products or services and the needs of its customers. By breaking down the customer experience into a Customer Profile and a Value Map, this model enables businesses to identify key customer jobs, pains, and gains, and tailor their offerings to deliver clear and compelling value. It is equally effective for refining existing products and for designing new market offerings from the ground up (B2B International, 2022).

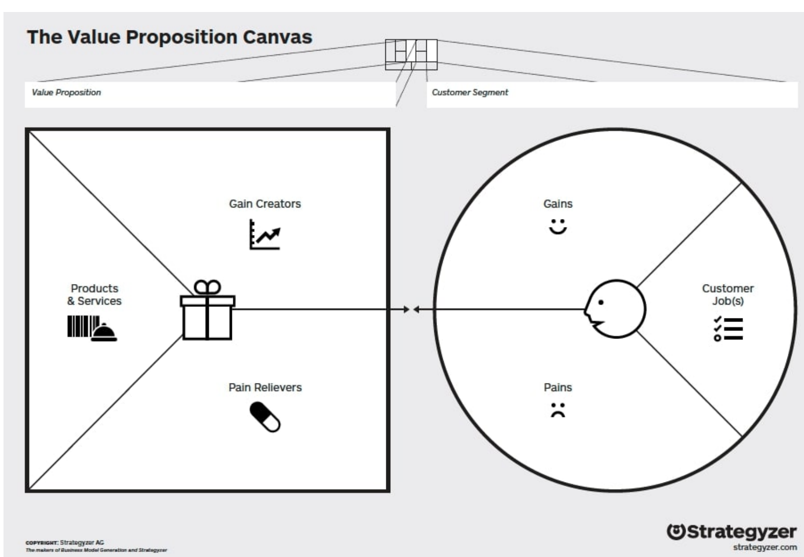

Figure 15 Value Proposition Canvas Model Example

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Note: *https://www.strategyzer.com/canvas/value-proposition-canvas*

When applying for the Value Proposition Canvas, businesses should begin with the Customer Profile to fully understand the needs, tasks, and expectations of their target segments. As shown in Figure 15, Customer Profile consists of three components: Customer Jobs, Pains, and Gains. These elements represent the tasks customers are trying to accomplish, the challenges they encounter, and the benefits they seek. Since different customer segments may have varying experiences, a unique profile should be created for each. On the left side of the canvas is the Value Map, which mirrors the Customer Profile by outlining Products and Services, Pain Relievers, and Gain Creators. This section describes how the business aims to solve customer pains, deliver desired gains, and align its offerings with actual customer needs.

6.1.2. Value Proposition Canvas Analysis

In the context of a vegetable processing factory, the combined product and service options help determine the most suitable "fit"—the core product offering that effectively addresses the pains and gains of each customer segment and delivers value to target clients such as elderly care centers. The following is an analysis of its Value Proposition Canvas.

Customer Profile

1. Demand Side: Elderly Care Centers

This business model addresses the institutional food service needs of elderly care centers in urban regions, specifically targeting facilities in Taipei City and New Taipei City. These centers are responsible for providing consistent, safe, and nutritionally adequate meals to elderly residents, many of whom require special dietary accommodations such as soft or pre-cut vegetables. However, these institutions often face limitations in kitchen capacity, staffing, and budget. The operational burden of sourcing, preparing, and managing fresh vegetables can strain already limited resources. As such, elderly care centers represent a customer segment with a clear demand

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for cost-effective, pre-processed vegetable products that are both compliant with food safety standards and tailored to meet the dietary needs of their residents. The ability to secure reliable, hygienic, and affordable food inputs is essential for maintaining daily operations and ensuring the well-being of their residents.

2. Supply Side: Farmers and Vegetable Providers

Small- and medium-sized farmers, as well as vegetable wholesale distributors in Taiwan, frequently face the issue of leftover or unsold produce. Surplus vegetables—often the result of overproduction, market fluctuations, or aesthetic imperfections—lack an efficient, structured outlet and are typically discarded or underutilized. Managing this unsold inventory can be financially and logistically burdensome, requiring time and resources to dispose of or donate informally. Farmers are increasingly interested in environmentally responsible and community-benefiting alternatives, but they face practical constraints, such as limited time, inadequate infrastructure, and limited access to institutional buyers. These suppliers are seeking simple, low-effort systems that not only reduce waste but also offer a modest return. By engaging in a streamlined redistribution model, these producers gain a stable and predictable channel to offload surplus produce, contributing to a circular food economy while also supporting social welfare through food recovery.

<u>Customer Jobs</u>

1. Demand Side: Elderly Care Centers

Elderly care centers—including nursing homes, long-term care facilities, and other institutional care providers—are responsible for a variety of essential tasks in their daily operations. Functionally, these institutions must provide safe, nutritious, and timely meals that accommodate the specific dietary needs of older adults, many of whom require **soft-textured**, **chopped**, **or pre-**

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processed vegetables due to chewing or swallowing difficulties. In addition to meeting these dietary criteria, care centers must comply with food safety regulations and maintain a consistent supply of fresh or pre-prepared produce. Efficient kitchen management is also crucial, particularly given limited staffing and time constraints.

Socially, these centers must uphold a strong reputation for quality care and hygiene, reinforcing trust with families, health authorities, and the broader community. Increasingly, institutions are also expected to demonstrate commitment to environmental and social responsibility, including reducing food waste and participating in sustainable sourcing practices. Emotionally, decision-makers value peace of mind in food sourcing, seeking reliable, ethically aligned solutions that reduce uncertainty, minimize operational stress, and support consistent, compliant meal delivery for vulnerable residents. Engaging with food systems that reflect these values enhances institutional confidence and public credibility.

2. Supply Side: Farmers and Vegetable Providers

Small- and medium-sized farmers, along with wholesale vegetable suppliers, face a distinct set of functional responsibilities centered around post-harvest management. A common challenge is dealing with surplus or unsellable produce caused by overproduction, market fluctuations, or cosmetic imperfections. These producers are often under pressure to find efficient, low-effort methods to reduce waste and avoid the costs associated with disposal or unstructured donations. Many seek access to alternative markets that do not require significant additional time, labor, or infrastructure—ideally, solutions that integrate smoothly into their existing workflows and do not interfere with their core farming activities.

In addition to these functional goals, farmers also hold social and emotional motivations. Many take pride in acting as responsible contributors to their communities and stewards of the

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environment. Participating in food redistribution not only prevents waste but also helps them align with broader sustainability goals and enhance their reputation within local cooperatives and social networks. Emotionally, surplus and waste can be a source of frustration, especially when producers feel powerless to address inefficiencies. These stakeholders value systems that validate their efforts, provide a sense of impact, and allow them to contribute meaningfully, without adding complexity or additional burdens to their already demanding roles.

Customer Pains

1. Demand Side: Elderly Care Centers

Elderly care centers often encounter a range of operational and logistical challenges that hinder their ability to deliver consistent and high-quality food services. One major pain point is the lack of access to certified central kitchens—facilities are often required to meet HACCP or ISO standards, but many smaller care centers do not have the budget or scale to invest in such infrastructure. As a result, they rely on limited in-house facilities or outsourced services, increasing dependency and risk. Additionally, the processing of raw vegetables is labor-intensive, requiring time, equipment, and staff that many centers simply do not have. For facilities without dedicated kitchens, this becomes an even greater burden.

Inconsistent supply chains and reliance on traditional distributors further exacerbate the problem, leading to unpredictable deliveries and the risk of running out of ingredients. Food spoilage and waste—especially when buying in bulk without proper storage—contribute to high costs, while limited capacity to verify food safety and quality adds uncertainty and potential liability. All of these challenges are compounded by the need to adhere to strict dietary guidelines on a tight budget, making it difficult for care centers to meet the nutritional and operational expectations placed upon them.

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2. Supply Side: Farmers and Vegetable Providers

Small- and medium-sized farmers, as well as wholesale vegetable suppliers, regularly face the challenge of managing surplus or unsellable produce. This surplus often results from market fluctuations, overproduction, or aesthetic imperfections that make vegetables unfit for retail sale despite being perfectly edible. Without efficient and structured outlets for redistribution, these producers are frequently left with no choice but to absorb financial losses or resort to informal donation methods. The lack of accessible, low-barrier channels makes it challenging to transform excess inventory into a viable resource, creating ongoing waste management problems that strain both time and operational budgets.

In addition to economic loss, the process of handling surplus vegetables imposes logistical burdens. Organizing ad-hoc donations or sales often requires time-consuming coordination, individual negotiations, and transportation efforts that divert attention from core farming operations. Many producers must also bear the cost of storing or disposing of unsold goods, adding further labor and expense. Emotionally, this situation can be discouraging, as farmers who are committed to responsible production are forced to watch usable food go to waste. Furthermore, when donations are made through informal channels, producers may question whether their contributions are having a meaningful or traceable impact. This combination of logistical difficulty, financial inefficiency, and emotional dissatisfaction highlights the need for a structured solution that validates their efforts and provides clear, low-effort avenues for participation in food redistribution systems.

Customer Gains

1. Demand Side: Elderly Care Centers

One of the most critical gains for elderly care centers is the operational simplicity offered

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by the vegetable processing factory. By providing pre-washed, chopped, and ready-to-cook vegetables, the service relieves centers of complex procurement processes and labor-intensive food preparation. This allows staff to redirect their time and energy toward caregiving tasks, improving the overall efficiency and quality of elderly care. The model delivers cost-effective sourcing and helps institutions manage limited budgets by reducing both ingredient expenses and the need for kitchen labor. For many centers, this combination of simplicity and affordability is essential to maintaining stable and sustainable operations.

The business further supports care centers through reliable and timely delivery of safe, pre-processed vegetables, made possible by a centralized consolidation and distribution system. This ensures consistency in supply, reducing the uncertainty and disruptions associated with traditional distribution channels. Although the produce may come from multiple farms or distributors, the system maintains basic source transparency by linking supply to a limited and verified group of local partners. Additionally, since the vegetables are handled under hygienic, standardized conditions, the service offers reduced compliance pressure, lowering the risks and responsibilities associated with food safety and regulatory adherence.

Beyond operational and safety benefits, care centers also gain by participating in a model that promotes environmental sustainability. By utilizing surplus vegetables that would otherwise go to waste, they contribute to a circular food economy and support broader ecological goals. The system also reinforces its social impact, as food that might be discarded is instead redirected to meet the nutritional needs of vulnerable populations. This socially responsible engagement helps care centers build goodwill and enhance their public image. Furthermore, participation in such sustainable sourcing efforts may qualify institutions for ESG-related government incentives, adding a potential layer of financial or policy-based support that strengthens the case for

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partnership with the vegetable processing factory.

2. Supply Side: Farmers and Vegetable Providers

For farmers and wholesale vegetable providers, participating in this business model offers several tangible and intangible benefits. Most notably, it transforms surplus produce—which would otherwise represent a financial loss or disposal cost—into a modest but consistent income stream. By providing a structured and dependable outlet for excess vegetables, the business helps farmers reduce waste while recapturing some economic value from their unsold goods. This model eliminates the need for one-on-one negotiations or informal donation efforts, offering a centralized system that matches supply with verified institutional demand. This not only simplifies sales logistics but also allows producers to plan harvest and distribution activities more efficiently.

In addition to the economic advantages, farmers gain reputational and social value from participating in a socially responsible initiative. Contributing surplus produce to a system that feeds vulnerable populations aligns with environmental sustainability and food security goals, reinforcing the farmer's role as a responsible community stakeholder. While individual batches may not be traced back to a single farm, the overall framework provides transparency and visibility within a known network of contributors, strengthening trust in the system. Moreover, participation may align with broader ESG expectations, potentially opening doors to future recognition, partnerships, or government-supported sustainability initiatives. Overall, the model offers farmers a low-effort, high-impact channel to reduce waste, earn supplemental income, and contribute meaningfully to the food system.

Value Map - Vegetable Processing Factory

The value map of the vegetable processing factory outlines how the business delivers value to its target customer segment—elderly care institutions—through a structured offering of products

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and services, pain relievers, and gain creators. The factory provides pre-washed, chopped, and ready-to-cook vegetables that are processed from surplus produce collected from smallholder farmers and wholesale distributors. Although these vegetables originate from an excess supply, they are still fresh and processed under hygienic conditions to ensure safety and suitability for institutional use.

The factory manages the logistics and distribution process, enabling reliable and timely delivery directly to care centers. By tailoring the format and packaging of the vegetables to meet the dietary needs of elderly residents—such as providing soft-textured or uniformly chopped ingredients—the business reduces preparation time and ensures compatibility with care center requirements. This integrated model presents a practical and socially responsible solution for elderly care institutions seeking cost-effective, compliant, and efficient food supply options.

<u>Products & Services</u>

The vegetable processing factory offers a comprehensive set of services designed to bridge the gap between surplus farm produce and the institutional food needs of elderly care centers. At the core of its offering is the provision of pre-washed, chopped, and portioned vegetables, made from surplus harvests and delivered on a daily or scheduled basis. These products are specifically tailored to meet the hygiene and dietary requirements of elderly residents, supporting ease of preparation and food safety in care facilities.

To facilitate this, the business operates a legally compliant central processing hub where surplus vegetables are washed, graded, and lightly processed. This facility is strategically located to balance accessibility to both rural supply sources and urban demand centers, helping to avoid the high costs and logistical constraints associated with Taipei's wholesale markets(果菜市場). A key component of the operation is the daily collection of surplus vegetables from small-scale farms,

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particularly in areas such as Taoyuan. This not only reduces post-harvest waste but also enables the vegetables to be offered at reduced prices, benefiting both producers and care institutions.

Through value-added processing, the factory transforms these vegetables into ready-to-use ingredients, with formats customized to suit the dietary needs of elderly consumers. This includes soft-textured and chopped options packaged to ensure food safety, consistency, and convenience in institutional kitchens. A reliable last-mile distribution system ensures timely delivery to care centers across Taipei and New Taipei City, supporting stable meal operations. Additionally, the business provides compliance documentation with each delivery, assisting care centers in meeting food safety and regulatory standards. Overall, the model represents a sustainable supply chain solution, linking rural surplus with urban nutritional needs while advancing food waste reduction and community support goals.

Pain Relievers

1. Demand Side (Elderly Care Centers)

The vegetable processing factory significantly relieves operational challenges faced by elderly care centers by providing pre-washed, chopped, and portioned vegetables, reducing the time and labor burden of in-house preparation. This is particularly beneficial for institutions lacking fully equipped kitchens or adequate staffing, as it enables kitchen teams to focus on meal service and caregiving instead of manual processing tasks. By outsourcing vegetable preparation, care centers can operate more efficiently and redirect resources to resident care.

Additionally, the factory's coordinated logistics network ensures consistent and timely delivery of vegetables, addressing the chronic problem of unreliable supply from traditional distributors. This reliability stabilizes meal planning and reduces stress associated with last-minute procurement. Importantly, the factory processes vegetables in hygienic, controlled environments,

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lowering food safety risks for centers unable to meet strict food handling standards. Even though produce is sourced from multiple suppliers, traceability is maintained within a known, certified network, enhancing transparency and building trust with administrators and families. The dedicated processing factory thus provides an essential service that care centers cannot find elsewhere in the market, removing a key operational pain point.

2. Supply Side (Farmers and Wholesale Distributors)

For farmers and wholesalers, the processing factory alleviates the significant challenge of managing unsold or surplus vegetables, which traditionally leads to disposal costs or labor-intensive donation processes. By offering a structured outlet for surplus, the factory transforms potential waste into a modest but steady revenue stream, making food recovery financially viable without disrupting core farming activities. This allows farmers to monetize produce that would otherwise incur losses, improving financial stability.

Moreover, the factory eliminates the barriers of self-processing imposed by *Taiwan's Agricultural Production and Certification Management Act*(農產品生產及驗證管理法; Taiwan Livestock Research Institute, 2019) and *the Good Hygienic Practice Guidelines for Food*(衛福部食品良好衛生規範準則; Ministry of Health and Welfare, n.d.). Under these regulations, individual farmers face complex requirements to legally process produce, including sourcing certified domestic materials, adhering to low-risk processing methods, and passing detailed risk assessments for primary processing. Building or operating a compliant facility is unrealistic for most small- and medium-sized farmers. By centralizing certified processing, the factory relieves farmers of regulatory, technical, and financial burdens, providing a compliant pathway to participate in value-added processing. Logistics coordination further reduces the need for farmers to handle transportation, allowing easy participation through scheduled pickups or drop-offs.

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Gain Creators

1. Demand Side (Elderly Care Centers)

Beyond alleviating immediate operational challenges, the vegetable processing factory creates long-term value for elderly care centers by delivering a sustainable, socially responsible sourcing solution. By using surplus vegetables, care centers can demonstrate active participation in food waste reduction, which aligns with institutional ESG objectives and strengthens their reputation among families, community stakeholders, and oversight bodies. Engagement in a circular food system can serve as a powerful differentiator in the competitive elder care sector, where trust and ethical operations are essential.

Furthermore, the dedicated nature of the processing facility represents a unique gain: elderly care centers gain access to a service tailored specifically to their needs, something not available through traditional suppliers. Flexible delivery volumes and scheduling allow centers to adjust orders based on resident intake or kitchen capacity, ensuring practicality and responsiveness. Consistent supply and clear communication build reliable, trust-based partnerships over time, replacing fragmented procurement systems with a dependable source. These relationships reduce administrative burdens and improve supply chain predictability, supporting both daily operations and long-term planning.

2. Supply Side (Farmers and Vegetable Providers)

For farmers and wholesalers, participation in the processing factory system converts surplus vegetables into assets rather than liabilities, contributing to stable income while supporting environmental sustainability goals. By being part of a structured redistribution model, farmers enhance their public image as responsible stewards who contribute to community well-being and reduce food waste, aligning with broader societal expectations and ESG principles. This visible

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engagement can improve farmers' standing in cooperative networks or regional markets, even if each transaction yields modest profits.

The system also provides a rare opportunity for farmers to access a consistent, low-barrier sales channel that offers predictable demand and clear expectations. Stable pricing and formal agreements reduce the uncertainty often experienced in selling surplus through informal channels or sporadic donations. Over time, these relationships encourage more efficient crop planning and reduce waste. Critically, by leveraging the factory's legal processing status, farmers gain a compliant route to value-added opportunities without the need to invest in costly facilities or navigate regulatory complexity themselves. This combination of economic, social, and regulatory gains encourages farmers' continued participation and strengthens the overall sustainability of the food supply chain.

With the above points, the value proposition canvas for **Vegetable Leftover ESG Solution** is shown in the next page, Figure 16:

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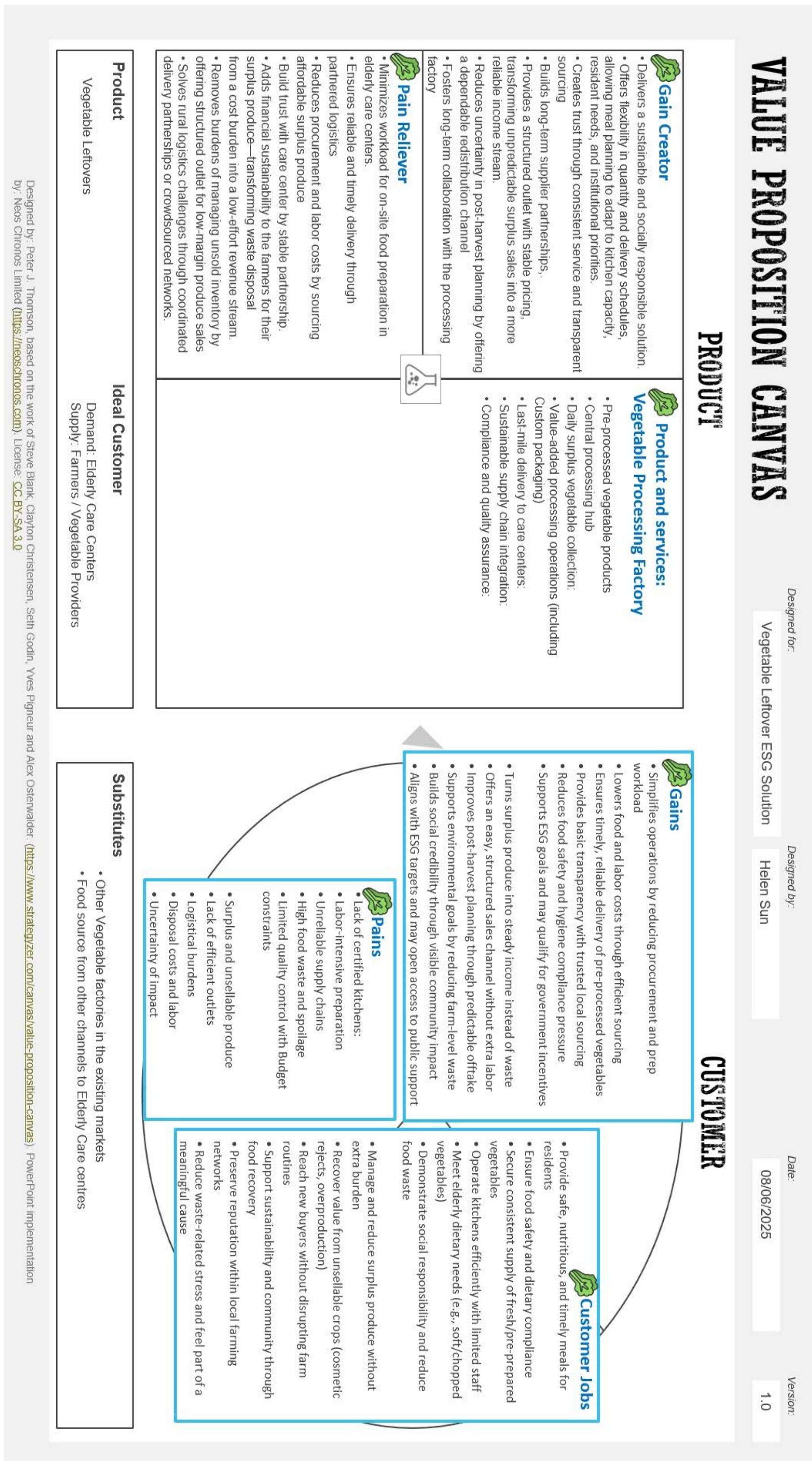

Figure 16 Value Proposition Canvas

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6.2. SWOT Analysis

6.2.1. SWOT Analysis Introduction

SWOT analysis is a strategic planning tool used to assess a business's position in the market. It helps decision-makers understand internal capabilities and external conditions by examining four key elements: Strengths, Weaknesses, Opportunities, and Threats. Originally developed by Albert Humphrey, SWOT provides a structured way to evaluate a business before formulating strategies, enabling better positioning in a target market. A sample SWOT analysis is illustrated in Figure 17.

1. Strengths refer to internal attributes that give the company an edge over competitors, such as strong brand recognition, customer loyalty, or technological capabilities.
2. Weaknesses are internal limitations that hinder performance or competitiveness, like limited brand awareness, weak supplier relationships, or underinvestment in key areas.
3. Opportunities are external conditions that could benefit the company, like favorable regulations, untapped markets, or a low level of competition.
4. Threats are external challenges that may negatively impact the business, such as rising raw material costs, new regulations, or intensified market competition.

	Helpful	Harmful
Internal Factor	Strength	Weakness
External Factor	Opportunity	Threats

Figure 17 SWOT analysis example

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6.2.2. Complete SWOT Analysis

<u>Strengths (Internal Positive Factors)</u>

The vegetable processing factory model presents several key strengths that reinforce its role as a connector between surplus supply and institutional demand. One of its primary advantages is the use of low-cost raw materials—specifically, non-commercial grade or leftover vegetables sourced from small and medium-sized farmers or wholesale distributors. This not only reduces procurement expenses but also supports food waste reduction efforts. The factory's centralized processing approach ensures consistent quality, improved hygiene, and extended shelf life, all of which are critical for meeting the nutritional and operational needs of elderly care institutions.

The model also features an efficient and scalable distribution system. Central kitchen operations allow for consolidated deliveries to multiple care centers, reducing per-unit transportation costs while increasing logistical efficiency. Importantly, the model creates mutual value across the supply chain: farmers gain a dependable outlet for surplus produce, while care institutions benefit from affordable, nutritious food options tailored to their residents.

Compliance with food safety and government regulations is another built-in strength. The facility is structured to meet legal standards for traceability, hygiene, and institutional food production. Furthermore, the model aligns with environmental, social, and governance (ESG) goals, making it attractive to both public funding bodies and mission-driven partners.

A significant operational advantage comes from the use of planned logistics supported by operations research tools. Instead of relying on real-time tracking, the factory applies routing optimization algorithms (e.g., solutions to the Vehicle Routing Problem) to efficiently serve a larger number of delivery points across the aging care market. This, combined with digital inventory and demand forecasting tools, enables the factory to adapt to supply fluctuations and

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improve overall planning accuracy. These strengths collectively position the model as a cost-efficient, sustainable, and scalable solution for institutional food provision.

Weaknesses (Internal Negative Factors)

Despite its strengths, the vegetable processing factory model faces several internal challenges that may hinder its implementation and growth. One major obstacle is the high initial investment required to build processing facilities, acquire permits, and install cold chain and specialized equipment. Coupled with a limited financial buffer, the model often operates on thin profit margins, which can constrain its ability to absorb unexpected costs or scale quickly. Additionally, the model depends on vegetable leftovers, which are inconsistent in both quantity and quality due to seasonal variations. Ensuring food-grade inputs requires dedicated systems for sorting, inspection, and staff training, increasing operational complexity.

The model also suffers from low initial brand trust as it represents a relatively new approach to food supply in institutional settings. Care centers may be hesitant to adopt a system unfamiliar to their procurement norms. Moreover, the business's dependence on long-term care institutions as its primary customer base introduces a degree of market rigidity, limiting diversification in product offerings or responsiveness to broader market trends.

Compliance with strict food safety, zoning, and traceability regulations further complicates operations, adding to the time, cost, and risk involved in setup and day-to-day management. Finally, labor recruitment and retention remain persistent challenges, particularly for overnight or repetitive tasks often associated with food processing. These roles are typically low-paying and may not attract stable or experienced workers, which can impact productivity and quality control.

Opportunities (External Positive Factors)

The vegetable processing factory model benefits from several favorable external trends

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that present significant growth opportunities. The most prominent is the rising elderly population, which is driving long-term growth in demand for institutional meal services, especially in care centers, nursing homes, and long-term care facilities. This creates a stable and expanding market for prepared food solutions tailored to the needs of aging populations.

The model also offers clear market differentiation by promoting sustainably sourced and socially responsible meals, which are increasingly valued by institutional buyers seeking to align with environmental, social, and governance (ESG) goals. This trend is reinforced by a growing demand for local and sustainable food sourcing, as public institutions become more conscious of their environmental footprint and procurement ethics.

In addition, government support in the form of policies and incentives targeting food waste reduction, circular economic initiatives, elderly care services, and social enterprise development creates a favorable policy environment for this model. These incentives can help lower entry barriers and encourage innovation in sustainable food systems.

Furthermore, technology integration, including the use of operations research tools, AI-driven logistics planning, and IoT-enabled monitoring, provides opportunities to enhance delivery efficiency, supply chain transparency, and scalability. Lastly, the model holds strong potential for replication across other institutional settings, such as schools, hospitals, and public meal programs, allowing it to evolve into a multi-sectoral solution addressing both social and environmental needs.

Threats (External Negative Factors)

The vegetable processing factory model faces several external threats that could disrupt operations or limit long-term viability. One significant concern is price volatility, particularly in logistics and energy costs, which can erode profit margins and affect the overall competitiveness of the model. In addition, the market faces increasing competition—both from larger, well-

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resourced food processors and catering companies, as well as from informal or unregulated “gray market” processors who may offer cheaper but non-compliant alternatives, potentially undercutting the model’s value proposition.

Another key threat lies in food safety perceptions. While the use of leftover vegetables supports sustainability, it may trigger public skepticism regarding food quality and safety, especially if incidents occur or are poorly managed. Compounding this, policy shifts—such as changes in food safety regulations, procurement guidelines, or reductions in funding for long-term care institutions—could raise compliance burdens or reduce market demand.

The operational environment also presents challenges. Urban logistics constraints in dense metro areas like Taipei—characterized by traffic congestion, restricted delivery windows, and high fuel prices—can hinder timely and cost-effective distribution. Furthermore, the model is vulnerable to market volatility, including sudden fluctuations in vegetable prices or institutional food budgets, which can affect both supply availability and demand predictability.

Finally, the climate impact on agriculture, such as typhoons, droughts, or crop diseases, poses a long-term threat to supply chain stability, especially for a model that depends on irregular streams of surplus produce.

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A full analysis of the SWOT is shown below in Figure 18.

	Helpful	Harmful
Internal Factor	**Strength** • Utilizes low-cost, surplus vegetables, reducing procurement costs and waste. • Centralized processing ensures consistent quality, hygiene, and shelf life. • Efficient, scalable distribution via central kitchen delivery model. • Creates mutual value for both farmers and care centers. • Strong alignment with ESG goals; attractive to public/private partners. • Designed for food safety and regulatory compliance. • Uses planned logistics algorithms (e.g., VRP solutions) to optimize delivery. • Tech-enabled forecasting and inventory improve adaptability.	**Weakness** • High capital requirements with limited financial buffer. • Challenges in recruiting and retaining low-wage processing labor. • Complex food safety, zoning, and traceability regulations. • Inconsistent quantity and quality of leftover vegetable supply. • Limited brand trust and reliance on a single market segment (care sector).
External Factor	**Opportunity** • Rising elderly population increases demand for institutional meals. • Differentiation through sustainable, socially responsible sourcing. • Government incentives for food waste reduction and social enterprises. • Technology adoption enhances efficiency and transparency. • Potential to scale into schools, hospitals, or public meal programs. • Growing institutional demand for local and sustainable food.	**Threats** • Price volatility in logistics, fuel, and raw material costs. • Competition from larger or unregulated low-cost food providers. • Public skepticism and risk of food safety incidents. • Policy changes or funding cuts may affect institutional demand. • Urban logistics issues in metro areas (e.g., Taipei) raise delivery costs. • Market instability due to price or budget fluctuations. • Climate risks (e.g., typhoons, droughts) affecting vegetable supply.

Figure 18 SWOT Analysis

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7. BUSINESS MODEL CANVAS

Business model canvas, also developed by Alexander Osterwalder, is a popular strategy tool used for communicating and defining a business idea. Figure 19 provides the template of the Business Model Canvas.

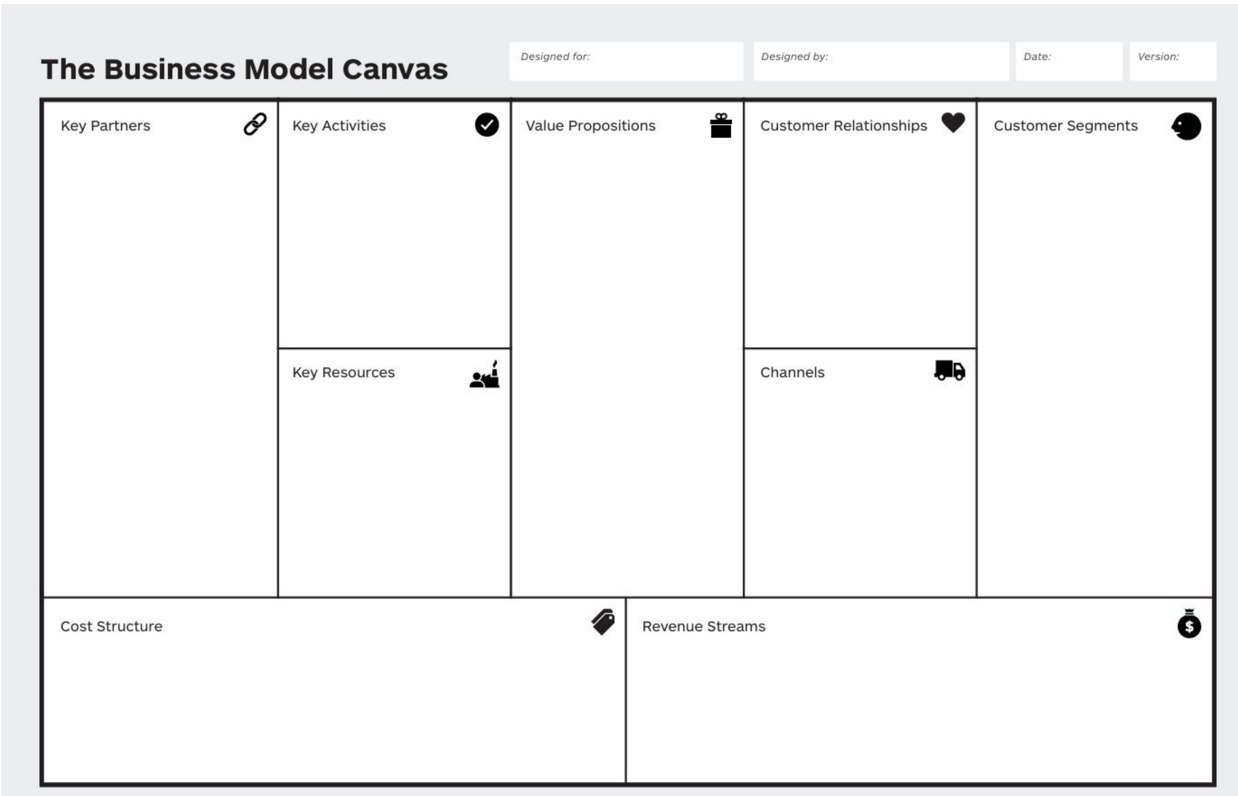

Figure 19 Business Model Canvas Example

Note: Source from Ebinum, O. (2022, October 28). How to: Business Model Canvas Explained. Retrieved April 12, 2025, from Business Model Canvas Template in Word (DOCX) - Neos Chronos

As shown above, the Business Model Canvas has nine elements and can be viewed in two parts. The right side of the model focuses on client analysis (external) and the left side of the model on business analysis (internal). All elements should match the result of the value proposition Canvas analysis conducted in chapter 6, and will assist the company in identifying the process of connecting business ideas to real practices. By completing the business model canvas, the company owner could vividly picture how the business will be in practice.

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7.1. Value proposition

In Taiwan, over 270,000 tons of vegetables are wasted annually due to oversupply, cosmetic standards, and logistical inefficiencies, posing both financial and environmental burdens on farmers. Many smallholder farmers face high disposal costs and lose potential income when produce that is edible but deemed unmarketable is discarded. The vegetable processing factory addresses this systemic issue by offering a legally compliant, low-barrier channel for farmers and wholesale distributors to move surplus or off-grade vegetables into a centralized processing and redistribution system. By aggregating this surplus and managing food safety, logistics, and quality control, the factory enables farmers to earn modest yet sustainable returns without having to navigate complex supply chains independently. This model not only reduces environmental waste but also positions farmers as contributors to ESG-aligned food systems that promote sustainability and resilience.

On the demand side, the factory supplies safe, clean, and ready-to-cook vegetables to elderly care institutions under the 長照 2.0 (Long-Term Care 2.0) system, or nursing homes. These vegetables are processed with attention to elderly dietary needs, including texture-modified cutting and ingredient combinations that facilitate digestion and reduce chewing difficulty. Using surplus produce also makes the service cost-effective, allowing institutions to improve meal quality while staying within budget constraints. The model delivers labor savings, consistency of supply, and enhanced food safety through standardized hygiene and packaging procedures. More broadly, it fosters a mutually beneficial exchange that supports elder nutrition, reduces food waste, and strengthens the local agricultural economy. Operating under a B-level business model, this enterprise prioritizes social and environmental value over profit, contributing to food justice and the development of a circular economy.

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7.2. Customer segments

The primary customers of the vegetable processing factory are central kitchens affiliated with elderly care institutions in Taipei and New Taipei City, including assisted living facilities, long-term care centers under the list of 2.0 programs, and geriatric medical institutions. These institutions require consistent, safe, and affordable vegetable supplies that meet dietary and food safety standards. However, many face labor shortages, and budget constraints limit their ability to procure and process fresh vegetables daily. The factory addresses this gap by offering pre-processed surplus vegetables that reduce operational burden while supporting institutions' nutritional and social responsibility goals.

On the supply side, the factory collaborates with small and medium-sized farmers and wholesale vegetable distributors who frequently face challenges related to overproduction, cosmetic rejection, or short shelf-life produce. The service offers them a structured and low-barrier outlet for surplus vegetables, converting waste into value.

Government agencies and public food programs focused on sustainability, food security, and elderly welfare are considered secondary customer segments. These stakeholders may serve as funding partners or service users, particularly in initiatives tied to ESG, environmental, or health-related objectives. In the long term, the model may extend to other underserved institutional buyers such as schools, hospitals, or food banks seeking cost-effective and reliable vegetable supplies.

7.3. Channels

The primary distribution channel for the vegetable processing factory is direct delivery to institutional clients via a cold chain logistics system. This ensures that vegetables remain fresh, safe, and on time—an essential requirement for elderly care facilities with tightly scheduled meal

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preparation. Regular deliveries help reduce the need for onsite storage and improve menu planning. Trust with institutional kitchens is further developed through face-to-face visits, product sampling, and demonstrations, which are especially effective during initial onboarding.

In addition to physical delivery, the factory maintains direct communication with care institution administrators through a supporting digital system. This system facilitates order scheduling, supply coordination, and access to food safety documentation, giving institutions visibility over incoming volumes and quality compliance. The centralized, institution-focused model supports streamlined communication across a fragmented customer base and aligns with government care delivery structures. Partnerships with local governments, elderly care associations, and agricultural organizations—such as the Taipei Agricultural Products Marketing Corporation (TAPMC) and regional Farmers Associations—further extend outreach capacity and reinforce operational efficiency on both the supply and demand sides.

7.4. Customer relationships

The factory prioritizes responsive and flexible service in its relationships with elderly care institutions, which often face unpredictable constraints such as limited access hours or last-minute changes in kitchen operations. To meet these needs, dedicated account staff maintain direct communication with institutional clients through phone calls and digital messaging platforms, enabling real-time coordination for delivery rescheduling or rerouting when necessary. Institutions are also encouraged to share their estimated vegetable requirements for the following day (D+1), allowing the factory to align processing volumes with actual demand, reduce waste, and improve operational efficiency.

On the supply side, the factory builds trust-based partnerships with small and medium-sized farmers and wholesale distributors by providing a consistent outlet for surplus or off-grade

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vegetables. These partners benefit from flexible collection arrangements and transparent reporting on how their produce is utilized. In some cases, co-branding or public recognition is offered to acknowledge their contributions, and the factory may also serve as a platform to help these partners promote other agricultural products or innovations. For example, participating farms may showcase new vegetable varieties or value-added goods through institutional networks. These practices support long-term collaboration and offer suppliers the opportunity to engage in a socially responsible, waste-reducing food system.

By aligning its relationships on both the supply and demand sides with broader environmental and social objectives, the factory operates under ESG principles—minimizing food waste, supporting vulnerable populations, and fostering sustainable agriculture through accountability and mutual benefit.

7.5. Key activities

The factory's core activities revolve around the collection, processing, and distribution of surplus vegetables sourced from small and medium-sized farms as well as wholesale markets. Collection involves coordinating with multiple producers to gather unsold or off-grade produce and transporting it to a food safety-compliant facility. Once received, vegetables undergo sorting, washing, trimming, cutting, and portioning according to the specific needs of elderly care institutions. These processes are carried out under strict hygiene protocols to meet Taiwan's regulatory standards and safeguard the health of vulnerable elderly populations. Cold chain logistics and routine scheduling are critical to ensuring product freshness and consistent delivery to institutional kitchens.

Beyond day-to-day operations, the factory engages in strategic planning and stakeholder coordination. This includes optimizing facility location and delivery routes using Operations

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Research (OR) methods to improve cost-efficiency and service coverage, particularly in dense urban areas like Taipei and New Taipei City. Other key activities include maintaining quality assurance systems, regulatory compliance, and tracking ESG-related outcomes such as food waste reduction. The factory also builds long-term relationships with farmers and care providers through continuous engagement, educational outreach, and sampling events. These efforts not only enhance brand credibility but also foster participation from stakeholders who may otherwise be hesitant due to labor constraints or negative past experiences with institutional partnerships.

7.6. Key resources

The factory's core resources include its processing facility, which is equipped for washing, cutting, sorting, and packaging vegetables in accordance with institutional food safety requirements. Cold chain logistics—particularly refrigerated vehicles and access to urban distribution hubs—are essential for preserving freshness and delivering on time to elderly care institutions. Supporting this is the ability to consolidate surplus vegetables from multiple smallholder farms and wholesale markets, which requires consistent visibility into what types of produce are available and when they were harvested or rejected. The ability to predict and match surplus supply with institutional demand is enhanced by routine data sharing and transparent communication with upstream partners.

Equally critical are digital and human resources. A technology-driven order and inventory system enables scheduling, demand forecasting, and real-time coordination with client institutions. Operations Research (OR) tools support strategic functions such as route optimization and facility siting, while ESG reporting tools help track food waste reduction and social impact metrics. Access to demand-side data—specifically, institutional preferences and next-day (D+1) volume forecasts—is a key enabler of processing efficiency. On the labor side, a stable and affordable

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workforce is needed for basic operations like washing, sorting, and packing. Given the labor shortages in Taiwan’s agricultural sector, ensuring reliable staffing for these routine tasks remains a critical operational pillar. Finally, food safety certifications such as HACCP are foundational to institutional credibility and legal compliance.

7.7. Key Partners

Partnerships with wholesale vegetable distributors are central to the factory’s sourcing strategy. These distributors operate in major urban hubs such as Taipei and New Taipei City and handle large volumes of produce, including items that are rejected for retail due to cosmetic or shelf-life issues. Collaborating directly with wholesalers allows the factory to access consistent quantities of surplus vegetables in a timely manner, reducing procurement risk and ensuring a reliable baseline supply. These partnerships are especially valuable for maintaining efficiency in aggregation and logistics, particularly during peak distribution hours when volume turnover is high.

In addition, smallholder farmers in central and northern Taiwan provide important seasonal and regional diversity in supply. However, many face barriers such as zoning regulations, limited labor for post-harvest processing, and difficulty complying with food safety requirements. By forming direct partnerships, the factory supports these farmers with a dependable outlet for surplus or off-grade vegetables that would otherwise go to waste, contributing to rural sustainability and social equity. Collaborations with agricultural cooperatives further enhance the ability to coordinate sourcing at scale.

On the demand side, partnerships with elderly care institutions and related public-sector stakeholders are equally critical. Institutional kitchens in Taipei and New Taipei City benefit from reliable, cost-effective supplies that meet nutritional standards. At the same time, local governments, NGOs, and community organizations play a vital role in navigating regulatory

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frameworks, securing operating permits, and providing policy or financial support. Logistics partners, particularly those offering cold-chain capabilities, ensure safe and timely delivery to end-users. Together, this multi-stakeholder network enables the factory to operate effectively while delivering environmental and social value under Taiwan's complex food and agricultural system.

7.8. Cost structure

A significant portion of the cost structure is tied to the upfront investment in establishing a compliant vegetable processing facility that meets Taiwan's stringent food safety and hygiene standards. Major capital expenditures include acquiring food-grade machinery for washing, cutting, and cleaning vegetables—core functions that ensure both product quality and regulatory compliance. Taiwanese regulations require certified factories to maintain three separate production lines for different processing functions, which increases both complexity and cost. These compliance demands extend beyond permitting and facility design, encompassing workflow separation, sanitation infrastructure, and proper zoning approvals. The strategic location of the facility is also a critical cost consideration. Proximity to key vegetable markets or major highways in Taipei and New Taipei City can substantially reduce fuel use, delivery time, and labor needs, while allowing more institutional clients to be served efficiently within a single route.

Recurring operational costs are equally substantial. These include wages for processing and logistics staff, utilities such as water and electricity (especially for washing stations and cold storage), and regular maintenance of machinery and equipment. Packaging materials—such as bags, trays, and labels—contribute to per-unit costs, while transport expenses add up through vehicle operation, fuel, and outsourced or in-house cold-chain logistics. The factory must also allocate a budget for food safety compliance, including certification fees, periodic audits, waste management, and environmental reporting. Maintenance of digital tools, such as Operations

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Research–based systems used for delivery route planning and demand forecasting, represents another essential line item. While the business is initially structured to operate at a break-even level to prioritize accessibility and impact, it aims to reach modest profitability by around the third year of operation through improved route efficiency, demand scaling, and cost control in logistics and processing.

7.9. Revenue streams

The primary revenue stream comes from the sale of processed and packaged vegetables to elderly care institutions, typically priced by weight, processing level, or delivery volume. Options include washed-only, pre-cut, or pre-portioned vegetable packs, with additional fees applied for customized cuts, specialized packaging, or preferred delivery time slots. These tiered offerings allow care institutions to choose based on their kitchen capacity and budget, while enabling the factory to recover operational costs and generate modest revenue. As a purpose-driven business, the factory is designed to operate at break-even in its early stages, with a goal of reaching modest profitability by approximately the third year through scaled demand, operational efficiencies, and route optimization.

In addition to direct sales, the factory seeks revenue stabilization and impact funding through public programs related to food waste reduction, elderly nutrition, and ESG innovation. Government subsidies, service contracts, and cross-sector initiatives help offset fixed costs and support broader service coverage. Supplementary income may also be generated from hosting "Farmer Vegetable Nutrition Sharing Sessions," which can attract institutional participation fees or sponsorships.

In the long run, once the business achieves operational stability, there may be an opportunity to offer a purchasing platform that allows staff or families at partner institutions to

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buy fresh vegetables directly from farmers. In this model, the factory would serve as the intermediary and logistics provider, potentially earning additional platform service fees for coordination, quality assurance, or delivery. Figure 20 shows the full Business Model Canvas Analysis.

Business Model Canvas	Designed for:	Designed by:	Date:	Version:
	Vegetable leftover ESG solution	Helen Sun	6/3/2025	1

Key Partners

1. Wholesaler Distributors

2. Smallholder Farmers and Agricultural Cooperatives

3. Elderly Care Institutions, Nursing Homes, Long-term care centers

4. Government Agencies (Agriculture, Health, Social Welfare)

5. NGOs and Foundations

6. Logistics Providers (Cold Chain Delivery)

Key Activities

1. Sourcing and collecting surplus vegetables
2. Cleaning, cutting, and packing
3. Cold storage and last-mile delivery
4. Demand coordination and support with institutions
5. Quality control and safety assurance
6. Relationship building with supply and demand partners

Key Resources

1. Processing Facility
2. Cold Chain Logistics Infrastructure
3. Supply Aggregation Capacity
4. Demand Data Visibility
5. Digital Tools, Technology Systems
6. Human Resources
7. Certifications and Legal Compliance

Value Propositions

1. **Elderly Institutions:**
- Safe, clean, ready-to-cook vegetables
- Custom cutting for elderly-friendly consumption
- Cost-effective due to the use of surplus/grade B vegetables

2. **Farmers/Distributors:**
- Outlet for surplus or imperfect vegetables
- Reduced post-harvest waste
- Stable offtake channel

3. **Social/Environmental Value:**
- Agricultural food waste reduction
- Circular economy promotion
- Enhanced elderly nutrition and welfare

Customer Relationships

1. **Elderly Institutions:**
- Real-time delivery coordination (e.g., rerouting if access fails)
- Regular D+1 demand communication for supply planning
- Ongoing contact via calls/messaging for service adjustments

2. **Farmers and Distributors:**
-Trust-based surplus donation relations
- Flexible pick-up/drop-off schedules
- Transparent reporting and recognition for contribution

Channels

1. Direct sales and delivery to elderly institutions
2. Partnership with local government and elderly care associations
3. Physical visits and sampling to build trust
4. Collaboration with Farmers Associations and Taipei Agricultural Products Marketing Corporation (TAPMC)

Customer Segments

1. **Primary Customers:**
- Elderly care institutions (assisted living facilities)
- Long-term care centers (e.g., listed under long-term care 2.0 Project)
- Medical institutions (nursing homes, hospitals with geriatric departments)

2. **Upstream Partners:**
- Small and medium-sized vegetable farmers
- Wholesale vegetable distributors

Cost Structure

1. Procurement of raw materials (often at reduced or zero cost)
2. Labor (processing, packaging, delivery)
3. Equipment and utilities
4. Cold chain transport and fuel
5. Packaging supplies
6. Marketing and outreach
7. Compliance and certification (e.g., HACCP) services

Revenue Streams

1. Product Sales:
- Processed/packaged vegetables sold by weight or processing level
- Premium charges for custom cuts or packaging
2. Government Support: Subsidies from food waste, elderly care, or agricultural programs
3. Grants/CSR Funding from ESG-aligned corporations or foundations
4. Service Fees or direct sales from the Vegetable Platform (Future)

Figure 20 Overall Business Model Canvas Analysis

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8. FINANCIAL ANALYSIS

8.1. Introduction

Understanding the cost structure of this business is the first step in building a financially viable model. Only by knowing the full scope of costs and expenses can we set a realistic and sustainable sales price. In turn, a clear grasp of total operating costs helps determine how much capital the owner can contribute and how much external funding is needed to maintain a stable cash flow.

This chapter begins by analyzing the core cost structure, including both direct costs of goods sold and ongoing operating expenses. Based on these figures, the next section examines how product pricing is set to ensure cost recovery and value creation. The third section addresses capital planning—how much initial and ongoing funding is needed, and how it can be split between owner contribution and potential loans. Finally, financial projections are presented to assess income and cost trends over a three-year period, concluding with a discussion on achieving long-term profitability.

The overall structure follows this logic: **Cost Structure → Pricing Strategy → Capital Planning → Financial Projections → Conclusion for achieving Profitability.**

8.2. Cost Structure

8.2.1. Operational Scale & Assumption

This business model focuses on processing and distributing surplus vegetables collected from a farm or wholesale distributor to institutional clients across Taipei and New Taipei City.

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The operation is designed to scale over three years, with increasing daily processing capacity and labor resources. Key assumptions are outlined as follows:

Daily Processing Volumes

The facility processes 1.5 tons of vegetables per day in Year 1, scales to 2 tons per day in Year 2, and reaches 3 tons per day in Year 3. Processing is conducted in batch workflows depending on volume and labor availability.

Workforce Structure and Roles

The workforce consists of a general manager, four drivers, a dispatcher, one administrative staff member, and four processing workers. During the first two years, when the daily processing volume is approximately 1.5 to 2 tons, the processing workers are responsible for key tasks including vegetable washing, machine feeding, quality inspection, weighing, packaging, and stacking. In the third year, as the daily processing volume increases to 3 tons, the processing team expands to seven members to maintain operational efficiency and manage the heavier workload. Simultaneously, the administrative team grows to two members to handle increased customer service demands and anticipated system upgrades.

Processing Scope and Utility Needs

Vegetables undergo basic cleaning, trimming, sorting, and packaging. The facility requires water access, food-safe washing stations, packing tables, refrigeration units, and cold storage. Processing 1 ton of vegetables typically requires around three hours of work by a team of four workers, including adequate rest periods.

Vehicle Use and Delivery Routes

Two vehicles are operated in double shifts. One vehicle runs a full-day delivery schedule

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of approximately 16 hours. The second vehicle is used for morning and evening collection of vegetable leftovers (from Taoyuan or Banqiao) and for an 8-hour afternoon delivery shift. Fuel costs are estimated at 300 NTD per day and are categorized separately from labor, as driver salaries are already included in the monthly payroll.

Cold Storage Capacity

The facility includes a cold storage system with a maximum capacity of 3 tons, including a 0.5-ton buffer area used during active processing. This allows for same-day or next-day distribution depending on routing and load schedules.

Vegetable Waste and Disposal Rate

Approximately 5% of incoming vegetables are unsuitable for use due to spoilage or damage. These are stored separately and disposed of every 10 days. At a disposal cost of 800 NTD per ton, this results in a monthly waste handling cost of 2,400 NTD.

Facility and Equipment Use

The operation utilizes a leased facility that houses the processing line and storage. Equipment includes cutting tables, wash basins, sealing machines, and industrial refrigerators, all with scheduled maintenance and depreciation over time.

Operating Days

The facility operates 12 months a year, at 30 days per month. While regular holiday breaks and maintenance periods are expected, logistics continue throughout the year to ensure uninterrupted food supply to the demand market, especially during holidays.

8.2.2. Direct Costs (COGS)

Direct costs refer to the variable expenses incurred in the daily handling, packaging, waste

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management of surplus vegetables, depreciation of the equipment and vehicles, and direct labor costs. These costs are directly proportional to operational volume and remain relatively stable across the first three years of operation, as shown in the following breakdown:

Raw Materials

No procurement costs are incurred for raw materials, as all vegetables are sourced free of charge from vegetable wholesale distributors or small and medium-sized farmers. This donation-based supply model reduces cost pressure while allowing for consistent volume.

Packaging Materials

Packaging is required for the safe transport and presentation of vegetables to institutional clients. Based on the estimated daily usage, the first-year daily usage is 75 bags at a unit cost of 2.5NTD, the second daily usage is 100 bags, and the third daily usage is 150 bags; the annual cost of packaging materials is calculated as:

Year 1 = 2.5 NTD × 75 bags × 30 days × 12 months = 67,500 NTD / year

Year 2 = 2.5 NTD × 100 bags × 30 days × 12 months = 90,000 NTD / year

Year 3 = 2.5 NTD × 150 bags × 30 days × 12 months = 135,000 NTD / year

This cost remains consistent throughout all three years, assuming stable delivery volume and baggy standards.

Vegetable Waste Disposal

On average, 5% of collected vegetables (approximately 100 kg per day from 2 tons) are deemed unfit for use due to spoilage or quality issues. These must be disposed of through regulated waste management channels.

Disposal is scheduled every 10 days, totaling approximately 3 times per month. At a unit cost of 800 NTD per ton, the annual disposal cost is:

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$$800 \text{ NTD} \times 3 \text{ disposals/month} \times 12 \text{ months} = 28{,}800 \text{ NTD / year}$$

Direct Labor Costs

Labor-related costs are separated into direct cost-related workers, including processing workers and logistics personnel. Administrative staff and the General Manager would be grouped under operating expenses, which would be discussed later on.

For Direct cost related workers, in Year 1 and Year 2, the labor force consists of 3 processing staffs, 1 cold storage receiver, 4 delivery drivers, 1 dispatcher; in Year 3, the growing volume to 3 tons per day necessitates the addition of 2 more processing. This results in the following total annual labor costs:

- Year 1 & 2: 4,044,000 NTD
- Year 3: 4,884,000 NTD

Equipment Depreciations

To handle daily processing volumes of up to 3 tons, the facility is equipped with the following machinery:

- Vegetable Cutter – 200,000 NTD
- Washing/Dehydrator Unit – 200,000 NTD
- Vacuum Packaging Machine – 150,000 NTD
- Refrigeration Unit (4 to 5-ton cold storage) – 550,000 NTD

These machines allow for efficient preparation, handling, and preservation of surplus vegetables following the food safety standards. The total equipment cost is 1,100,000 NTD, and annual depreciation is allocated as follows:

- Vegetable Cutter: 66,667 NTD /year

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- Washing Unit: 66,667 NTD/year
- Packaging Machine: 50,000 NTD/year
- Refrigerator Unit: 183,333 NTD/year
- Total Equipment Depreciation: 366,667 NTD/year

Vehicle Depreciations

Cold chain delivery is supported by two 3.5-ton chilled trucks, used for both the collection and distribution of vegetables across Taipei and New Taipei City. Each truck costs 1,850,000 NTD, totaling 3,700,000 NTD. These are depreciated evenly over three years:

- Truck A: 616,667 NTD/year
- Truck B: 616,667 NTD/year
- Total Vehicle Depreciation: 1,233,333 NTD/year

This figure is projected to remain stable, as it is based on percentage waste rather than volume increases, and the table below summarizes the total direct costs over a three-years period:

Category	Year 1	Year 2	Year 3	Comments
Raw materials	–	–	–	Free from distributors or farmers
Packaging materials	67,500	90,000	135,000	Based on 2.5 NTD per bag
Vegetable Waste Disposal	28,800	28,800	28,800	800 NTD per ton, disposed ~3 times/month
Labor Cost	4,044,000	4,044,000	4,884,000	Processing labor as Direct cost
Depreciation	1,600,000	1,600,000	1,600,000	Fridge & Machines 366,667 NTD Two Vehicles 1,233,333 NTD
Total COGS	**5,740,300**	**5,762,800**	**6,647,800**	

Table 8 COGS summary

8.2.3. Operating Expenses

Operating expenses include all fixed and semi-variable costs required to support the

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ongoing functionality of the processing and distribution operation. These expenses span labor, utilities, facility usage, logistics, compliance, and administrative overhead. The breakdown below presents the detailed structure of these costs across the first three years of operation.

Admin Costs

Administrative staff and the General manager would be grouped under operating expenses. In Year 1 and Year 2, the labor force consists of 1 admin and a general manager; in Year 3, the growing volume of 3 tons per day necessitates the addition of 1 more customer service staff member as admin staff. This results in the following total annual labor costs:

- Year 1 & 2: 1,152,000 NTD
- Year 3: 1,608,000 NTD

Utilities

Utilities include electricity and water used primarily in processing, cooling, and cleaning operations. Electricity is calculated based on 50 kWh per day at 5NTD/kWh, totaling 90,000 NTD annually in the first two years, while water consumption is based on 3 tons per day at 45 NTD/ton, totaling 48,600 NTD annually. In Year 3, as volume increases, utility usage is expected to rise by 50%, resulting in 207,900 NTD in total utility costs.

Cleaning and Consumables

Items such as gloves, detergents, and sanitation supplies are required for food-safe processing. For 6 workers in Years 1 and 2, consumables are estimated at 21,600 NTD/year (300 NTD/month per worker). In Year 3, with 9 workers, the cost increases to 32,400 NTD/year.

Facility Costs

Facility expenses include Factory Rental: 720,000 NTD per year, based on 60 pings at a monthly rental fee of 1,000 NTD/ping; management and Utilities costs like telecommunications,

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waste, and site management total 72,000 NTD/year. Wastewater Treatment is fixed at 120,000 NTD annually (with 10,000 NTD/month). Hence, the total facility cost remains stable at 912,000 NTD per year across all three years.

Logistics and Fuel

While driver salaries are included in labor costs, fuel and maintenance costs for two trucks are separately calculated. Estimated fuel and maintenance cost:

$$300 \text{ NTD/day} \times 2 \text{ trucks} \times 30 \text{ days/month} \times 12 \text{ months} = 216{,}000 \text{ NTD/year.}$$

In addition, as mentioned in Chapter Five, the competitiveness advantage of this business is to have the operation research scheduling tool to optimize the delivery routes; hence, a custom planning and IT support system for scheduling and logistics must be budgeted at 180,000 NTD annually (15,000 NTD/month), ensuring efficient routing and batch tracking.

Quality, Compliance, and Training

To maintain food safety and meet certification standards, Routine Food Inspections are arranged every month at 24,000 NTD/year (2,000 NTD/month). Since the business is aiming for high standards of surplus vegetable processing, the HACCP/ISO 22000 Certification Maintenance of 30,000NTD/year, and regular staff training for processing factories are needed: 6,000 NTD in Year 1 and 2 (6 workers × 1,000 NTD), and 9,000 NTD in Year 3 (9 workers × 1,000 NTD).

Miscellaneous

Other costs may include office Supplies cost 3,000 NTD per year, and insurance of 20,000 NTD per year. About the marketing fees, since there is one employee hired to work on admin work, the marketing duties are then embedded within administrative functions, so there would not be extra marketing costs.

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The total annual operating expenses are summarized as follows:

Category	Year 1	Year 2	Year 3
Processing Costs (Labor + Utilities + Cleaning)	1,312,200	1,312,200	1,848,300
Facility	912,000	912,000	912,000
Logistics and Fuel	396,000	396,000	396,000
Quality, Compliance, Training	60,000	60,000	63,000
Miscellaneous	23,000	23,000	23,000
Total Operating Expenses	**2,703,200**	**2,703,200**	**3,242,300**

Table 9 Total Operating Expenses Summary

Note: These operating costs support a processing system that runs 30 days per month, 12 months per year. Labor costs reflect full-time staffing and do not account for seasonal variations.

8.2.4. Cost Structure Summary

The operation's cost structure consists of direct costs (COGS), which reflect the per-unit costs tied to production/delivery (helps with pricing per kg, gross margin), and operating expenses, which reflect fixed or overhead costs (helps with break-even and capital planning).

COGS includes essential items like packaging and waste disposal, while operating expenses cover labor, utilities, facility use, logistics, and compliance. Together, these costs represent the total financial requirements for processing and distributing surplus vegetables on a large scale. The table below outlines the annual COGS, operating expenses, and total cost across the three-year plan.

Category	Year 1	Year 2	Year 3
Total COGS	5,740,300	5,762,800	6,647,800
Total Operating Expenses	2,703,200	2,703,200	3,242,300
Total Cost	**8,443,500**	**8,466,000**	**9,890,100**

Table 10 Total Cost Summary

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8.3. Pricing Strategy

8.3.1. Pricing Anchor

At the start of this business planning process, the appropriate unit sales price was unclear. It was essential to determine a price that could ensure financial sustainability without overburdening the institutional buyers, many of whom operate under limited budgets. To identify this pricing anchor, the first step was to calculate the real cost of processing each kilogram of surplus vegetables, considering both direct costs (Cost of Goods Sold) and indirect Operating Expenses. This grounded approach helps avoid setting a price that leads to long-term losses, while leaving room for potential profit or reinvestment. As a result, based on average annual processing volumes, we know that:

- **Year 1**: 1.5 tons/day × 365 days = 547,500 kg
- **Year 2**: 2 tons/day × 365 days = 730,000 kg
- **Year 3**: 3 tons/day × 365 days = 1,095,000 kg

By dividing total costs by annual processing volume, the estimated cost per kilogram is:

- **Year 1:** 8,443,500 NTD ÷ 547,500 kg ≈ 15.42 NTD/kg
- **Year 2:** 8,466,000 NTD ÷ 730,000 kg ≈ 11.60 NTD/kg
- **Year 3:** 9,879,300 NTD ÷ 1,095,000 kg ≈ 9.02 NTD/kg

Category	Year 1	Year 2	Year 3
Processing volumes (KG)	547,500 kg	730,000 kg	1,095,000 kg
Unit-level COGS (NTD/kg)	10.48 NTD/kg	7.89 NTD/kg	6.07 NTD/kg
Unit-level Operating Expenses (NTD/kg)	4.94 NTD/kg	3.70 NTD/kg	2.96 NTD/kg
Total Cost/kg	**15.42 NTD/kg**	**11.60 NTD/kg**	**9.03 NTD/kg**

Table 11 Cost per Kilogram at Different Scales and Different Years

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Understand the Market Benchmark

By knowing the unit cost per kg shown above, we then need to compare it to the current market price. According to the Taipei Fruit and Vegetable Wholesale Market open data, the average transaction price for leafy vegetables is **12.8 NTD/kg; t**his represents the ceiling of what bulk buyers typically pay on the open market for similar products.

Since the buyers of the vegetable processing factory are care institutions or elderly institutions, they may be more price-sensitive and unlikely to match open market prices, especially since they typically require **lower procurement risk**, **steady supply**, and **possibly semi-processed vegetables**. Thus, we can conservatively estimate that the maximum acceptable price for this target market should be at least 5–15% below the wholesale benchmark.

$$\text{Estimated acceptance upper price} = 12.8 \times 0.95 = 12.26 \text{ NTD/kg}$$

$$\text{Estimated acceptance lower price} = 12.8 \times 0.85 = 10.88 \text{ NTD/kg}$$

Therefore, the pricing ceiling for the target buyers is likely in the range of **10.88 to 12.26 NTD/kg.**

Define a Competitive Price

To come up with competitive pricing, the unit sales should be **Below market average** for competitiveness and social alignment, and **Above cost** for long-term viability.

At this point, we know that:

- **Price** > Cost in Year 3 (~9.03 NTD/kg) is necessary; and
- **Price** < Institutional price ceiling (~10.88–12.26 NTD/kg) is ideal for retention.

This gives a feasible pricing window of:

9.03 NTD/kg < **Unit Price** < ~12.26 NTD/kg

After conducting several rounds of simulations, we decided to set a fixed unit sale price at

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12 NTD/kg. The rationale behind considering several balancing factors:

1. Cost Coverage: Considering the value-added services provided, such as the pre-sorted, processed, and bundled vegetables, cold chain delivery to hundreds of points in the New Taipei area, and the reduced procurement burden for care centers, the aim is still to make the business profitable as early as possible. This price covers both direct and indirect costs by Year 2 and generates a healthy margin by Year 3.
2. Market Viability: Considering the 5%~15% deduction from the market price already, the unit sale price of 12 NTD/kg is within the range that the institutional buyers may be willing to buy, and also can make the business profitable soon.
3. Breakeven Logic:

   In Year 2 (2 tons/day): Cost ≈ 11.60 NTD/kg; Profit margin ≈ 0.40 NTD/kg

   In Year 3 (3 tons/day): Cost ≈ 9.03 NTD/kg; Profit margin ≈ 2.97 NTD/kg ;

Gross margin: 2.97 NTD/kg ÷ 12 NTD/kg **≈ 25%**

The reasonable Margin (~25%) in Year 3 would then **compensate for losses** in Year 1 and modest gains in Year 2. It also allows **Risk absorption** from price volatility or operational disruptions, **Strategic flexibility** to offer discounts or serve lower-income institutions, and **Readiness for expansion or reinvestment** in systems and equipment.

8.3.2. Sensitivity Analysis

While the standard unit price is set at **12 NTD/kg**, sensitivity analysis suggests that the business remains operationally sustainable down to approximately **9.63 NTD/kg**. This threshold reflects a cost-plus pricing scenario with a 5% margin over Year 3's unit cost of **9.03 NTD/kg,** providing a practical and flexible floor for future price negotiations, targeted subsidies, or socially driven programs, without jeopardizing financial stability.

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Even though the sale price is currently fixed at **12 NTD/kg**, several scenarios may require price adjustments. Future contracts, especially with government institutions or NGOs, might request lower pricing. Strategic discounts may also be necessary to serve lower-income or subsidized care centers. Additionally, operational realities such as inflation, donation inconsistency, or temporary overcapacity could create downward pressure on pricing.

By testing this lower-bound price scenario, the model confirms that the central processing operation could continue functioning at **9.63 NTD/kg**, maintaining both coverage of costs and a modest financial buffer. If prices were to drop below this level, the business would need to rely on external subsidies (such as government grants or impact investments) or pursue internal cost reductions. This analysis reinforces the importance of a price anchor that is not only rooted in cost structure but also aligned with the project's broader social mission—to deliver affordable, nutritious food to long-term care institutions and community-based clients.

8.3.3. Revenue Model

At the established price of 12 NTD/kg, processed vegetables are delivered daily to approximately 200 long-term care centers across Greater Taipei. Based on the specific processing volumes and 365 days of operation, projected gross revenues are as follows:

Gross Revenue Year 1: 1.5 tons/day × 12 NTD × 365 days = 6,570,000 NTD

Gross Revenue Year 2: 2.0 tons/day × 12 NTD× 365 days = 8,760,000 NTD

Gross Revenue Year 3: 3.0 tons/day × 12 NTD× 365 days = 13,140,000 NTD

These figures reflect revenue from core service delivery, excluding any supplemental income from donations or subsidies.

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8.4. Capital Planning

8.4.1. Funding Requirements

The launch of the surplus vegetable processing and delivery operation requires a set of essential equipment and vehicles to support cold-chain logistics, on-site processing, and proper food storage. All capital investments are made in Year 1, enabling full functionality from the outset. These fixed assets are depreciated on a straight-line basis over three years.

Total Capital Requirement for Fixed Assets

As mentioned in 8.2.2, the total fixed asset investment includes Processing equipment, Refrigerators, and chilled trucks, and the payment happens all together in Year 1 is as follows:

Asset Category	Total Cost (NTD)	Annual Depreciation (over 3 Years)
Processing Equipment	1,100,000	366,667
Refrigeration Unit	Included above	Included above
Chilled Trucks × 2	3,700,000	1,233,333
Total CAPEX	**4,800,000**	**1,600,000**

Table 12 Total CAPEX

These purchases form the operational foundation of the business and account for the full capital expenditure required before operations begin. The total annual depreciation of these assets is 1,600,000 NTD, which will be reflected in the income statement over the three-year depreciation period.

This investment ensures that the business can process, store, and distribute surplus vegetables at scale with the necessary hygiene, safety, and logistical standards.

8.4.2. Owner Equity & External Financing

To meet the total capital requirement of 4.8 million NTD in Year 1 for essential equipment and vehicles, the business adopts a blended financing model combining personal equity with a 3-

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year bank loan.

Owner Equity

A personal capital contribution of 500,000 NTD is provided by the owner at the outset. This equity accounts for approximately **10.4%** of the total fixed asset investment and demonstrates initial financial commitment and operational readiness. While modest in scale, this injection strengthens the business's credibility in securing additional financing and creates a personal stake in the project's success.

Market-Based Financing Strategy

Several borrowing options were evaluated through market research and financial simulations:

- Short-Term Credit (TAIBOR Benchmark):

  As of November 2024, the 3-month TAIBOR stands at 1.68%, commonly used for short-term corporate borrowing. Without compounding, the lending rate for short-term credit would be 6.72% per annum.

- Commercial Bank Loan (3-Year Term):

  The average commercial lending rate in Taiwan as of March–April 2025 is 3.27% per annum. While this option offers fixed repayment terms, it incurs a relatively higher cumulative interest burden.

After reviewing cash flow projections, a bank loan of a 3-year term was selected, applying a conservative 3.2% rate. This choice is based on internal projections showing that cash deficits only occur in Year 1, while net income turns positive from Year 2, allowing debt to be repaid steadily without refinancing.

Loan Structure and Repayment Plan

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As the total Amount needed to borrow is 4,900,000 NTD, the bank loan's interest rate turns out to be a more suitable choice for raising funds. Considering the Interest Rate applied conservatively at **3.2% per annum**, below are the interest rate breakdown per year:

- Total Interest (3 years): 422,400 NTD
- Year 1: 156,800 NTD
- Year 2: 156,800 NTD
- Year 3: 108,800 NTD

Repayment Schedule:

- Year 2: 1,500,000 NTD (~32%)
- Year 3: 3,400,000 NTD (remaining balance)

This repayment timeline was designed to reflect the expected growth in profit margins through economies of scale. While Year 2 marks the transition into profitability, the repayment burden is kept modest to preserve working capital. In Year 3, with full processing capacity and higher efficiency, the operation is projected to generate sufficient margin to cover the remaining debt without straining operations.

Strategic Rationale

This financing approach offers key advantages that ensure a healthy financial runway while allowing the project to build up internal reserves and move toward debt-free sustainability by the end of Year 3:

- Lower interest burden compared to standard term loans
- Responsiveness to operational scale-up, with repayment aligned to income growth
- Preservation of equity and operational control
- Built-in flexibility for early-stage liquidity without long-term liability

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8.4.3. Cash Flow and Risk Discussion

The cash flow plan is intentionally structured to maintain liquidity while managing startup investment and operating demands. With Year 1 being capital-intensive and unprofitable on a net income basis, a careful balance between financing and operational ramp-up allows the project to remain solvent and accumulate reserves by Year 3.

Cash Flow Dynamics Across Three Years

The cash flow projections show a deliberate plan to maintain liquidity while building operational scale. Year 1 reflects a significant negative net income (–2,063,300 NTD) due to upfront investments in vehicles and equipment, which together required 4.8 million NTD in capital expenditure. These purchases were funded by an owner's capital injection of 500,000 NTD and a bank loan draw of 4,900,000 NTD. Despite the operating loss, cash flow from financing activities enabled a positive ending cash balance of 326,500 NTD in Year 1.

As the business matures, cash generation improves significantly: Year 2 produces positive EBITDA of 1,894,000 NTD, and Year 3 further accelerates to 4,849,900 NTD. This trajectory supports strong cumulative cash positions by year-end 720,500 NTD and 2,170,400 NTD in Year 2 and Year 3, respectively, providing a healthy buffer against unforeseen disruptions.

Why Financing Was Necessary

A 3-year bank loan was chosen after reviewing Taiwan's lending market. Although short-term TAIBOR-linked rates are low (1.6% for 3 months), the 3.27% average rate for term loans offers a more cost-effective and manageable repayment structure over three years.

This cash flow strategy intentionally relied on a bank loan to bridge the initial cash deficit caused by large capital purchases. As the initial investment is substantial, the assets could not have been acquired solely through operating revenue or owner equity. The financing plan is scheduled

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for gradual repayment, with 1,500,000 NTD in Year 2 and 3,400,000 NTD in Year 3, aligning debt reduction with the expected ramp-up in revenue and profitability. This structure is to minimize the strain on operating cash flow and avoid liquidity crises during the critical early growth phase.

Risk Outlook and Financial Safeguards

While the improving cash position by Year 3 reduces immediate liquidity risk, several factors still warrant careful monitoring:

1. Operational Risks: Fluctuations in demand from long-term care centers, potential spoilage, or unforeseen increases in labor and fuel costs could pressure cash flow.
2. Loan Risks: The timely repayment of 4.9 million NTD in yearly bank loans hinges on achieving the planned sales volumes; any shortfall could necessitate refinancing or renegotiation.
3. Tax and Regulatory Risks: The projected tax liabilities increase sharply by Year 3, highlighting the need for proactive cash planning to avoid cash flow shocks.

It is essential to maintain a positive ending cash balance each year, and there should be close alignment between debt repayment and revenue growth. By leveraging strong margins, the business can then create an operational cushion. All the above measures are designed to help ensure the business remains solvent and adaptable, even in the face of fluctuating market or operating conditions.

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8.5. Three-Year Financial Projection Chart

8.5.1. Income Statement Chart

		Income Statement		
[NTD]	**Year 1**	**Year 2**	**Year 3**	**Comments**
Revenue				
Sales Revenue	**6,570,000**	**8,760,000**	**13,140,000**	Year 1: 1.5 tons/day → 1.5ton x 365 days x 12NTD = 547,500 kg x 12NTD = 6.57M NTD Year 2: 2.0 tons/day → 2ton x 365 days x 12NTD = 730,000 kg x 12NTD = 8.76M NTD Year 3: 3.0 tons/day → 3ton x 365 days x 12NTD = 1,095,000 kg x 12NTD = 13.14M NTD
Total Revenues	**6,570,000**	**8,760,000**	**13,140,000**	
COGS	**156,800**			
Raw materials	-	-	-	Free goods from vegetable wholesale distributors or small and medium-sized farmers
Packaging materials	(67,500)	(90,000)	(135,000)	2.5NTD/bag; Daily 104 delivery points, consider consumables 150 bags used per day 2.5NTD x 150 x 30days x 12months = 135,000NTD
Vegetable Waste disposal	(28,800)	(28,800)	(28,800)	Raw material loss and destruction cost: Destruction cost 800NTD/ton, consider 5% of vegetable leftovers will be loss, 2,000kg x 5%=100kg loss everyday, destroy cycle=every 10 days. Destruction frequency: About 3 times a month → 800NTD × 3 × 12 = 28,800 NTD/ year
- Labor Cost	**(4,044,000)**	**(4,044,000)**	**(4,884,000)**	Processing and logistics costs are under direct COGS
Processing staff	(1,260,000)	(1,260,000)	(2,100,000)	35,000NTD × 3 × 12 = 1.26M NTD ; Year 3 added 2 more processing staffs due to 3ton sales
Cold storage receiver	(384,000)	(384,000)	(384,000)	32,000NTD × 1 × 12 = 384,000 NTD
Delivery drivers	(1,920,000)	(1,920,000)	(1,920,000)	40,000NTD × 4 × 12 = 1.92M NTD
Dispatcher	(480,000)	(480,000)	(480,000)	40,000NTD × 1 × 12 = 480,000 NTD
Depreciations	**(1,600,000)**	**(1,600,000)**	**(1,600,000)**	
Depreciation – Equipment	**(366,667)**	**(366,667)**	**(366,667)**	fridge + machines
Vegetable Cutter	(66,667)	(66,667)	(66,667)	200,000NTD per machine
Washing / Dehydrator Unit	(66,667)	(66,667)	(66,667)	200,000NTD per machine
Vacuum Packaging Machine	(50,000)	(50,000)	(50,000)	150,000NTD per machine
Refrigeration Unit (3 tons)	(183,333)	(183,333)	(183,333)	550,000NTD for fridge of 4~5ton storage space
Depreciation – Vehicles	**(1,233,333)**	**(1,233,333)**	**(1,233,333)**	3.5Ton Chilled Trucks x 2
3.5Ton Chilled truck A	(616,667)	(616,667)	(616,667)	1,850,000NTD per truck (chilled)
3.5Ton Chilled truck B	(616,667)	(616,667)	(616,667)	
Total COGS	**(5,740,300)**	**(5,762,800)**	**(6,647,800)**	
Total Gross Profit	**829,700**	**2,997,200**	**6,492,200**	

Figure 21 Income Statement - 1

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	Income Statement (continued)			
[NTD]	**Year 1**	**Year 2**	**Year 3**	**Comments**
Expenses				
SG&A (Selling , General & Admin)	**(1,312,200)**	**(1,312,200)**	**(1,848,300)**	
- Labor Cost	**(1,152,000)**	**(1,152,000)**	**(1,608,000)**	Labor costs for General manager and admin are grouped under Operating Expenses, but processing and logistics labors are under direct COGS
Admin staff	(456,000)	(456,000)	(912,000)	38,000NTD × 1 × 12 = 456,000 NTD ; Year 3 added 1 more Admin staffs due to 3ton sales
General admin manager	(696,000)	(696,000)	(696,000)	58,000NTD × 1 × 12 = 696,000 NTD
- Utilities	**(138,600)**	**(138,600)**	**(207,900)**	Year 3 consider 150% increase in energy and water
Electricity	(90,000)	(90,000)	(135,000)	50 kWh × 5NTD × 30 × 12 = 90,000 NTD
Water	(48,600)	(48,600)	(72,900)	3 tons × 45NTD × 30 × 12 = 48,600 NTD
- Cleaning & Consumables	**(21,600)**	**(21,600)**	**(32,400)**	Items like Gloves, detergents, etc. 6 workers × 300NTD/month × 12 = 21,600 NTD; Year 3 increased to total 9 workers
Facility	**(912,000)**	**(912,000)**	**(912,000)**	
Factory Rental	(720,000)	(720,000)	(720,000)	60 ping × 1,000 NTD/Month × 12 months = 720,000 NTD/year
Management fees/utilities	(72,000)	(72,000)	(72,000)	Site water, Telecommunication, electricity and management fees = 6,000NTD /month × 12 = 72,000 NTD/year
Wastewater treatment	(120,000)	(120,000)	(120,000)	10,000 NTD/month × 12 months = 120,000 NTD/year
Logistics and Fuel	**(396,000)**	**(396,000)**	**(396,000)**	
Fuel & maintenance	(216,000)	(216,000)	(216,000)	Vehicle operating costs (fuel + maintenance) 300NTD × 2 trucks × 30 days × 12 months = 216,000 NTD / year Driver salary is included in the processing labor cost and is not double-counted
IT/OR System Planning Tool	(180,000)	(180,000)	(180,000)	Mid-range for scalable custom Excel + support + algorithm-based scheduling 15,000NTD x 12 months = 180,000NTD/year
Quality, Compliance, Trainings	**(60,000)**	**(60,000)**	**(63,000)**	
Routine Food inspection fee	(24,000)	(24,000)	(24,000)	2,000 NTD × 12 times (once per month) = 24,000 NTD/year
HACCP/ISO 22000 certification	(30,000)	(30,000)	(30,000)	Annual fixed maintenance fee 30,000 NTD
Staff training	(6,000)	(6,000)	(9,000)	6 workers × 1,000 NTD = 6,000 NTD/year ; Year 3 increase to 9 workers
Miscellaenous	**(23,000)**	**(23,000)**	**(23,000)**	
Office supplies	(3,000)	(3,000)	(3,000)	Annual estimate
Insurance	(20,000)	(20,000)	(20,000)	Annual estimate
Marketing	-	-	-	Considered zero, already included in administrative staff salary
Total Expenses	**(2,703,200)**	**(2,703,200)**	**(3,242,300)**	

Figure 22 Income Statement - 2

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	Income Statement (continued)			
[NTD]	**Year 1**	**Year 2**	**Year 3**	**Comments**
EBITDA	**(273,500)**	**1,894,000**	**4,849,900**	Earnings before Interests & Tax, Depreciation & Amortization = EBIT + Depreciation
Depreciations				
Depreciation – Equipment	**(366,667)**	**(366,667)**	**(366,667)**	fridge + machines
Vegetable Cutter	(66,667)	(66,667)	(66,667)	200,000NTD per machine
Washing / Dehydrator Unit	(66,667)	(66,667)	(66,667)	200,000NTD per machine
Vacuum Packaging Machine	(50,000)	(50,000)	(50,000)	150,000NTD per machine
Refrigeration Unit (3 tons)	(183,333)	(183,333)	(183,333)	550,000NTD for fridge of 4~5ton storage space
Depreciation – Vehicles	**(1,233,333)**	**(1,233,333)**	**(1,233,333)**	3.5Ton Chilled Trucks * 2
3.5Ton Chilled truck A	(616,667)	(616,667)	(616,667)	1,850,000NTD per truck (chilled)
3.5Ton Chilled truck B	(616,667)	(616,667)	(616,667)	
Total Depreciation	**(1,600,000)**	**(1,600,000)**	**(1,600,000)**	
EBIT	**(1,873,500)**	**294,000**	**3,249,900**	Earnings Before Interest, Taxes= Revenue - Operating expenses-COGS
Interest (3.2% on Yearly Bank Loan)	(156,800)	(156,800)	(108,800)	interest paid annually
EBT	**(2,030,300)**	**137,200**	**3,141,100**	EBT = EBIT – Interest Expenses
Vehicle Fuel Tax & License Tax	(33,000)	(33,000)	(33,000)	Each truck: License Tax 11,000 NTD/year ; Fuel Tax 5,500NTD/year
Business Income Tax (20%)	-	(27,440)	(628,220)	Year 1: EBT is negative, meaning no taxable profit, hence no tax owed
Net Income	**(2,063,300)**	**76,760**	**2,479,880**	Bottom-line profit after all expenses

Figure 23 Income Statement - 3

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8.5.2. *Cashflow Sheet*

	Cashflow			
[NTD]	**Year 1**	**Year 2**	**Year 3**	**Comments**
Cash Flows from Operating Activities				
Net Income	**(2,063,300)**	**76,760**	**2,479,880**	After Tax
Interest (3.2% on Short term Credit)	156,800	156,800	108,800	Added back as non-cash
Tax	33,000	60,440	661,220	
Adjustments for Non-Cash Items	**1,600,000**	**1,600,000**	**1,600,000**	
Depreciation – Equipment	366,667	366,667	366,667	
Depreciation – Vehicles	1,233,333	1,233,333	1,233,333	
Cashflow from Operating Activites (EBITDA)	**(273,500)**	**1,894,000**	**4,849,900**	Net Income+Interest+Taxes+Depreciation
Cash Flows from Investing Activities				
Purchase of Equipment	(1,100,000)	-	-	
Purchase of Vehicles	(3,700,000)	-	-	
Cash Flow from Investing Activities	**(4,800,000)**	**-**	**-**	
Cash Flows from Financing Activities				
Capital Injection (Owner)	500,000	-	-	
Yearly Bank Loan Drawn	4,900,000	-	-	
Yearly Bank Loan Repayment	-	(1,500,000)	(3,400,000)	
Cash Flow from Financing Activities	**5,400,000**	**(1,500,000)**	**(3,400,000)**	
Net Change in Cash	**326,500**	**394,000**	**1,449,900**	Operating Cash Flow
Opening Cash Balance	-	326,500	720,500	
Ending Cash Balance	**326,500**	**720,500**	**2,170,400**	Cumulative Cash Position

Figure 24 Cashflow Sheet

8.5.3. *Balance Sheet*

	Balance Sheet			
[NTD]	**Year 1**	**Year 2**	**Year 3**	**comments**
ASSETS				
Cash	326,500	720,500	2,170,400	Cumulative Cash Position
Net Equipment	733,333	366,667	-	Net of Depreciation
Equipment (at cost)	1,100,000	1,100,000	1,100,000	1,100,000NTD for Fridge & 3 types of machines
– Accumulated Depreciation: Equipment	(366,667)	(733,333)	(1,100,000)	
Net Vehicles	2,466,667	1,233,333	-	Net of Depreciation
Vehicles (at cost)	3,700,000	3,700,000	3,700,000	3,700,000NTD for 1,850,000NTD *2 trucks
– Accumulated Depreciation: Vehicles	(1,233,333)	(2,466,667)	(3,700,000)	
Total Non-Current Assets	(1,600,000)	(3,200,000)	(4,800,000)	Sum of Accumulated depreciations
Total Assets	**3,526,500**	**2,320,500**	**2,170,400**	
TOTAL ASSETS	**3,526,500**	**2,320,500**	**2,170,400**	
LIABILITIES				
Yearly Bank Loan	4,900,000	3,400,000	0	Assumed No account payables owed to suppliers/wages payables/unearned revenue
Short-term Liabilities	0	0	0	Assumed no short term credits
Total Liabilities	**4,900,000**	**3,400,000**	**-**	
EQUITY				
Shareholder's Equity	500,000	500,000	500,000	
Retained Earnings (Cumulative)	(1,873,500)	(1,579,500)	1,670,400	Net Income−Financing Interest
Retained Earnings (Current Year)	(2,063,300)	76,760	2,479,880	Net Income after Tax (current year)
Interests (Yearly Bank Loan)	156,800	156,800	108,800	
Tax	33,000	60,440	661,220	
Total Equity	**(1,373,500)**	**(1,079,500)**	**2,170,400**	
TOTAL LIABILITIES + EQUITY	**3,526,500**	**2,320,500**	**2,170,400**	

Figure 25 Balance Sheet

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CONCLUSION

This thesis demonstrates the feasibility and sustainability of establishing a vegetable processing and delivery operation built on surplus agricultural inputs, with a focus on both financial viability and social impact. Through detailed financial modeling, operational analysis, and site selection optimization, the proposed model offers a replicable blueprint for tackling food waste while supporting vulnerable communities.

1. Profitability and Financial Resilience

From a financial perspective, the business proposal shows that it can achieve both profitability and resilience through disciplined cost control, strategic pricing, and efficient capital use, enabling a surplus-based processing model with long-term sustainability. Despite significant upfront investments in equipment and vehicles, the business is projected to break even in Year 2 and generate over 2.4 million NTD in net income by Year 3, with a cumulative cash surplus of 2.17 million NTD reinforcing stability.

By Year 3, COGS represents ~50.6% of revenue, and operating expenses account for ~24.7% of revenue, leaving a healthy margin for net profit. This cost structure ensures that net income reaches nearly 18.9% of revenue at maturity, demonstrating not just survival, but a strong capacity for reinvestment or expansion. The fixed unit price of 12 NTD/kg balances affordability for institutional clients with stable gross margins, and sensitivity analysis confirms viability down to 9.63 NTD/kg, allowing flexibility for bulk partnerships, public programs, or subsidies.

To avoid higher short-term interest costs, a 3-year term loan is used to bridge early cash flow gaps, with full repayment by Year 3 reflecting financial discipline and earning stability. Integrating depreciation, interest, and business tax into the projections ensures realistic and transparent planning. This planning supports profitability and validates a circular economy

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approach, transforming surplus food into valuable social and economic outcomes.

2. Operational Research: Optimizing Logistics Results and Factory Location

Operational simulations reveal clear strategies for enhancing delivery efficiency and cost-effectiveness. Delivering two days' worth of vegetable volume per trip significantly reduces the frequency of delivery points and operational costs. For example, shipping 3 tons every two days only requires servicing 36–43 locations, compared to 110–114 locations if delivered daily, proving this method to be more efficient and scalable.

Site selection analysis, based on proximity to both highways and produce markets, evaluated six candidate zones in New Taipei. Among them, **TuCheng(土城)** emerges as the optimal location for the central processing facility. It offers the fewest required delivery points and the shortest overall distance per route, resulting in lower transportation costs and improved route density across the 537 target delivery points in the region.

3. Bridging Supply and Demand: A Win-Win Ecosystem

Beyond operational and financial success, this model provides a practical and scalable mechanism for connecting surplus vegetable suppliers with institutions serving vulnerable populations. On the supply side, farmers and wholesalers gain a consistent and dignified channel to reduce food waste and monetize surplus produce. On the demand side, nursing homes, elderly care facilities, and long-term care centers benefit from a stable, affordable source of processed vegetables delivered reliably and hygienically.

In doing so, the processing factory becomes more than just an intermediate; it becomes a critical infrastructure in a socially integrated, environmentally conscious food system. This win-win dynamic aligns agricultural efficiency with social welfare and lays a foundation for expanding similar circular economic solutions across Taiwan and beyond.

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References

Agriculture and Food Agency, Council of Agriculture, Executive Yuan. (n.d.). *Agricultural statistics: Yearly vegetable volume* [Web page]. https://agr.afa.gov.tw/afa/afa_frame.jsp

Agriculture and Food Agency, Council of Agriculture, Executive Yuan. (2024). *2023 Wholesale Market Agricultural Yearbook* (112 年批發市場農業年報) [PDF]. https://amis.afa.gov.tw/doc/112%E5%B9%B4%E5%A0%B1.pdf

Agriculture and Food Agency, Council of Agriculture, Executive Yuan. (n.d.). *Overview of vegetable production* (蔬菜生產概況) [Web page]. https://www.afa.gov.tw/cht/index.php?code=list&ids=365

Agriculture and Food Agency, Council of Agriculture, Executive Yuan. (2023, December 7). *Taiwan vegetable production and sales statistics, December 2023* [Web page]. https://www.afa.gov.tw/cht/index.php?code=list&flag=detail&ids=307&article_id=24167

Agricultural and Food Agency. (2024, May 8). *推動農產品初級加工管理制度 提升農業附加價值 [Promoting primary agricultural processing management systems to enhance agricultural added value]* https://www.afa.gov.tw/cht/index.php?code=list&flag=detail&ids=307&article_id=24167

BioCycle. (2015). *Food for people initiatives: Israel*. https://www.biocycle.net/food-people-initiatives-israel/

CTCI Foundation. (2020). 負責任的生產和消費食品模式研議: *The Responsible food production and consumption models*. [PDF]. https://reurl.cc/Z4qWXp

Council of Agriculture, Executive Yuan. (2023). *Agricultural statistics overview* (農業統計要覽) [Web page]. https://agrstat.moa.gov.tw/sdweb/public/inquiry/InquireAdvance.aspx

Council of Agriculture, Executive Yuan. (2024). *Food supply and demand annual report, 2023 (112 年)* (糧食供需年報) [PDF]. https://agrstat.moa.gov.tw/sdweb/public/book/Book.aspx

Council of Agriculture, Executive Yuan. (n.d.). *Integrated information platform for food and agricultural education* (食農教育資訊整合平臺) [Web page]. https://fae.moa.gov.tw/theme_list.php?theme=links

Council of Agriculture, Executive Yuan. (n.d.). *Agriculture theme pavilion* (農業主題館) [Web page]. https://kmweb.moa.gov.tw/theme_list.php?theme=subject_list_view&type=img&crop_type=A

Council of Agriculture, Executive Yuan. (n.d.). *Organic agriculture production information platform* (有機農業生產資訊平台) [Web page]. https://oapi.i-organic.org.tw/Default.aspx

Council of Agriculture, Executive Yuan. (2020). *Agricultural primary processing management system manual, 2020 (109 年度農產品初級加工場管理制度講義)* [PDF]. https://shorturl.at/MYtgH

DevelopmentAid. (2023, August 11). *Tackling food loss and waste* [Web page]. https://www.developmentaid.org/news-stream/post/150878/tackling-food-loss-waste

doi:10.6342/NTU202502954

Directorate-General of Budget, Accounting and Statistics, Executive Yuan. (2024). *Agricultural employment population statistics* [Web page]. Ministry of Labor, Taiwan. https://criteria.ilosh.gov.tw/iLosh/wSite/ct?ctNode=323&mp=3&xItem=40478
EIT Food. (n.d.). *Get Wasted: Circular food platform that fights food waste*. https://www.eitfood.eu/projects/get-wasted-circular-food-platform-that-fights-food-waste
Fair Trade Commission, Executive Yuan. (2020). *Study on the overview, production structure, marketing channels, and transaction systems of Taiwan's agricultural and livestock products industry* (我國農畜產品產業概況、生產結構、運銷通路及交易制度之研究) [PDF]. https://www.ftc.gov.tw/upload/selfanalysis/10902.pdf
Food and Agriculture Organization. (2013). *Food wastage footprint: Impacts on natural resources*. FAO. https://www.fao.org/3/i3347e/i3347e.pdf
Food and Agriculture Organization. (2011). *Global food losses and food waste – Extent, causes and prevention*. https://www.fao.org/4/mb060e/mb060e00.pdf
Food Industry Research and Development Institute. (2024). *2023 annual report* [eBook]. https://www.firdi.org.tw/PageData/Reports/112%E5%B9%B4/ebook_en/HTML5/pc.html#/page/18
Google. (n.d.). *OR-Tools license* [Text file]. GitHub. https://github.com/google/or-tools/blob/stable/LICENSE
Homemakers United Foundation. (2016).台灣量販店及超市處理剩食調查: *Survey on the handling of food waste in Taiwan's hypermarkets and supermarkets* [PDF]. https://shorturl.at/I80eb
Interreg Europe. (n.d.). *Ortomercato – Recovery of food and vegetables*. https://www.interregeurope.eu/good-practices/ortomercato-recovery-of-food-and-vegetables
JAM Wiki. (n.d.). *Value proposition canvas* [Web page]. https://www.jamwiki.org/value-proposition-canvas/
Jubo Health. (2025). *Jubo data report 2025* [Web page]. https://jubo-health.com/jubo-data-report2025/
Ministry of Agriculture, Executive Yuan. (n.d.). *Enforcement rules of the Agricultural Products Market Transaction Act* (農產品交易法施行細則) [Web page]. https://law.moa.gov.tw/LawContent.aspx?id=FL014796
Ministry of Health and Welfare, Executive Yuan. (n.d.). *Long-Term Care 10-Year Plan 2.0 statistics* (長期十年計畫 2.0 相關統計表) [Web page]. https://1966.gov.tw/LTC/lp-6485-207.html
Ministry of Health and Welfare, Department of Statistics. (2024). *Population by age and gender, May 2024* [Web page]. https://dep.mohw.gov.tw/DOS/cp-5099-79483-113.html
Ministry of Health and Welfare, Executive Yuan. (n.d.). *Nursing home care management system homepage* [Web page]. https://shorturl.at/9w7hI
Ministry of Health and Welfare, Executive Yuan. (2023, December 25). *Nursing manpower statistics, December 2023* [Web page]. https://nurse.mohw.gov.tw/cp-98-2273-64091-2.html

doi:10.6342/NTU202502954

Ministry of Health and Welfare, Executive Yuan. (n.d.). *Long-term care planning and promotion platform* [Web page]. https://ltcpap.mohw.gov.tw/public/index.html
Ministry of Health and Welfare, Executive Yuan. (n.d.). *List of residential long-term care institutions* (住宿式長照機構清冊) [Web page]. https://1966.gov.tw/LTC/cp-6443-71027-207.html
Ministry of Health and Welfare, Executive Yuan. (n.d.). *Good Hygienic Practice Guidelines for Food* (食品良好衛生規範準則) [Web page]. https://shorturl.at/1AHHi
Ministry of Health and Welfare. (2017). *Nursing Personnel Act* (護理人員法). Laws & Regulations Database of The Republic of China. https://lawplayer.com/act/6437d235e800e5f0b9305271/0
Ministry of Health and Welfare. (2017, June 3). *長期照顧服務法 [Long-Term Care Services Act]*. Laws & Regulations Database of The Republic of China. https://lawplayer.com/act/6437d251e800e5f0b9305620
Ministry of Justice, Republic of China (Taiwan). (n.d.). *Agricultural Products Market Transaction Act* (農產品市場交易法) [Web page]. https://law.moj.gov.tw/LawClass/LawParaDeatil.aspx?pcode=M0030070&bp=1
Neos Chronos. (n.d.). *Business model canvas template* [Word document]. Neos Chronos. https://neoschronos.com/download/business-model-canvas/docx/
Neos Chronos. (n.d.). *Value proposition canvas* [PowerPoint slides]. Neos Chronos. https://neoschronos.com/download/value-proposition-canvas/pptx/
New Taipei City Government Department of Health. (n.d.). *Long-term Care Services Overview* [Web page]. https://www.health.ntpc.gov.tw/basic/?mode=detail&node=585
OzHarvest. (n.d.). *OzHarvest: Nourishing our country*. https://www.ozharvest.org/
Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 3065–3081. https://doi.org/10.1016/j.resconrec.2008.07.009
Perron, L., & Furnon, V. (2020). *OR-Tools vehicle routing solver: A generic constraint programming solver with heuristic search for routing problems* [Web page]. Google Research. https://research.google/pubs/or-tools-vehicle-routing-solver-a-generic-constraint-programming-solver-with-heuristic-search-for-routing-problems/
REAP Food Group. (2022, August). *Vegetable processing feasibility study* [PDF]. https://reapfoodgroup.org/wp-content/uploads/2024/02/REAP-Vegetable-Processing-Feasibility-Study-August-2022.pdf
Silver Gate for Elders. (n.d.). *Homepage* (銀色大門老人送餐) [Web page]. https://www.silvergateforelders.com/
Silver Linings Global. (n.d.). *Services* [Web page]. https://silverliningsglobal.com/services/
Stadt Wien. (n.d.). *Fakten zum Thema Lebensmittelabfälle* [Facts about food waste]. https://www.wien.gv.at/umweltschutz/abfall/lebensmittel/fakten.html

doi:10.6342/NTU202502954

Social and Family Affairs Administration, Ministry of Health and Welfare, Executive Yuan. (n.d.). *Taiwan Elder Welfare and Services Overview* [Web page]. https://www.sfaa.gov.tw/sfaa/pages/VDetail.aspx?nodeid=358&pid=460

Social and Family Affairs Administration, Ministry of Health and Welfare, Executive Yuan. (n.d.). *Elder welfare services* [Web page]. https://www.sfaa.gov.tw/SFAA/Pages/List.aspx?nodeid=366

Taipei City Government Department of Health. (n.d.). *Nutrition and Food Safety Resources* [Web page]. https://health.gov.taipei/Content_List.aspx?n=F87C1EFB8D67D9D5

Taiwan Livestock Research Institute. (n.d.). Agricultural Production and Certification Management Act (農產品生產及驗證管理法) [Web page]. https://www.angrin.tlri.gov.tw/goat/gfa42/gfa42p15-19.htm

Taiwan Long-Term Care Professional Association. (2024, January 24). *2024 long-term care service capacity and policy recommendations report* [PDF]. https://www.ltcpa.org.tw/uploadfile/file/20240124/20240124165259_98323.pdf

The News Lens News & Market. (2023, October 11). *「年年過剩卻沒人要」：台灣蔬果浪費驚人，醜蔬果如何走出銷售困境？* [News article]. https://www.newsmarket.com.tw/blog/120413/

United Daily News. (2024, June 12). *農委會揭示糧食浪費數據，每年蔬果損失驚人* [News article]. https://udn.com/news/story/7266/8561156

doi:10.6342/NTU202502954

Appendix A – P&L Forecast Year 1 – Year 3

Profit & Loss Sheet - Year 1

Year	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	*Y1*	***Y1***
Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	***TTL***
Processing Volume KG/Day	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	**1.5**
Processing Volume KG/Month	45,625	45,625	45,625	45,625	45,625	45,625	45,625	45,625	45,625	45,625	45,625	45,625	**547,500**
Revenue NTD/Month	547,500	547,500	547,500	547,500	547,500	547,500	547,500	547,500	547,500	547,500	547,500	547,500	**6,570,000**
COGS	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	(478,358)	**(5,740,300)**
Packaging materials NTD/Month	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	(5,625)	**(67,500)**
Waste disposal NTD/Month	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	**(28,800)**
Labor cost NTD/Month	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	**(4,044,000)**
Depreciation – Equipment	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	**(366,667)**
Depreciation – Vehicles	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	**(1,233,333)**
Operating Expenses	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	**(2,703,200)**
Processing Costs	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	**(1,312,200)**
Facility	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	**(912,000)**
Logistics and Fuel	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	**(396,000)**
Quality, Compliance, Trainings	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	**(60,000)**
Miscellaenous	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	**(23,000)**
EBITDA	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	**(273,500)**
EBIT	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	(156,125)	**(1,873,500)**
Interest (3.2% on Bank Loan)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	**(156,800)**
EBT	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	(169,192)	**(2,030,300)**
Taxes	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	**(33,000)**
Vehicle Fuel Tax & License Tax	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	**(33,000)**
Business Income Tax (20%)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Net Income	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	(171,942)	**(2,063,300)**
Purchase of Equipment	(1,100,000)	0	0	0	0	0	0	0	0	0	0	0	**(1,100,000)**
Purchase of Vehicles	(3,700,000)	0	0	0	0	0	0	0	0	0	0	0	**(3,700,000)**
Capital Injection (Owner)	500,000	0	0	0	0	0	0	0	0	0	0	0	**500,000**
Bank Loan Drawn	4,900,000	0	0	0	0	0	0	0	0	0	0	0	**4,900,000**
Bank Loan Repayment	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Net Change in Cash	577,208	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	(22,792)	**326,500**
Opening Cash Balance	0	577,208	554,417	531,625	508,833	486,042	463,250	440,458	417,667	394,875	372,083	349,292	**0**
Ending Cash Balance	577,208	554,417	531,625	508,833	486,042	463,250	440,458	417,667	394,875	372,083	349,292	326,500	**326,500**

Figure 26 P&L Sheet Year 1

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Profit & Loss Sheet - Year 2

Year	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	*Y2*	***Y2***
Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	***TTL***
Processing Volume KG/Day	2	2	2	2	2	2	2	2	2	2	2	2	**2**
Processing Volume KG/Month	60,833	60,833	60,833	60,833	60,833	60,833	60,833	60,833	60,833	60,833	60,833	60,833	**730,000**
Revenue NTD/Month	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	**8,760,000**
COGS	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	(480,233)	**(5,762,800)**
Packaging materials NTD/Month	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	(7,500)	**(90,000)**
Waste disposal NTD/Month	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	**(28,800)**
Labor cost NTD/Month	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	(337,000)	**(4,044,000)**
Depreciation – Equipment	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	**(366,667)**
Depreciation – Vehicles	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	**(1,233,333)**
Operating Expenses	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	(225,267)	**(2,703,200)**
Processing Costs	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	(109,350)	**(1,312,200)**
Facility	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	**(912,000)**
Logistics and Fuel	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	**(396,000)**
Quality, Compliance, Trainings	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	(5,000)	**(60,000)**
Miscellaenous	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	**(23,000)**
EBITDA	157,833	157,833	157,833	157,833	157,833	157,833	157,833	157,833	157,833	157,833	157,833	157,833	**1,894,000**
EBIT	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	**294,000**
Interest (3.2% on Bank Loan)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	(13,067)	**(156,800)**
EBT	11,433	11,433	11,433	11,433	11,433	11,433	11,433	11,433	11,433	11,433	11,433	11,433	**137,200**
Taxes	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	(5,037)	**(60,440)**
Vehicle Fuel Tax & License Tax	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	**(33,000)**
Business Income Tax (20%)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	(2,287)	**(27,440)**
Net Income	6,397	6,397	6,397	6,397	6,397	6,397	6,397	6,397	6,397	6,397	6,397	6,397	**76,760**
Purchase of Equipment	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Purchase of Vehicles	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Capital Injection (Owner)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Bank Loan Drawn	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Bank Loan Repayment	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	(125,000)	**(1,500,000)**
Net Change in Cash	32,833	32,833	32,833	32,833	32,833	32,833	32,833	32,833	32,833	32,833	32,833	32,833	**394,000**
Opening Cash Balance	326,500	359,333	392,167	425,000	457,833	490,667	523,500	556,333	589,167	622,000	654,833	687,667	**326,500**
Ending Cash Balance	359,333	392,167	425,000	457,833	490,667	523,500	556,333	589,167	622,000	654,833	687,667	720,500	**720,500**

Figure 27 P&L Sheet Year 2

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Profit & Loss Sheet - Year 3

Year	Y3	Y3	Y3	Y3	Y3	Y3	Y3	Y3	Y3	Y3	Y3	Y3	**Y3**
Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	***TTL***
Processing Volume KG/Day	3	3	3	3	3	3	3	3	3	3	3	3	**3**
Processing Volume KG/Month	91,250	91,250	91,250	91,250	91,250	91,250	91,250	91,250	91,250	91,250	91,250	91,250	**1,095,000**
Revenue NTD/Month	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	1,095,000	**13,140,000**
COGS	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	(553,983)	**(6,647,800)**
Packaging materials NTD/Month	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	(11,250)	**(135,000)**
Waste disposal NTD/Month	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	(2,400)	**(28,800)**
Labor cost NTD/Month	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	(407,000)	**(4,884,000)**
Depreciation – Equipment	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	(30,556)	**(366,667)**
Depreciation – Vehicles	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	(102,778)	**(1,233,333)**
Operating Expenses	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	(270,192)	**(3,242,300)**
Processing Costs	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	(154,025)	**(1,848,300)**
Facility	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	(76,000)	**(912,000)**
Logistics and Fuel	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	(33,000)	**(396,000)**
Quality, Compliance, Trainings	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	(5,250)	**(63,000)**
Miscellaenous	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	(1,917)	**(23,000)**
EBITDA	404,158	404,158	404,158	404,158	404,158	404,158	404,158	404,158	404,158	404,158	404,158	404,158	**4,849,900**
EBIT	270,825	270,825	270,825	270,825	270,825	270,825	270,825	270,825	270,825	270,825	270,825	270,825	**3,249,900**
Interest (3.2% on Bank Loan)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	(9,067)	**(108,800)**
EBT	261,758	261,758	261,758	261,758	261,758	261,758	261,758	261,758	261,758	261,758	261,758	261,758	**3,141,100**
Taxes	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	(55,102)	**(661,220)**
Vehicle Fuel Tax & License Tax	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	**(33,000)**
Business Income Tax (20%)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	(52,352)	**(628,220)**
Net Income	206,657	206,657	206,657	206,657	206,657	206,657	206,657	206,657	206,657	206,657	206,657	206,657	**2,479,880**
Purchase of Equipment	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Purchase of Vehicles	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Capital Injection (Owner)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Bank Loan Drawn	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Bank Loan Repayment	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	(283,333)	**(3,400,000)**
Net Change in Cash	120,825	120,825	120,825	120,825	120,825	120,825	120,825	120,825	120,825	120,825	120,825	120,825	**1,449,900**
Opening Cash Balance	720,500	841,325	962,150	1,082,975	1,203,800	1,324,625	1,445,450	1,566,275	1,687,100	1,807,925	1,928,750	2,049,575	**720,500**
Ending Cash Balance	841,325	962,150	1,082,975	1,203,800	1,324,625	1,445,450	1,566,275	1,687,100	1,807,925	1,928,750	2,049,575	2,170,400	**2,170,400**

Figure 28 P&L Sheet Year 3

doi:10.6342/NTU202502954

Appendix B – Taiwan Government Social and Healthcare Bureau Contact

Department	Website	Section	Contact number
衛生福利部	https://1966.gov.tw/LTC/mp-207.html		(02)85906666
臺北市政府社會局	https://dosw.gov.taipei/	首頁\相關服務\銀髮族服務\長照服務單位專區	(02)27208889
新北市政府衛生局	https://www.health.ntpc.gov.tw/	首頁\主題專區\長照服務	(02)22577155
桃園市政府社會局	https://sab.tycg.gov.tw/index.jsp	首頁\福利服務\老人福利\生活照顧	(03)3322101
臺中市政府衛生局	https://www.health.taichung.gov.tw/	首頁\長照專區	(04)25265394
臺南市政府社區局長期照顧管理中心	https://ltc.tainan.gov.tw/default.asp		(06)2931232
高雄市政府衛生局長期照顧中心	https://ltc.kchb.gov.tw/		(07)7131500
宜蘭縣政府衛生局長期照護 服務管理所	https://ltc.ilshb.gov.tw/		(03)9359990
新竹縣政府社會處	https://social.hsinchu.gov.tw/Default.aspx	首頁\業務專區\老人福利	(03)5518101
苗栗縣政府長期照護管理中心	https://longcare.miaoli.gov.tw/Default.aspx		(037)559346
彰化縣政府衛生局	https://care.nccu.idv.tw/		(04)7278503
南投縣政府社會及勞動處	https://welfare.nantou.gov.tw/	首頁\長照2.0專區	(049)2244221
雲林縣政府衛生局	https://ylshb.yunlin.gov.tw/Default.aspx	首頁\長照2.0專區	(05)5345520
嘉義縣社會局	https://sabcc.cyhg.gov.tw/Default.aspx	首頁\業務專區\老人福利	(05)3620900
屏東縣長期照護處	https://www.pthg.gov.tw/care/Default.aspx		(08)7662900
臺東縣政府衛生局	http://ttshbltc.ttshb.gov.tw/index.php		(089)323214
花蓮縣政府衛生局	http://long-term.hlshb.gov.tw/		(03)8227141
澎湖縣政府社會處	https://www.penghu.gov.tw/society/index.jsp	首頁\業務專區\老人福利服務	(06)9274400
基隆市政府社會處	https://www.klcg.gov.tw/tw/social	首頁\主題服務\社會福利專區\老人福利\長照10年2.0專區	(02)24201122
新竹市政府衛生局	https://dep.hcchb.gov.tw/ch/index.jsp	首頁\衛生主題\長期照顧服務	(03)5355191
嘉義市政府衛生局長期照顧管理中心	https://longcare.chiayi.gov.tw/Default.aspx		(05)2336889
金門縣政府衛生局	https://longtermcare.kinmen.gov.tw/default.asp		(082)337521
連江縣政府衛生局	https://www.matsuhb.gov.tw/	首頁\醫療衛生\高齡暨長照業務	(0836)22095

Figure 29 Information on family care services by the Central/County/City Governments

Appendix C – Relevant Legal Framework for Agricultural Processing

According to the Agricultural Production and Certification Management Act (農產品生產及驗證管理法; legislated May 2019), administered by the Ministry of Economic Affairs through the issuance of a Factory Registration Certificate (工廠登記證), small-scale farmers are permitted to engage in agricultural processing activities using relatively simple processing methods. The key regulatory requirements are as follows:

1. Raw Material: The raw materials used must be domestically sourced agricultural products with traceable origins.
2. Applicants: Eligible applicants are natural persons actively engaged in agricultural production.
3. Facility Type: The processing must take place in a facility approved for agricultural processing (農業加工) situated on agricultural land.
4. Processing Scope: Permissible processing activities are limited to low-risk operations such as drying, crushing, grinding, and roasting.

The agricultural products must either have production and marketing record processing certification (產銷履歷) or organic processing certification (有機加工驗證), and the products must pass an assessment review of the primary agricultural processing methods and items (初級加工方式品項風險評估).

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Appendix D – OR Tool Configuration and Constraint Demonstration

1. Order Constraints

Define each order $k \in K$, where $4 \times |K| \leq |I|$

Each order k consists of four sequential tasks:

a) $i_1(k) \in$ I: Arrive at the farm or distributor to prepare vegetable pick up (pre-loading)

b) $i_2(k) \in$ I: Arrive at the processing factory, ready to unload vegetables (pre-unloading)

c) $i_3(k) \in$ I: Finished processing, ready to pick up processed vegetables (pre-loading)

d) $i_4(k) \in$ I: Arrive at the delivery site, ready to unload processed vegetables (pre-unloading)

The following constraints apply:

a) Location Consistency:

The unloading and loading tasks at the processing factory must occur at the same location; location abbreviated as Loc:

$$\mathrm{Loc}(i_2(k)) = \mathrm{Loc}(i_3(k)) = \text{unique processing factory}$$

b) Flow Integrity:

All four tasks in the same order must be active if the order is processed:

$$\mathrm{Active}(i_1(k)) = \mathrm{Active}(i_2(k)) = \mathrm{Active}(i_3(k)) = \mathrm{Active}(i_4(k))$$

c) Time Precedence:

The task sequence within an order must follow the correct time order:

$$t_{i_1(k)} \leq t_{i_2(k)} \leq t_{i_3(k)} \leq t_{i_4(k)}$$

d) Vehicle Consistency Constraint (allows possible vehicle switch):

The same vehicle must handle pickup and drop-off within each sub-trip:

$$\mathrm{Vehicle}(i_1(k)) = \mathrm{Vehicle}(i_2(k))$$

$$\mathrm{Vehicle}(i_3(k)) = \mathrm{Vehicle}(i_4(k))$$

e) Processing Time Constraint (cross-vehicle switch allowed):

The unloading time plus processing duration must be earlier than the time when the processed vegetables are ready for pickup:

$$t_{i_2(k)} + \mathrm{UnloadingTime} + \mathrm{ProcessingTime} \leq t_{i_3(k)}$$

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2. Vehicle constraints

Each vehicle $v \in V$ is defined as:

a) A **start and end location** $(i_v^{start}, i_v^{end}) \in I$, representing the start and end of a shift (no backlog inventory from previous day **at start**, and no backlog inventory pushed to the next day **at end**).

b) An **empty route** means that if the vehicle performs no tasks, it directly travels from i_v^{start} to i_v^{end}, consistent with the OR-Tools vehicle routing model.

3. Transition Scenarios Overview

All transitions are categorized between event nodes based on the **order step** (pickup, unloading, processing, loading) and whether the nodes belong to the **same order** or **different orders**.

Each row specifies:

a) **Node Transition:** The transition from one event node to another

b) **Order Relationship:** Whether they belong to the same or different orders

c) **Time Transition:** Travel time + handling time involved; time calculated based on Google Map Distance *GMD(i)*

d) **Capacity Transition:** How vehicle load changes, based on order demand *DEM(k)*

Below are the detailed node settings:

- **From Vehicle Start or End Nodes**

Node Transition	Order ID	Time Transition	Capacity Transition
$i_v^{start} \rightarrow i_1(k_1)$	k_1	*GMD* (start location, i_1)	0
$i_4(k_1) \rightarrow i_v^{end}$	k_1	Unloading time + *GMD* (i_4 , end location)	- *DEM* (k_1)

Table 13 From Vehicle Start or End Nodes

- **Within the same order $\boldsymbol{k_1}$**

Node Transition	Order ID	Time Transition	Capacity Transition
$i_1(k_1) \rightarrow i_2(k_1)$	k_1	Loading time + *GMD* (i_1, i_2)	+ *DEM* (k_1)
$i_2(k_1) \rightarrow i_3(k_1)$	k_1	Unloading time + processing time	- *DEM* (k_1)
$i_3(k_1) \rightarrow i_4(k_1)$	k_1	Loading time + *GMD* (i_3, i_4)	+ *DEM* (k_1)

Table 14 Within the same order Node Setting

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- **Across Different Orders** $k_1 \neq k_2$

Node Transition	Order ID	Time Transition	Capacity Transition
$i_1(k_1) \rightarrow i_1(k_2)$	$k_1 \neq k_2$	0 (same location) or Loading time + $GMD\ (i_1, i_2)$	$+ DEM(k_1)$
$i_1(k_1) \rightarrow i_2(k_2)$	$k_1 \neq k_2$	Loading time + $GMD\ (i_1, i_2)$	$+ DEM(k_1)$
$i_1(k_1) \rightarrow i_3(k_2)$	$k_1 \neq k_2$	∞ (invalid sequence; Correct sequence should include step 2, e.g., 11233)	
$i_1(k_1) \rightarrow i_4(k_2)$	$k_1 \neq k_2$	Loading time + $GMD\ (i_1, i_4)$	$+ DEM(k_1)$
$i_2(k_1) \rightarrow i_1(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_2, i_1)$	$- DEM\ (k_1)$
$i_2(k_1) \rightarrow i_2(k_2)$	$k_1 \neq k_2$	0	$- DEM\ (k_1)$
$i_2(k_1) \rightarrow i_3(k_2)$	$k_1 \neq k_2$	Unloading time	$- DEM\ (k_1)$
$i_2(k_1) \rightarrow i_4(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_2, i_4)$	$- DEM\ (k_1)$
$i_3(k_1) \rightarrow i_1(k_2)$	$k_1 \neq k_2$	Loading time + $GMD\ (i_3, i_1)$	$+ DEM(k_1)$
$i_3(k_1) \rightarrow i_2(k_2)$	$k_1 \neq k_2$	∞ (invalid sequence; Step 2 should be followed by Step 3 in sequence, e.g., 222333)	
$i_3(k_1) \rightarrow i_3(k_2)$	$k_1 \neq k_2$	0	$+ DEM(k_1)$
$i_3(k_1) \rightarrow i_4(k_2)$	$k_1 \neq k_2$	Loading time + $GMD\ (i_3, i_4)$	$+ DEM(k_1)$
$i_4(k_1) \rightarrow i_1(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_4, i_1)$	$- DEM\ (k_1)$
$i_4(k_1) \rightarrow i_2(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_4, i_2)$	$- DEM\ (k_1)$
$i_4(k_1) \rightarrow i_3(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_4, i_3)$	$- DEM\ (k_1)$
$i_4(k_1) \rightarrow i_4(k_2)$	$k_1 \neq k_2$	Unloading time + $GMD\ (i_4, i_4)$	$- DEM\ (k_1)$

Table 15 Across the different order Node settings

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Appendix E – Prototype Demo for Greater Taipei Area Vegetable Scheduling

1. OR Tool Vege Nexton: Prototype Visualization

a) Delivery type: there are Model I, 2 tons of vegetables delivered, or Model II, 3 tons of vegetables delivered to choose from.

b) Processing sites: locations are selected from 6 nominated processing site set up locations, including TuCheng, WanHua, ChongHe, WuGu, ShuLin, LinKou

c) Days of delivery per trip: The thesis tested the feasibility of delivering 1-day vegetables and 2-day vegetables during one trip.

d) Weekday: this was set up only between Monday and Friday, and based on Google Maps window data per institution, to calculate the results.

e) Solver setting – Calculate second from the OR tool; supposedly, the longer the time for calculations, the more optimized the results become.

f) The memo column is for noting down each run criteria.

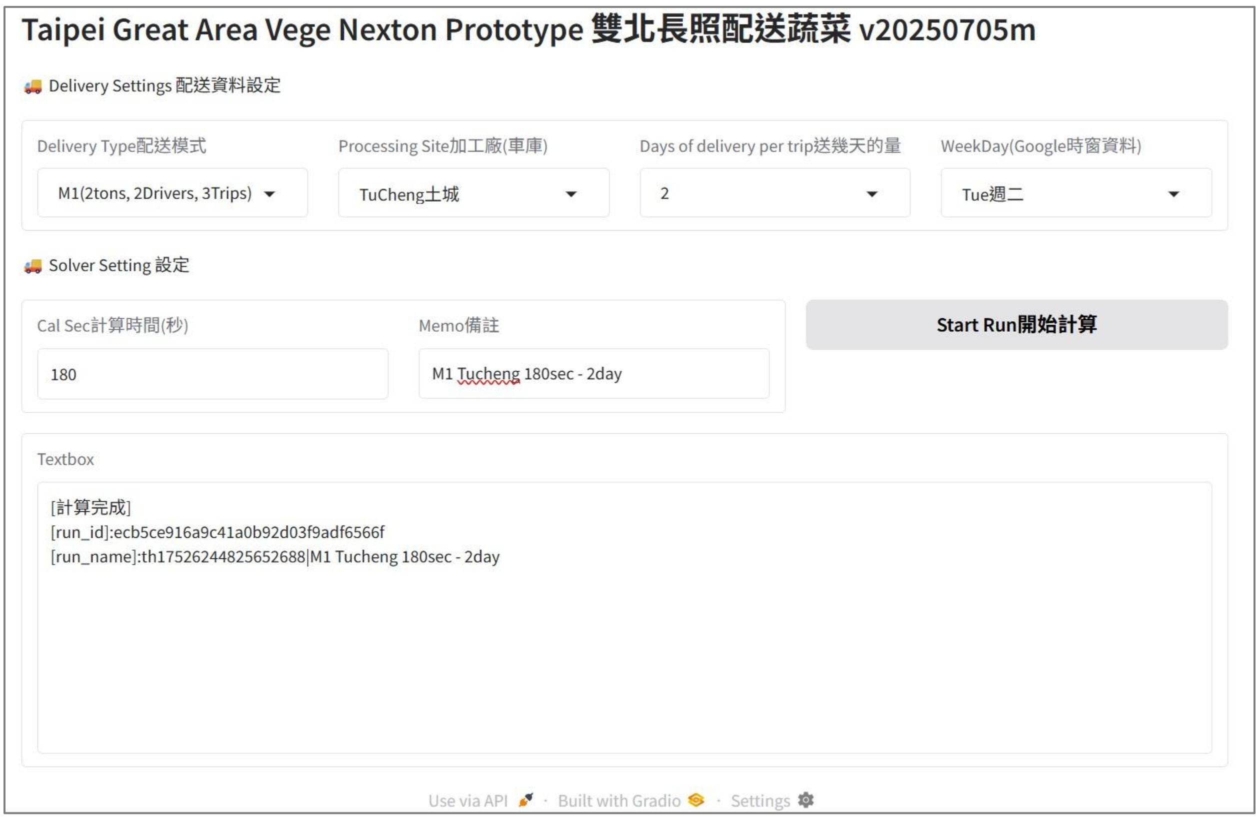
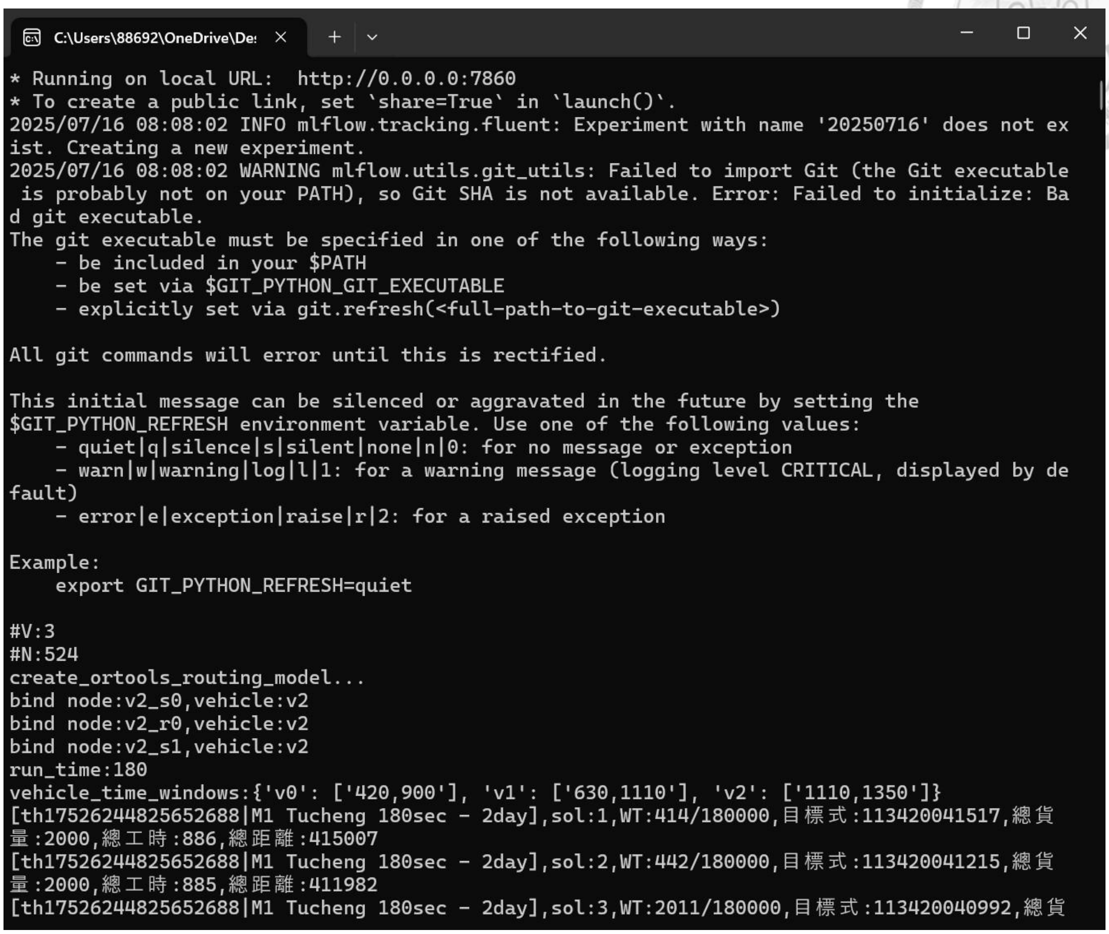


Figure 30 OR Tool Vege Nexton: Prototype Visualization

doi:10.6342/NTU202502954

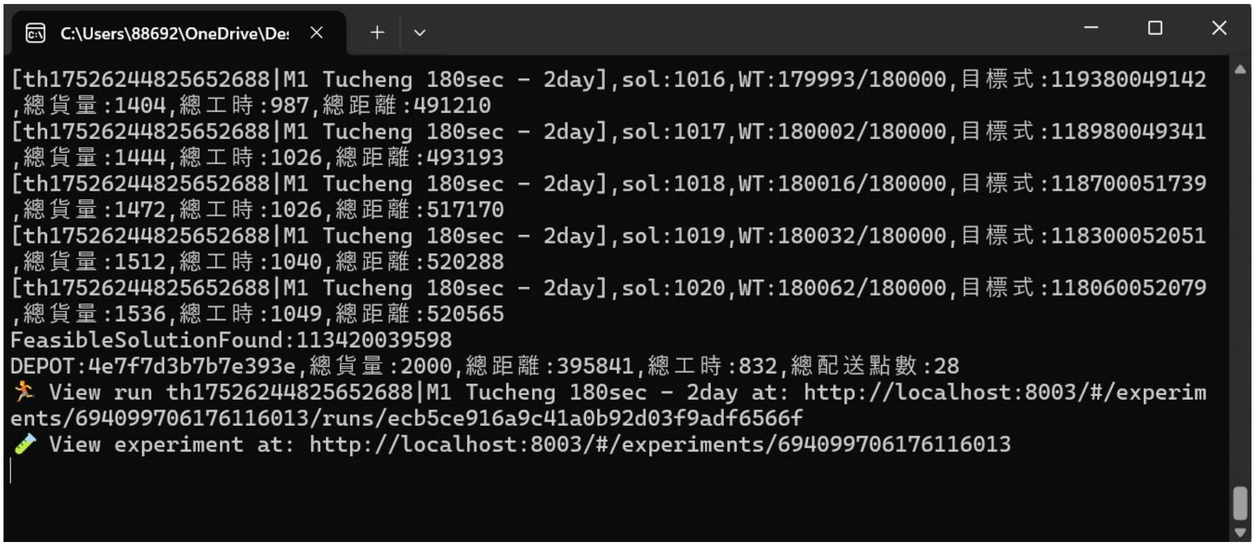
2. OR Tool Python Calculations screenshots

Below two screenshots show the system's run results before a feasible solution is found.



```
C:\Users\88692\OneDrive\De:
* Running on local URL:  http://0.0.0.0:7860
* To create a public link, set `share=True` in `launch()`.
2025/07/16 08:08:02 INFO mlflow.tracking.fluent: Experiment with name '20250716' does not ex
ist. Creating a new experiment.
2025/07/16 08:08:02 WARNING mlflow.utils.git_utils: Failed to import Git (the Git executable
 is probably not on your PATH), so Git SHA is not available. Error: Failed to initialize: Ba
d git executable.
The git executable must be specified in one of the following ways:
    - be included in your $PATH
    - be set via $GIT_PYTHON_GIT_EXECUTABLE
    - explicitly set via git.refresh(<full-path-to-git-executable>)

All git commands will error until this is rectified.

This initial message can be silenced or aggravated in the future by setting the
$GIT_PYTHON_REFRESH environment variable. Use one of the following values:
    - quiet|q|silence|s|silent|none|n|0: for no message or exception
    - warn|w|warning|log|l|1: for a warning message (logging level CRITICAL, displayed by de
fault)
    - error|e|exception|raise|r|2: for a raised exception

Example:
    export GIT_PYTHON_REFRESH=quiet

#V:3
#N:524
create_ortools_routing_model...
bind node:v2_s0,vehicle:v2
bind node:v2_r0,vehicle:v2
bind node:v2_s1,vehicle:v2
run_time:180
vehicle_time_windows:{'v0': ['420,900'], 'v1': ['630,1110'], 'v2': ['1110,1350']}
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1,WT:414/180000,目標式:113420041517,總貨
量:2000,總工時:886,總距離:415007
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:2,WT:442/180000,目標式:113420041215,總貨
量:2000,總工時:885,總距離:411982
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:3,WT:2011/180000,目標式:113420040992,總貨
```

Figure 31 OR Tool Python Calculations screenshot - 1



```
C:\Users\88692\OneDrive\De:
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1016,WT:179993/180000,目標式:119380049142
,總貨量:1404,總工時:987,總距離:491210
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1017,WT:180002/180000,目標式:118980049341
,總貨量:1444,總工時:1026,總距離:493193
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1018,WT:180016/180000,目標式:118700051739
,總貨量:1472,總工時:1026,總距離:517170
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1019,WT:180032/180000,目標式:118300052051
,總貨量:1512,總工時:1040,總距離:520288
[th17526244825652688|M1 Tucheng 180sec - 2day],sol:1020,WT:180062/180000,目標式:118060052079
,總貨量:1536,總工時:1049,總距離:520565
FeasibleSolutionFound:113420039598
DEPOT:4e7f7d3b7b7e393e,總貨量:2000,總距離:395841,總工時:832,總配送點數:28
🏃 View run th17526244825652688|M1 Tucheng 180sec - 2day at: http://localhost:8003/#/experim
ents/694099706176116013/runs/ecb5ce916a9c41a0b92d03f9adf6566f
🧪 View experiment at: http://localhost:8003/#/experiments/694099706176116013
```

Figure 32 OR Tool Python Calculations screenshot - 2

doi:10.6342/NTU202502954

3. ML Flow Solution Finding Results Demonstration

The result tabs shown below reflect the feasible solution identified by the OR tool. These outputs include task sequencing, vehicle assignments, time scheduling, and capacity transitions for each order. They illustrate how the constraints and routing logic defined in the model are applied in a practical scenario.

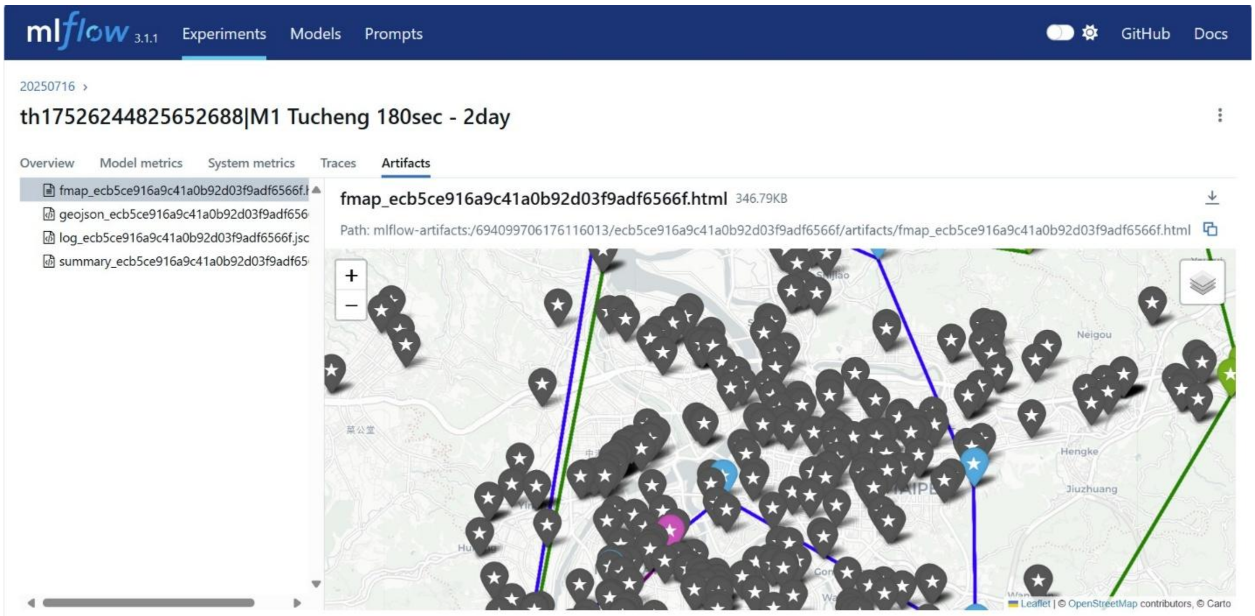


Figure 33 Task and Vehicle Assignment Output

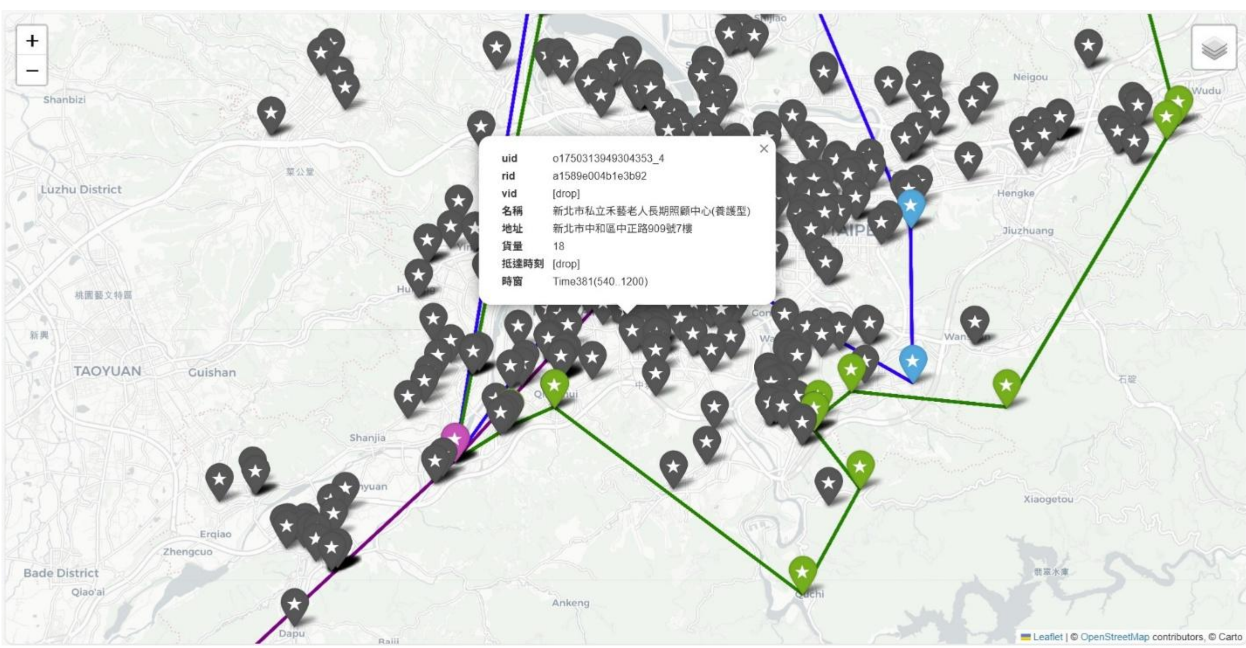


Figure 34 Detail Info for Vehicle Assigned Site Output

doi:10.6342/NTU202502954

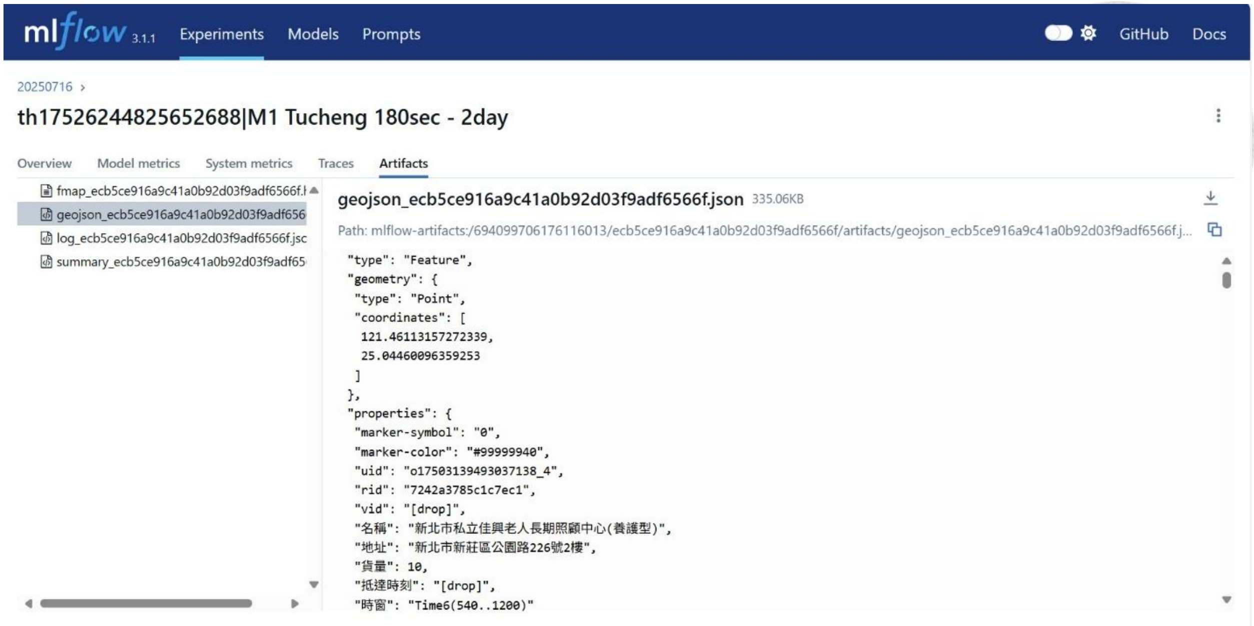


Figure 35 GeoJSON Script setting View for Order Execution

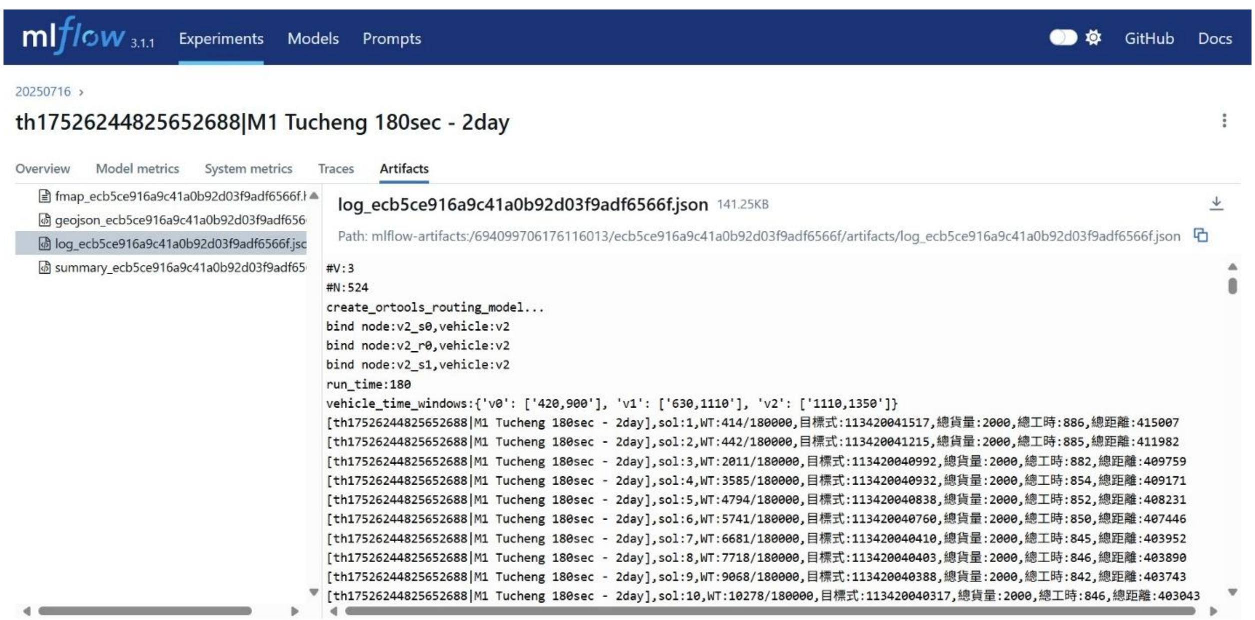


Figure 36 Order Execution Output - 1

doi:10.6342/NTU202502954

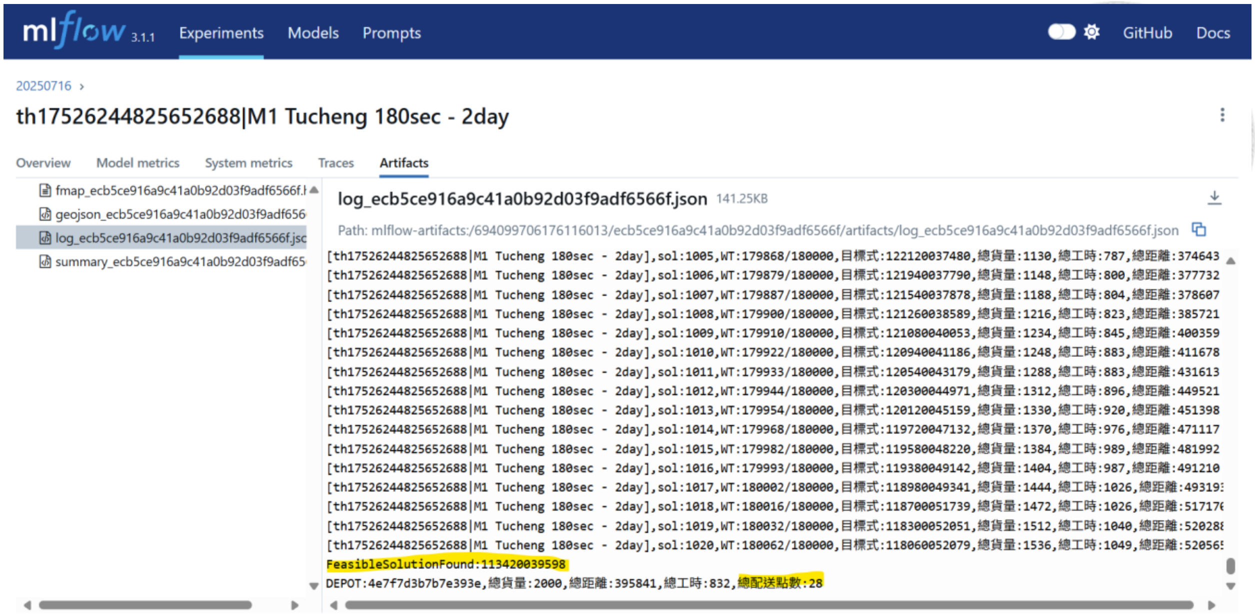


Figure 37 Order Execution Output - 2

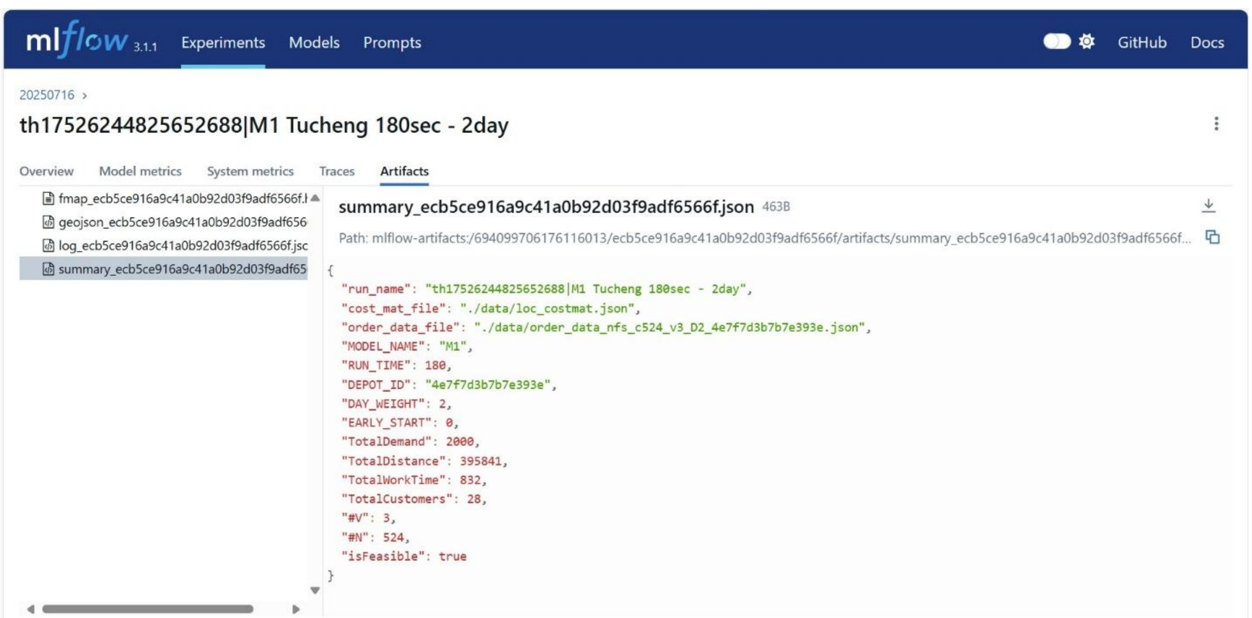


Figure 38 Order Execution Output Summary

doi:10.6342/NTU202502954